



Perspectivas económicas y encaje del almacenamiento

31-03-2025

JAVIER REVUELTA

Agenda

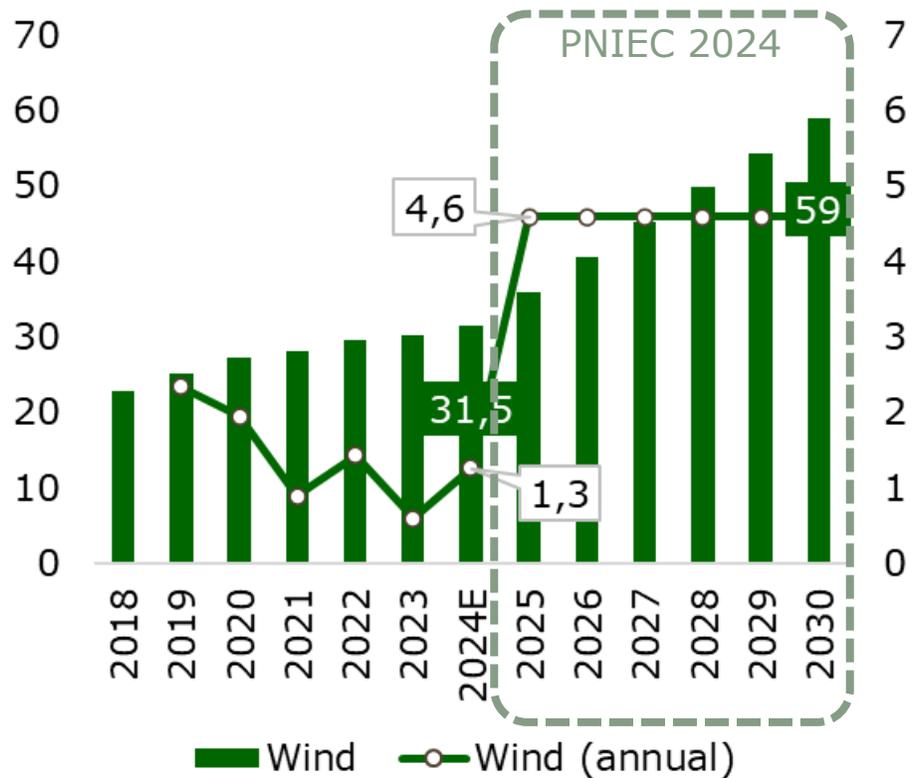
1. Mix eléctrico
2. Precios
3. Spreads del almacenamiento
4. Regulación



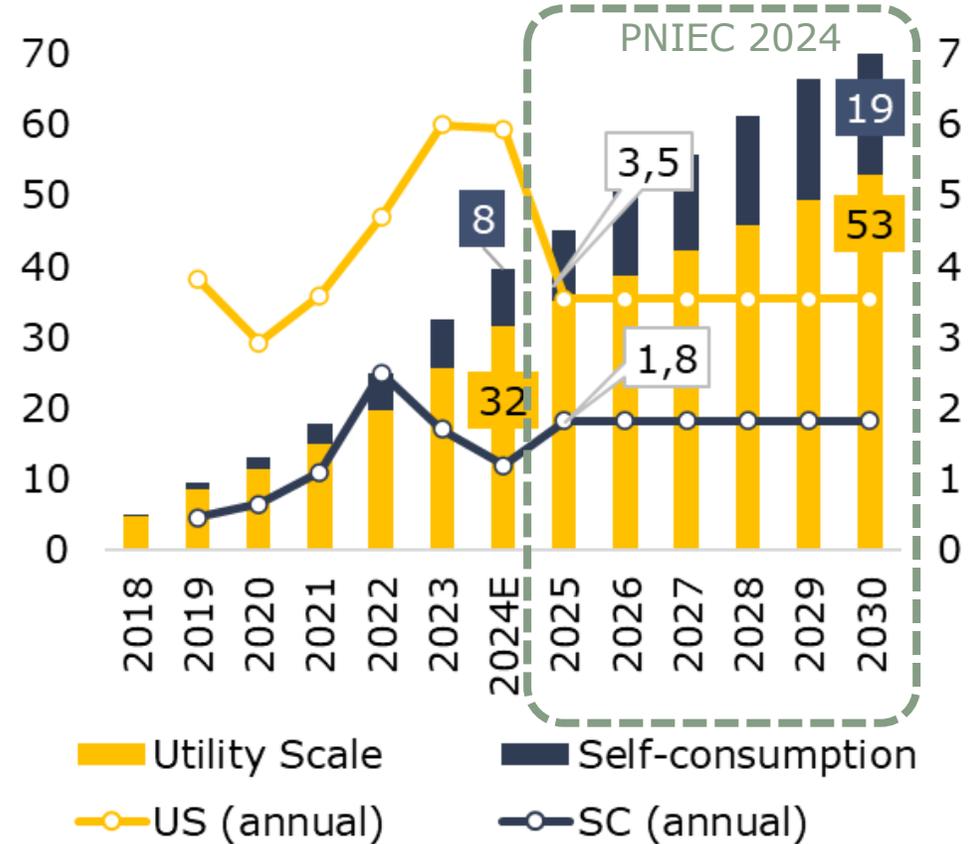
CAPACITY MIX

The PV buildout rate remains strong with large pipelines in RTB. Will new demand and flexibility arrive on time?

INSTALLED CAPACITY WIND (GW, GW/Y)



INSTALLED CAPACITY PV (GW, GW/Y)

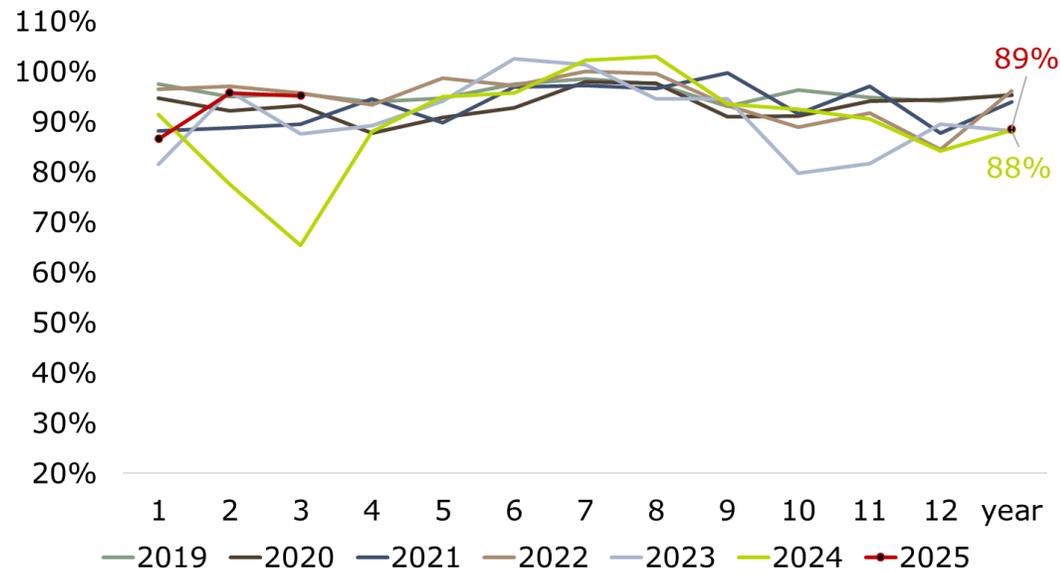


Source: ESIOS (updated in March 2025) and PNIEC

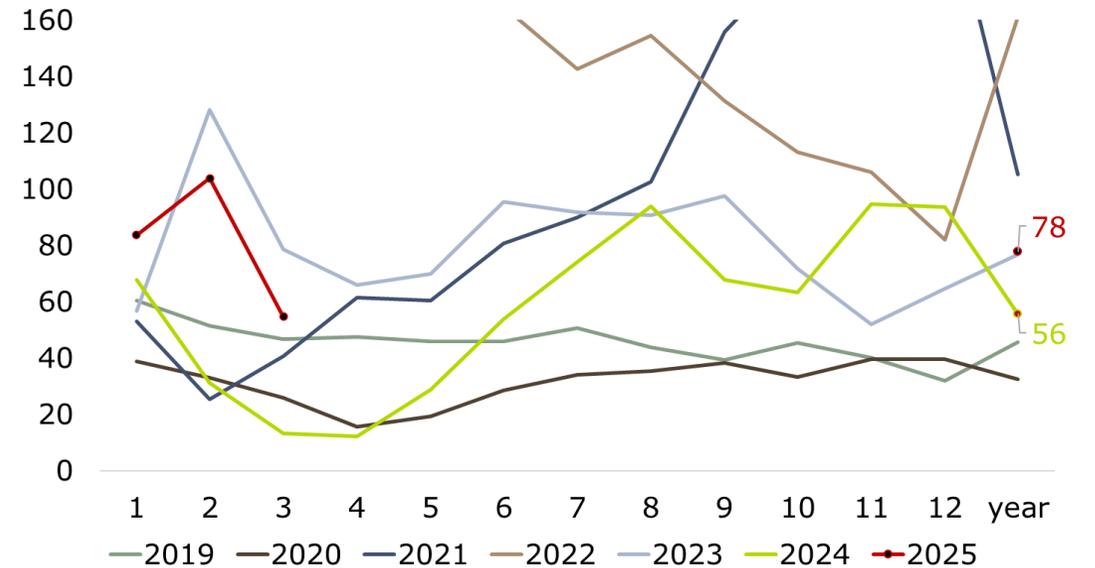
MARKET PRICES

Wind captured rates remain steady as wind power produces less in some low solar hours and captures high non-solar hours

WIND CAPTURED RATES



WIND CAPTURED PRICES (€/MWH)

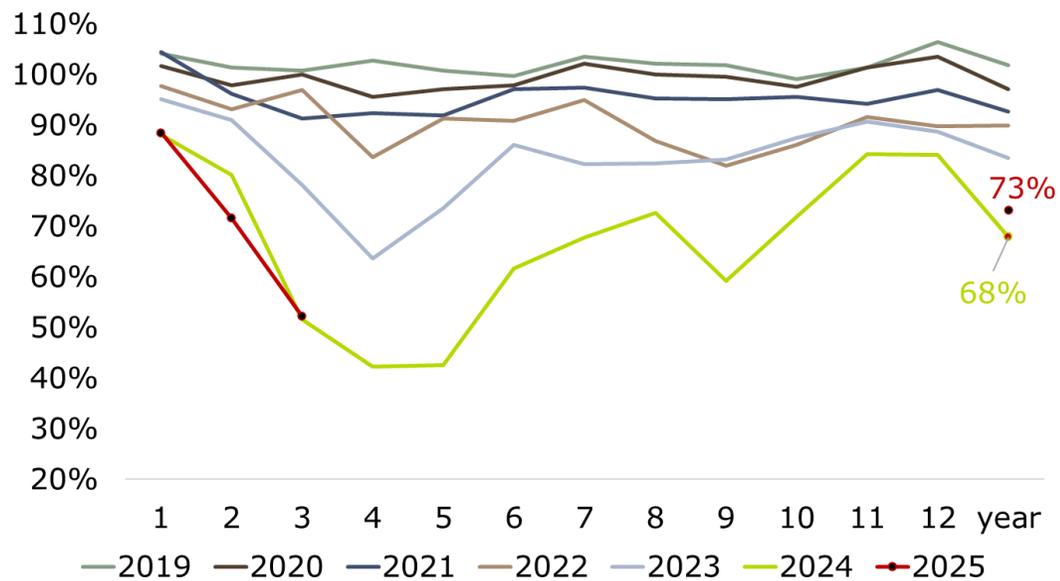


Source: ESIOS and AFRY analysis. Data until 27/03/2025

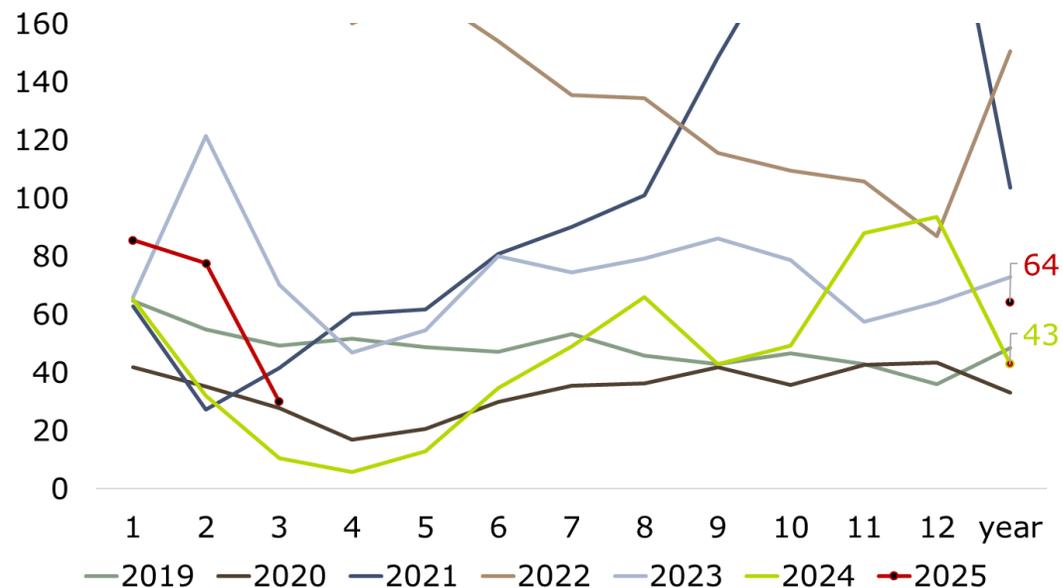
MARKET PRICES

PV captured rates have increased the rate of decrease, with volatile baseload prices driven by volatile gas and frequency of RES market curtailments

SOLAR PV CAPTURED RATES



SOLAR PV CAPTURED PRICES (€/MWH)



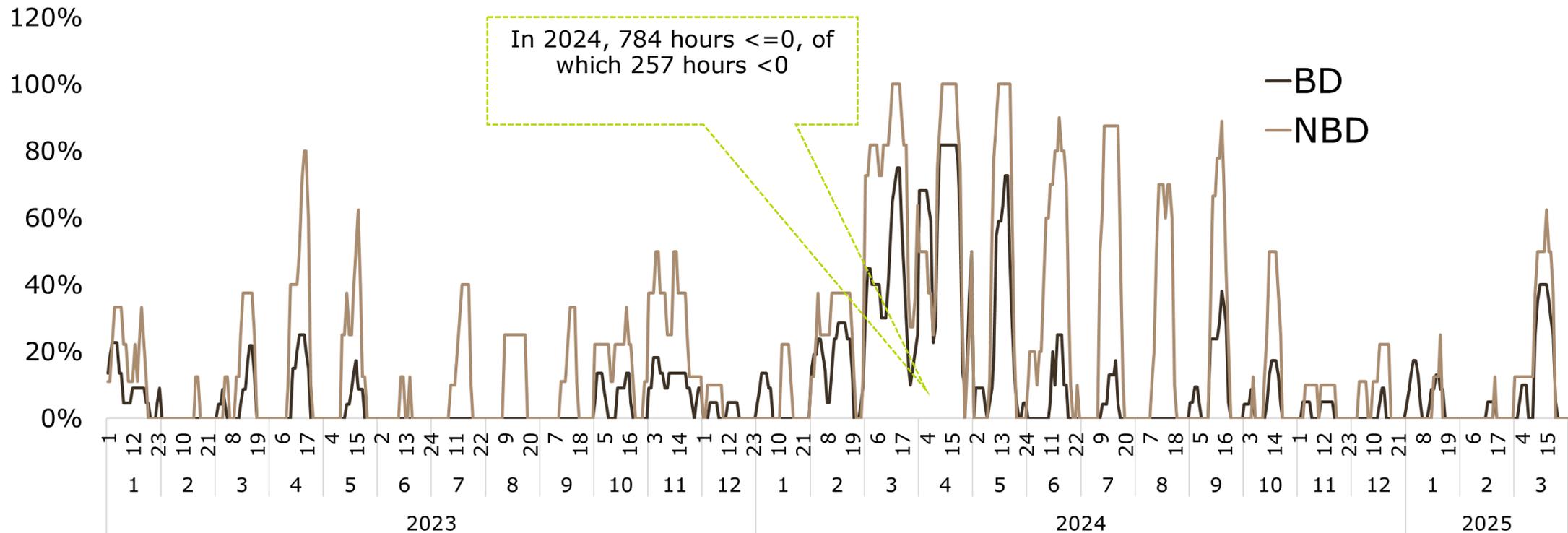
Source: ESIOS and AFRY analysis. Data until 27/03/2025



MARKET PRICES

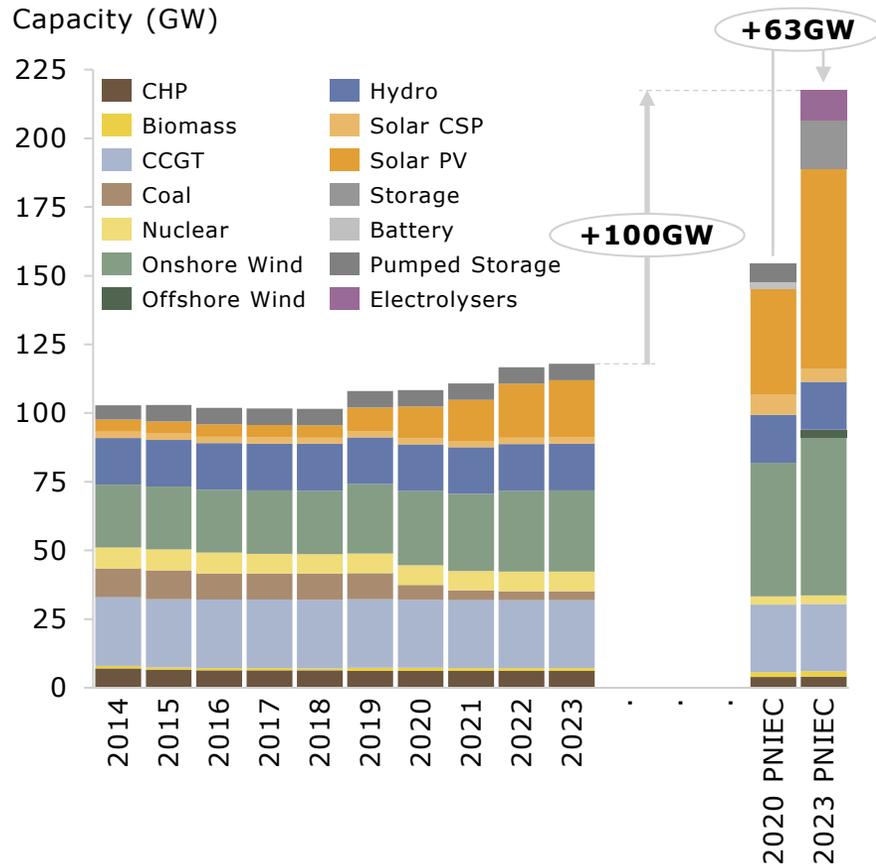
Low price periods have become somewhat structural in NBD of March to September, yet how will this analysis evolve?

HISTORIC FREQUENCY OF LOW PRICE PERIODS



Source: ESIOS and AFRY analysis. 'Business Day / Non Business Day'

The new Spanish NECP 2023 brings extremely ambitious targets, more setting a long term path than reasonable figures for year 2030

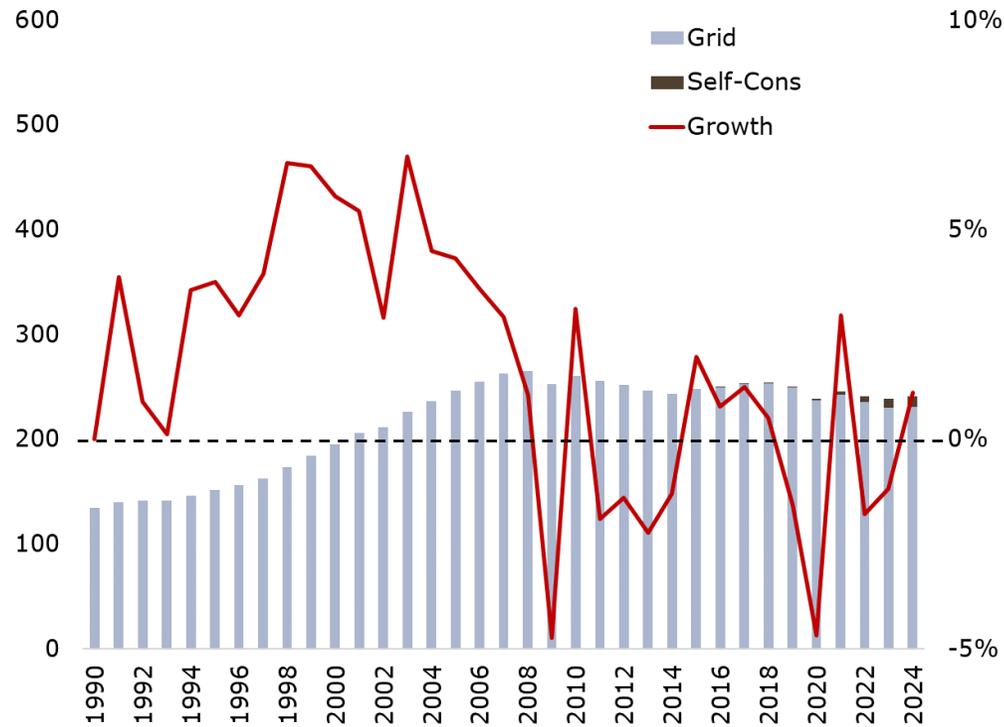


| Technology | Dec 2023 | NECP 2020 | NECP 2023 | |
|--------------------------------|-------------|-----------|----------------------|-------------|
| Onshore Wind | 30 | 48.5 | 57.5 (+2.8 offshore) | 3.5GW/y |
| Solar PV | 25 (+7 BTM) | 38.4 | 53.8 (+19 BTM) | 6GW/y |
| Solar CSP | 2.3 | 7.3 | 4.8 | 0.5W/y |
| Biomass | 1.1 | 1.7 | 1.9 | 0.1GW/y |
| Nuclear | 7.1 | 3.0 | 3.0 | -4 reactors |
| CCGT | 24.7 | 24.6 | 24.6 | - |
| Coal | 3.2 | 0 | 0 | close all |
| CHP | 6.1 | 4.0 | 4.1 | -375MW/y |
| Hydro | 17.0 | 17.5 | 17.5 | - |
| Pumped Storage | 6 | 6.7 | 22 | >2GW/y |
| Batteries | 0.0 | 2.5 | | |
| Interconnection SPA-FRA | 2.8 | 8.0 | 5.0 | +1 project |
| Electrolysers | 0.0 | 0.0 | 12 | 2GW/y |

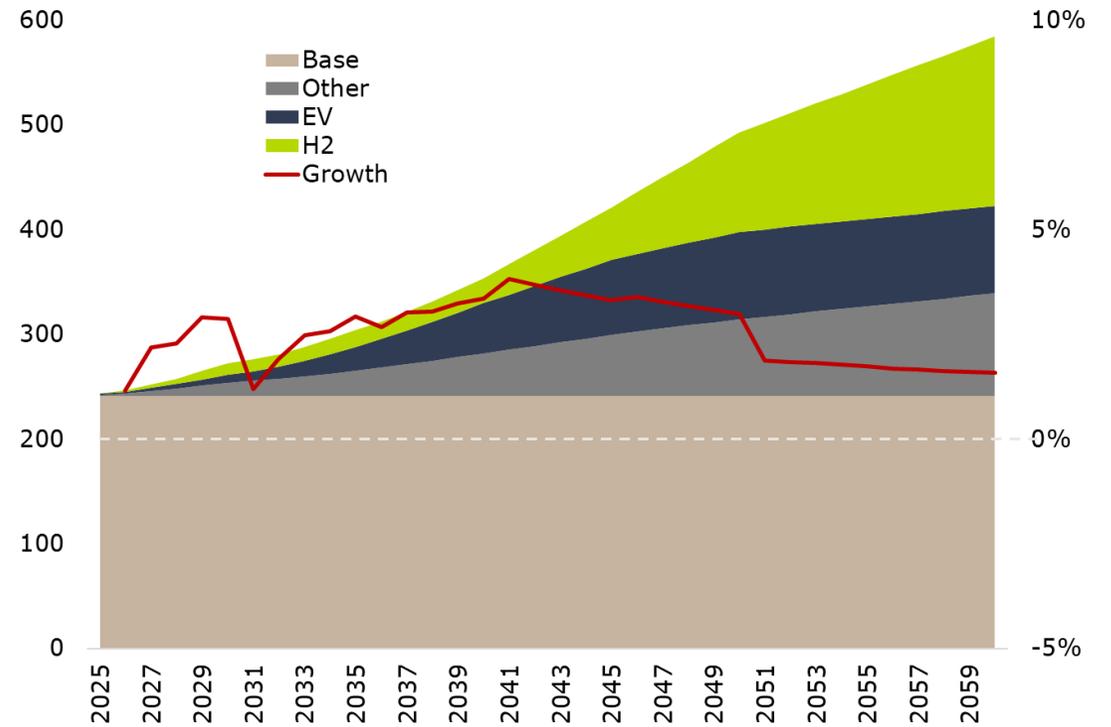
ELECTRICITY DEMAND

System planning is about the long term; annual electricity demand is back to growth and expected to double in the long run from new drivers

HISTORICAL DEMAND EVOLUTION (TWH)

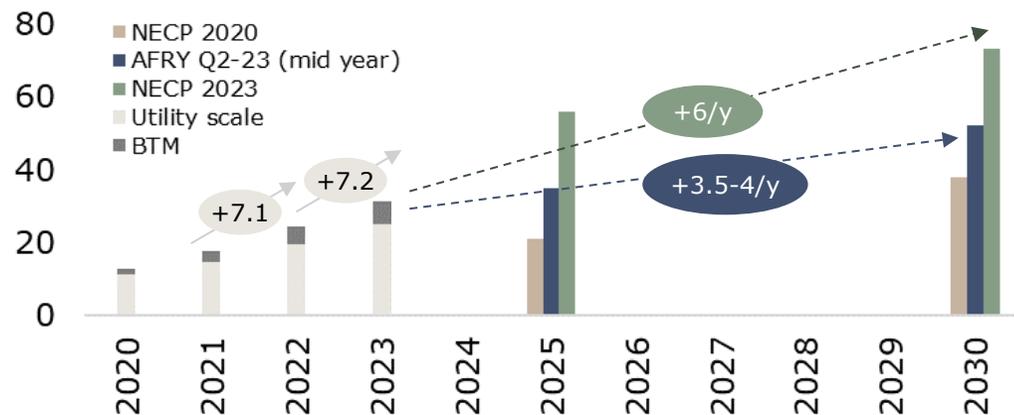


AFRY'S DEMAND PROJECTION (TWH)



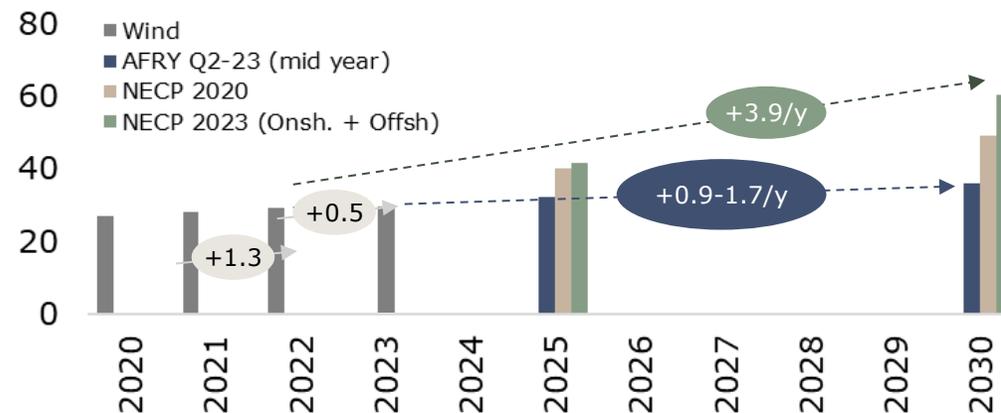
Very ambitious RES plans, but can the market, PPAs and auctions deliver before flexibility elements arrive?

SOLAR PV CAPACITY (GW)



- Technically possible targets, but unlikely economics and insufficient PPA / auction volumes / storage

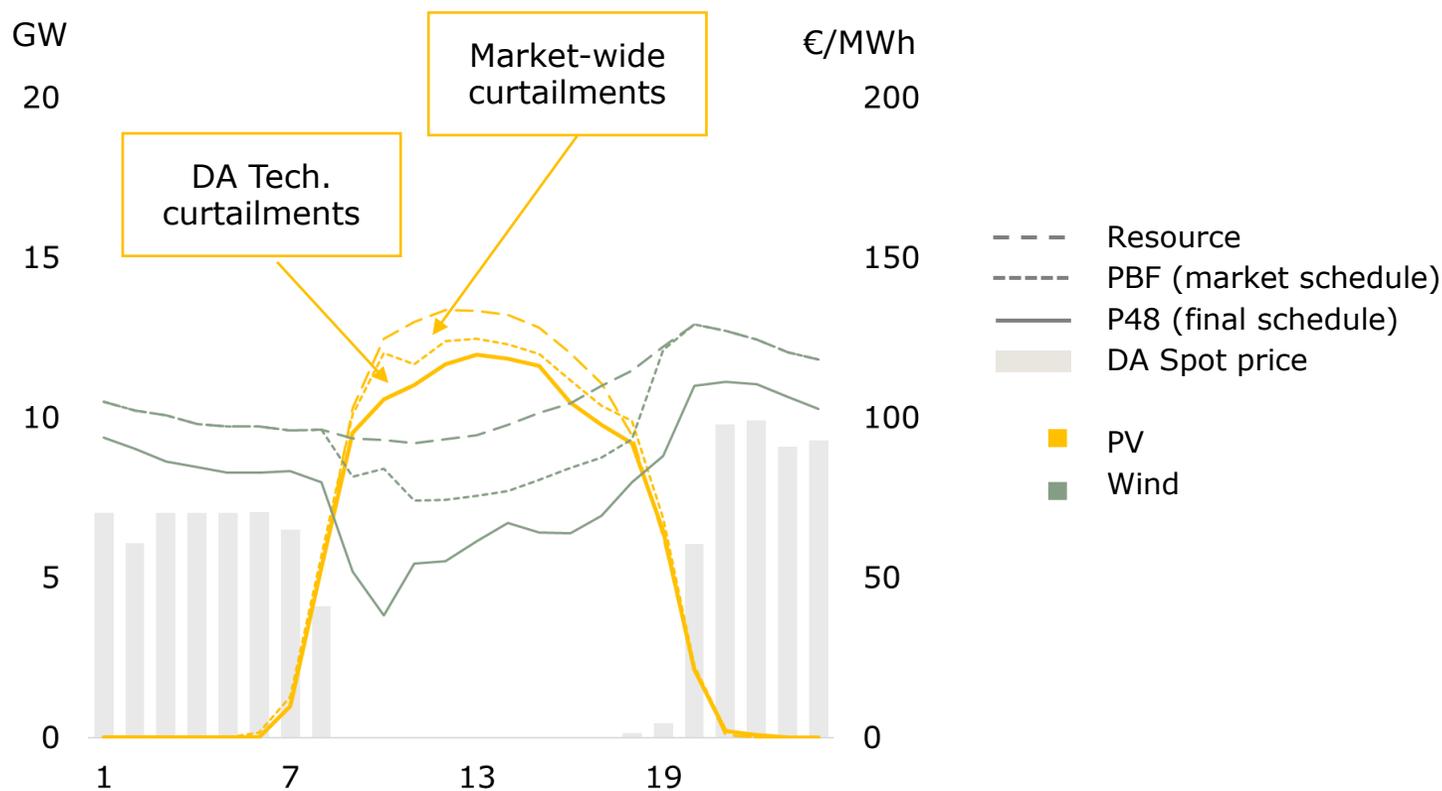
WIND CAPACITY (GW)



- Targets technically unlikely driven by permitting and construction bottlenecks

RES resource is 'curtailed' first by economics in the unconstrained market schedule and further by technical constraints from the grid operator

MARKET PERFORMANCE ON 14 MAY 2023



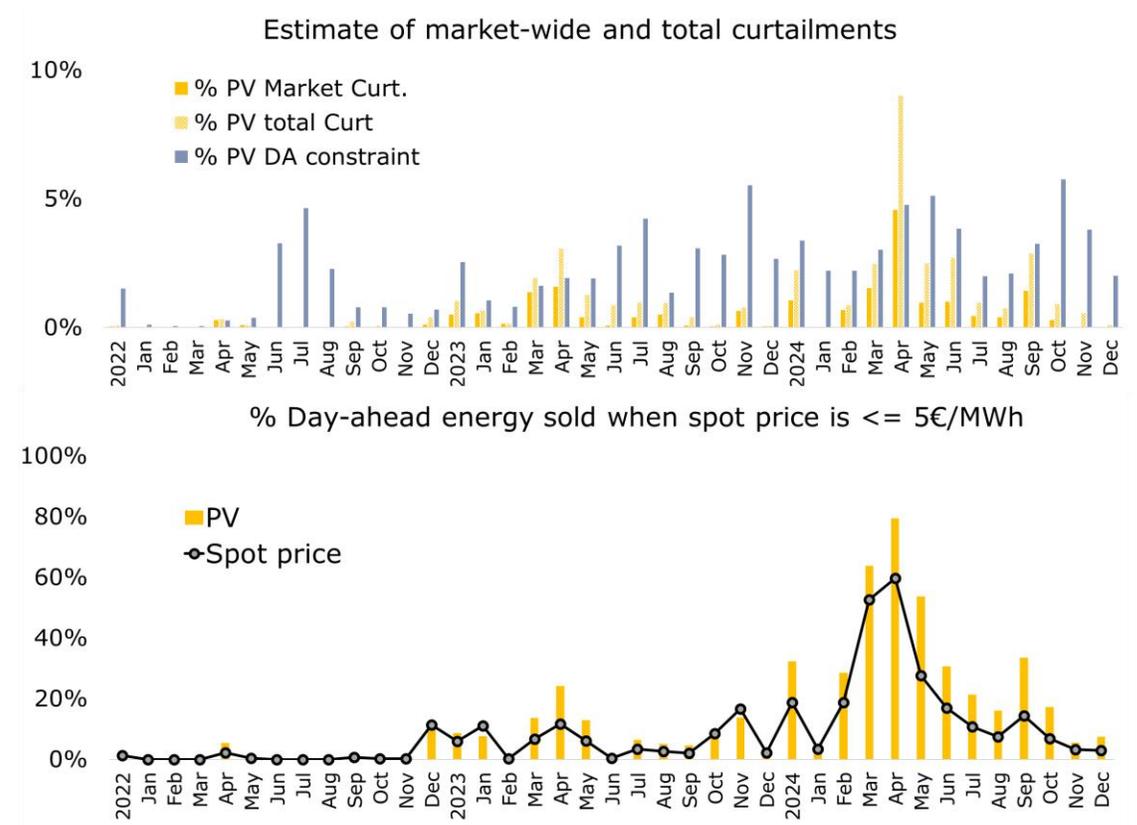
Source: REE and AFRY

ANÁLISIS HISTÓRICO

El problema no son los 'vertidos por mercado' o los 'curtailments' sino el precio capturado (o el diseño del PPA)

- Precios horarios
- Precios capturados
- **Vertidos por mercado**
- **Vertidos técnicos**

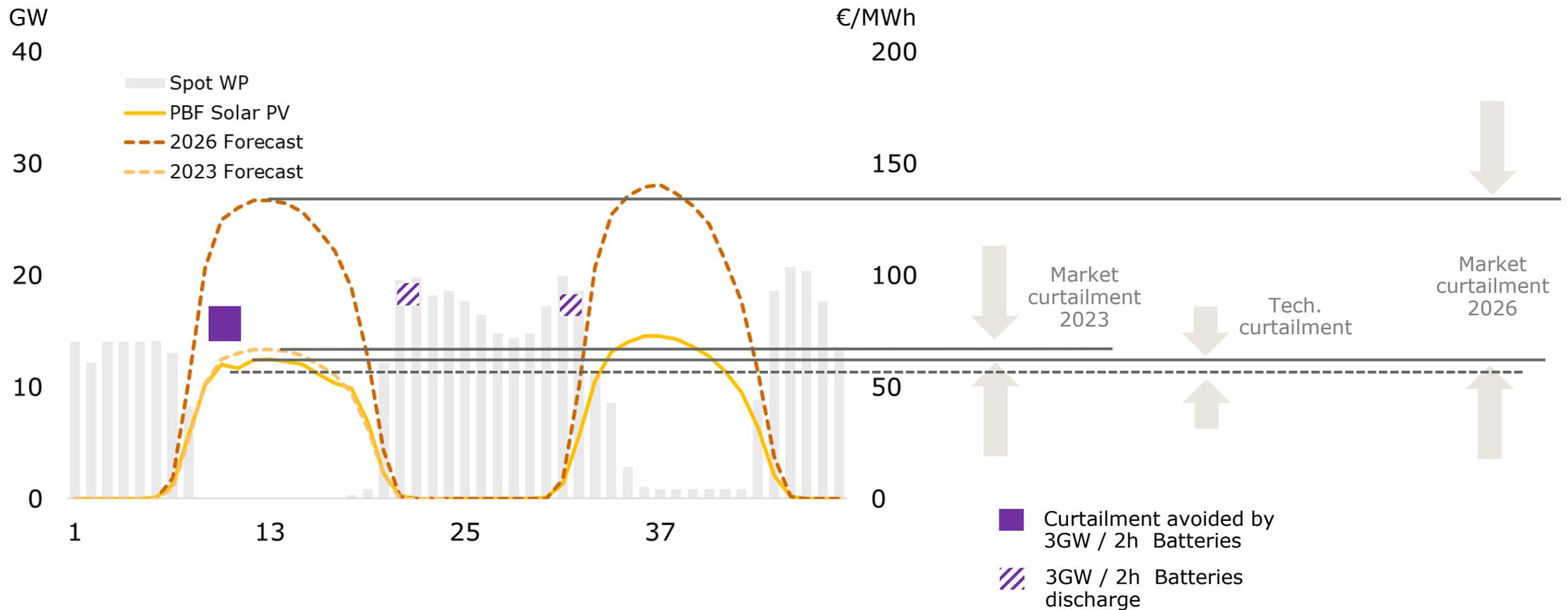
% DE VERTIDOS Y DE ENERGÍA VENDIDA A <5€/MWH



Fuente: ESIOS y Análisis AFRY

Market RES curtailments will increase substantially in absence of substantial additional storage

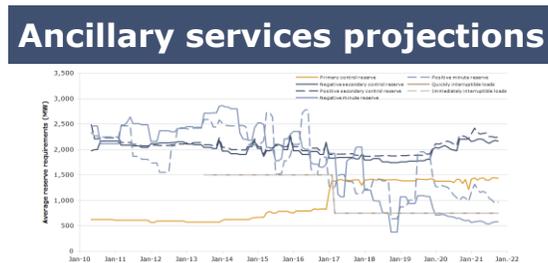
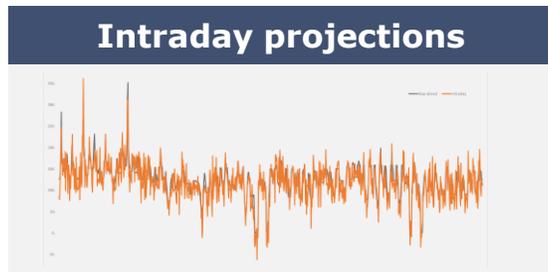
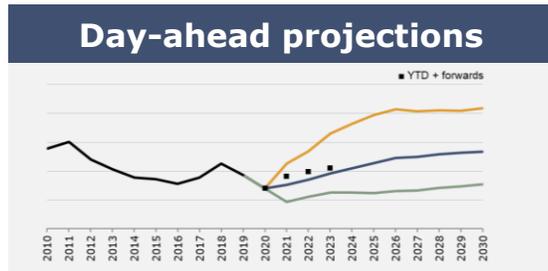
ILLUSTRATIVE MARKET PERFORMANCE ON 14 TO 15 MAY 2026



Source: AFRY

AFRY's analysis on storage projects includes the project's gross margin optimisation based on co-optimised markets dispatch

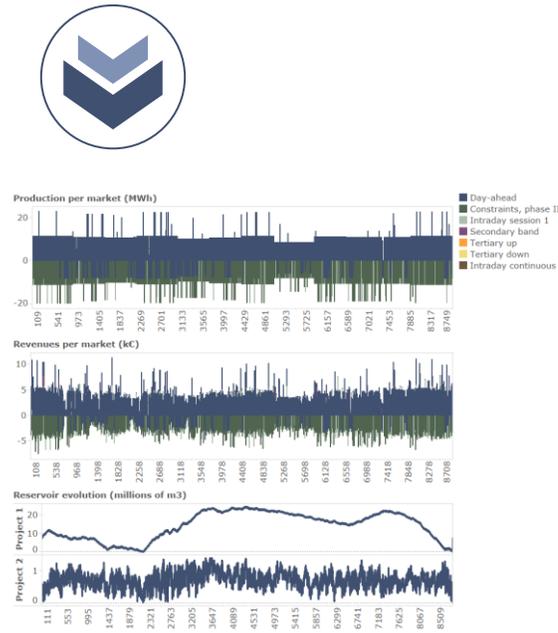
PRICE PROJECTIONS



OPTIMIZATION

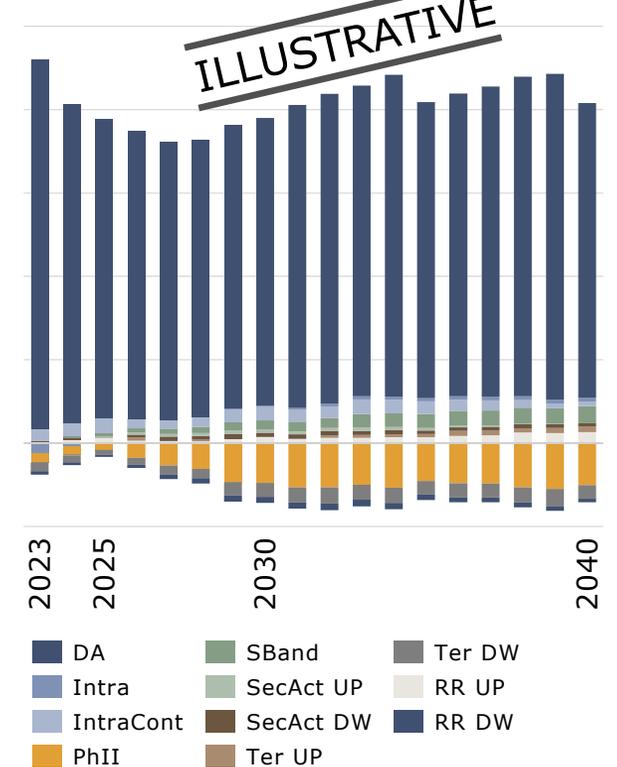


Dispatch per market



OUTPUTS

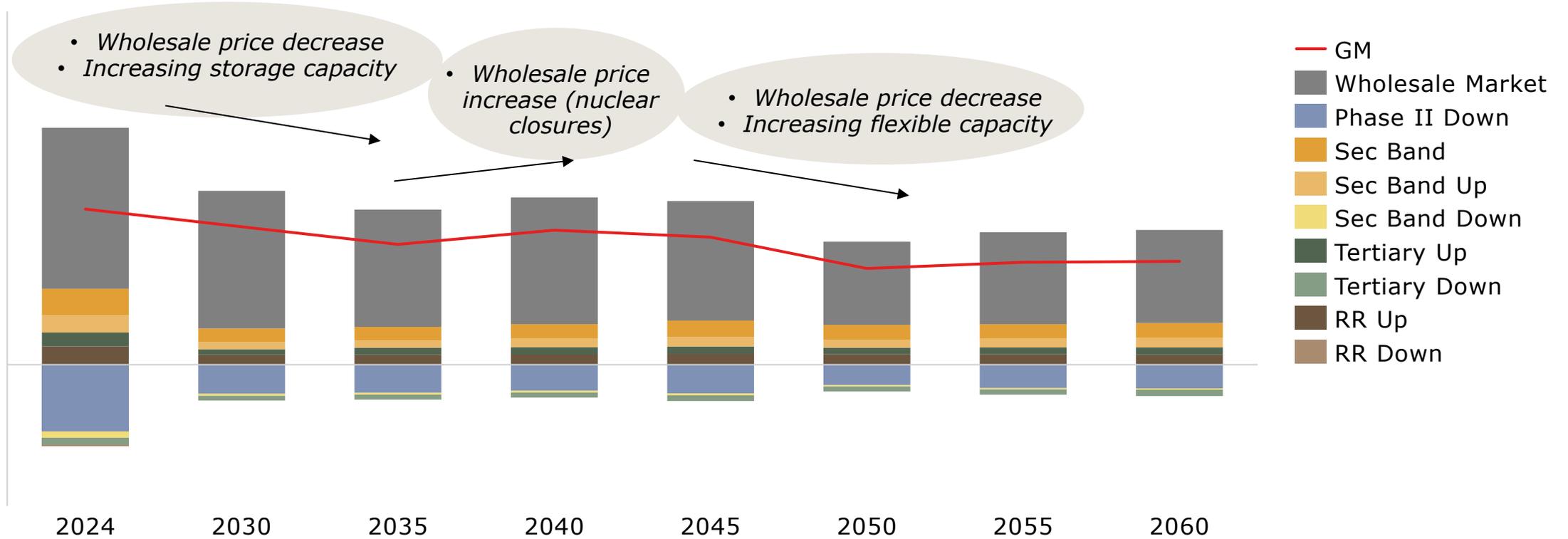
Gross margin projections in €m or €/kW



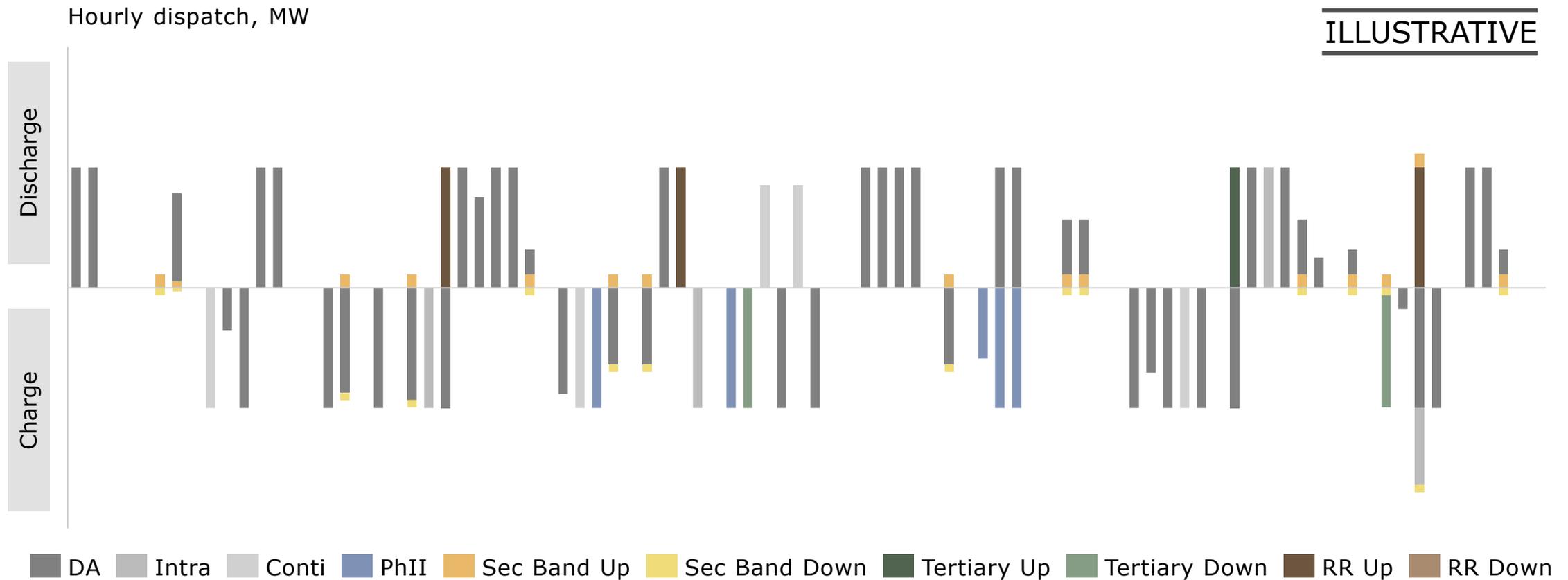
Modelled results show storage gross margins from Day-Ahead market and Ancillary Services will cannibalise as more batteries enter the system

ILLUSTRATIVE

Gross Margin, €/kW, real 2022

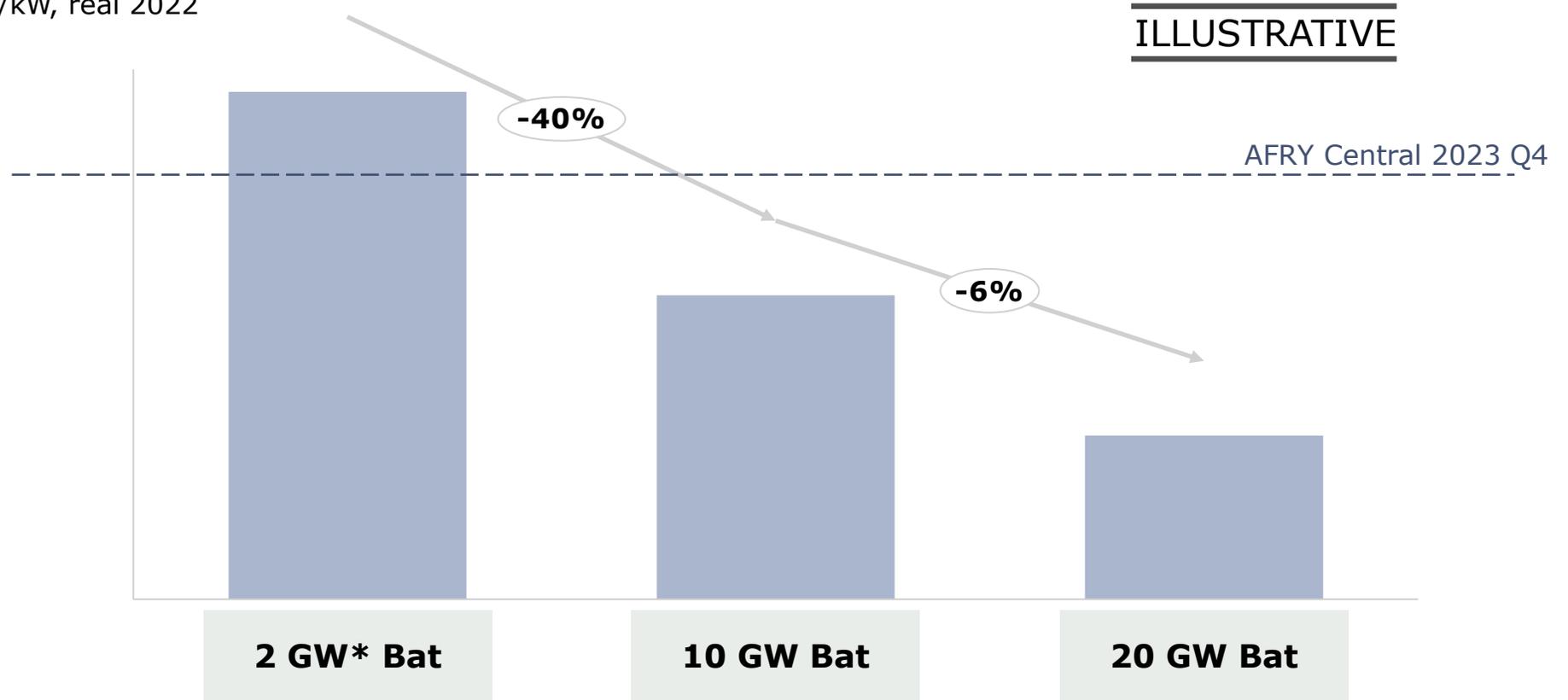


Hourly modelling allows to optimise the dispatch of the battery in the different markets in order to benefit from price arbitrage opportunities



The deployment of batteries in the system leads to cannibalisation of revenues from day-ahead and ancillary services

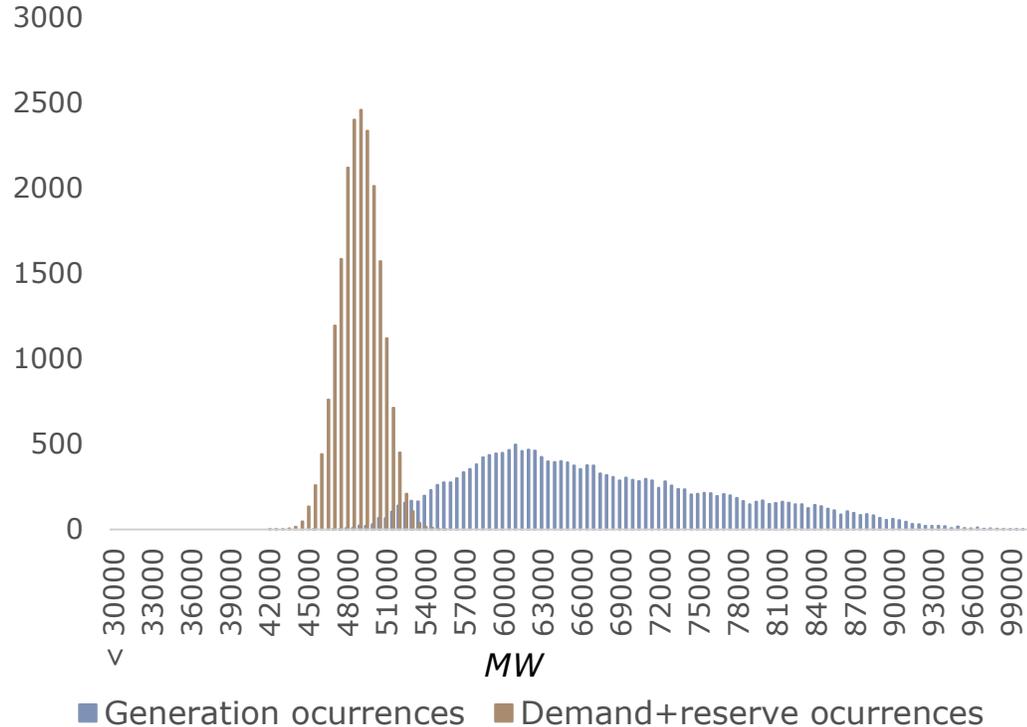
Gross Margin 2030, €/kW, real 2022



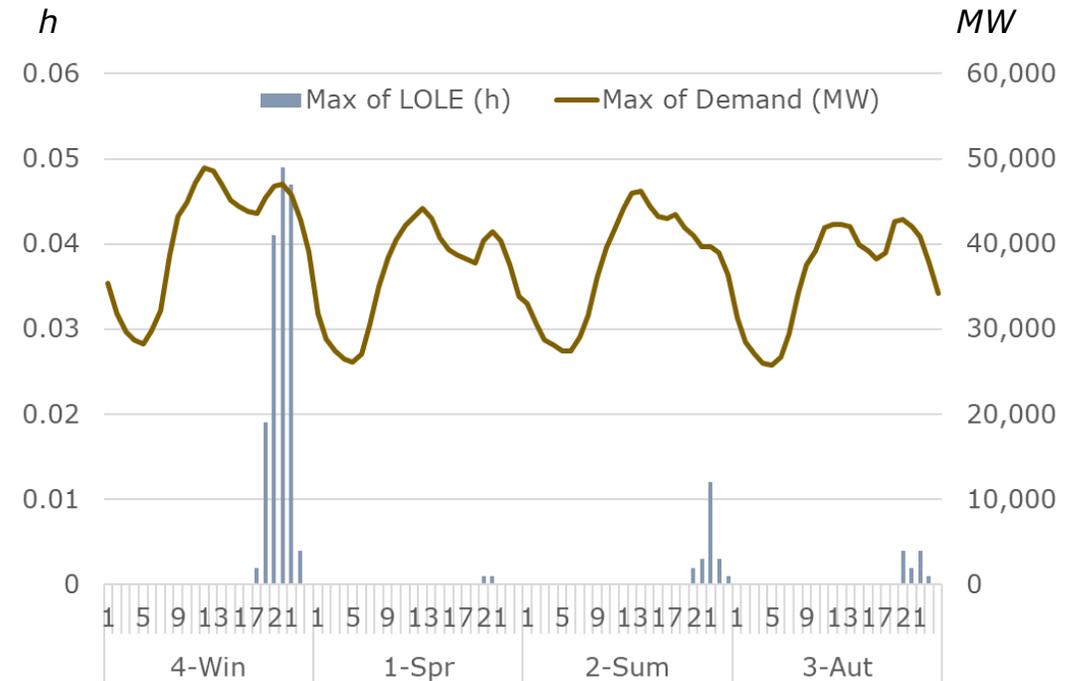
*Battery capacity over existing (negligible) capacity

Critical demand is expected to remain in winter after sunset, and drives the need for system backup capacity

GENERATION AND DEMAND PROBABILITY FUNCTIONS (SAMPLE CRITICAL HOUR IN 2030)



HOURLY DISTRIBUTION OF LOLE (SAMPLE 2030)



The Iberian power market will need reliable capacity after the sunset, mostly in Winter

In 2023&2024, regulatory bodies published reliability standards which follow the 2021 Capacity Market mechanism draft order

Capacity Market mechanism: overview

Regulation



- European Regulation 2019/943
- Reliability standard for Spain, LOLE: 1.5 (2024)
- Derating factors and auctioned capacity to be published.

Remuneration design

- Bids submitted in €/MW/year; remuneration is pay-as-bid.



A1

The **main auctions** for new capacity at a 5-year horizon. Designed to cover firm capacity needs and promoting investment in new storage.

A2

The **adjustment auctions** for existing capacity at a 1-year horizon. Designed to solve eventual capacity adequacy problems.

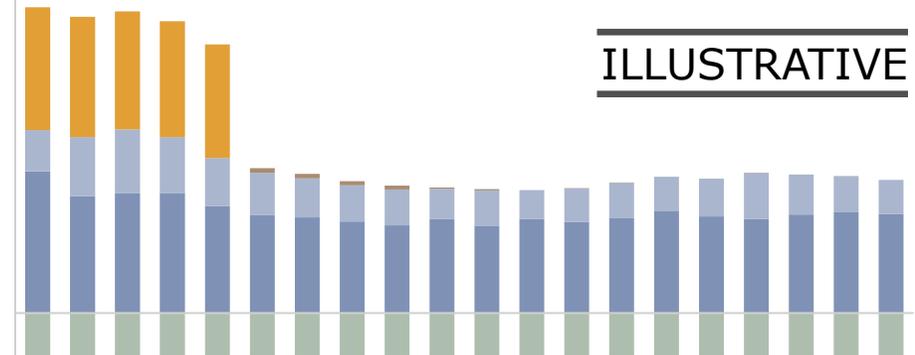
Key barriers



- Lower volume attracted vs. NECP (design based on SoS analysis, and not to promote flexibility or integration of RES).
- The specific design parameters may benefit some technologies.

4-hour battery capacity mechanism, €/kw real 2022

Larger duration batteries are expected to show more competitive results in a capacity mechanism since they could benefit from favorable derating factor values.



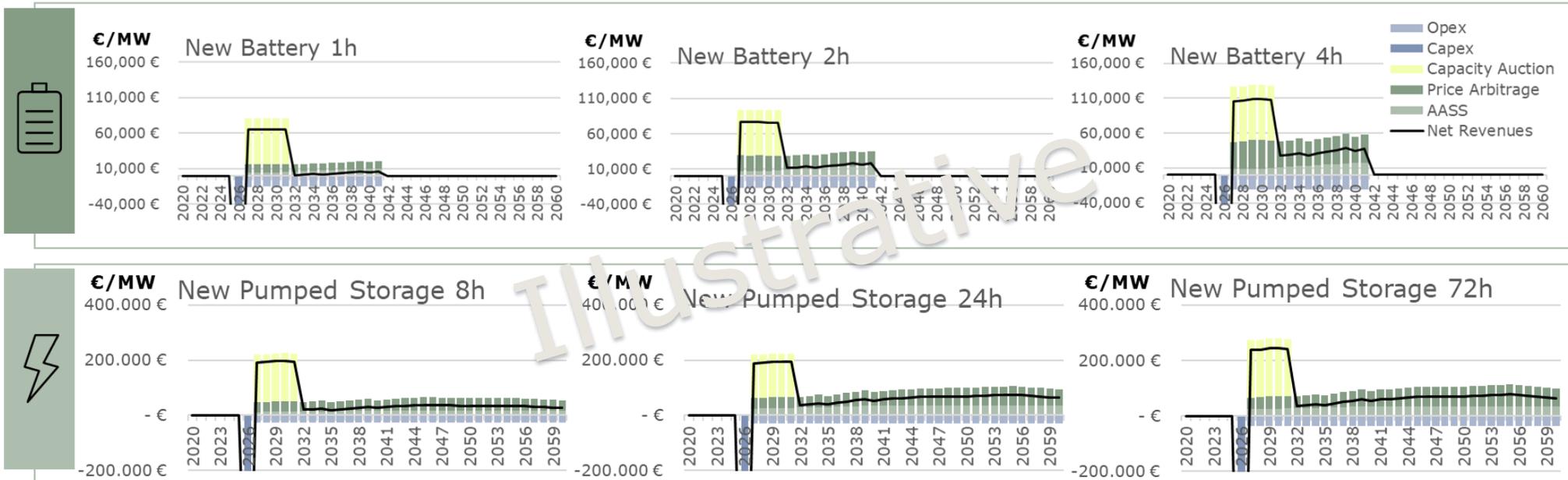
ILLUSTRATIVE

- Fixed OPEX
- Gross margin DA
- Gross margin AS
- Annual capacity payment
- 5-year capacity payment

'Missing Money' of storage projects depends on project specifics and design of capacity markets or other support mechanisms

- Project:
 - Capex/Opex, lifetime
 - degradation, round-trip efficiency
- Regulatory design
 - Derating factors
 - Duration of payment
 - Capacity Market, Flexibility markets (?), Grants/incentives

Technology economics



The Capacity Market under development and Capex grants ('PERTE') will be key to bring (most) storage capacity. But how much is that?

ERAA AND NRAA

The screenshot shows the ERAA 2023 website with a navigation menu (OVERVIEW, DOWNLOADS, VISUALS, STAKEHOLDER INTERACTIONS, ERAA EDITIONS) and a grid of download links for the following documents:

- ERAA 2023: Executive Report (PDF, 4.9 MB)
- Annex 1: Input Data & Assumptions (PDF, 2.1 MB)
- Annex 2: Methodology (PDF, 2.7 MB)
- Annex 3: Detailed Results (PDF, 2.3 MB)
- Annex 4: Country Comments (PDF, 243 KB)
- Annex 5: Definitions and Glossary (PDF, 248 KB)

Below the grid is a large blue graphic with the text: "red eléctrica Una empresa de Redeia. Análisis nacional de cobertura del Sistema Eléctrico Peninsular Español. Como complemento al análisis europeo de cobertura de la edición de 2022. Octubre 2023."

<https://www.entsoe.eu/outlooks/eraa/2023/eraa-downloads/>

https://www.ree.es/sites/default/files/01_ACTIVIDADES/D_ocumentos/informe_os_nov23.pdf

STILL MANY UNCERTAINTIES...

- Assumptions of ERAA and NRAA 2024?
- Additional capacity required for RS=1,5h/y
 - LOLE>RS only in 2027 & 2028
 - Presumably 1.5-1.8GW firm capacity for 2027&2028
- Derating factors of all technologies?
- Available funds for Capex grants
- Any other new 'flexibility market' under consideration?
- AFRY Multiclient study proposals to complement the CM
 - Proposal A: Long and Short duration storage (2 buckets or 'scaling factors')
 - Proposal B: Two round CM (Socio Economic Welfare vs. Security of Supply)

The Capacity Market under development and Capex grants ('PERTE') will be key to bring (most) storage capacity. But how much is that?

ERAA AND NRAA

entsoe

OVERVIEW - DOWNLOADS - VISUALS - STAKEHOLDER INTERACTIONS - ERAA EDITIONS -

- ERAA 2023: Executive Report
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red eléctrica
Una empresa de Redeia

Análisis nacional de cobertura del Sistema Eléctrico Peninsular Español

Como complemento al análisis europeo de cobertura de la edición de 2022

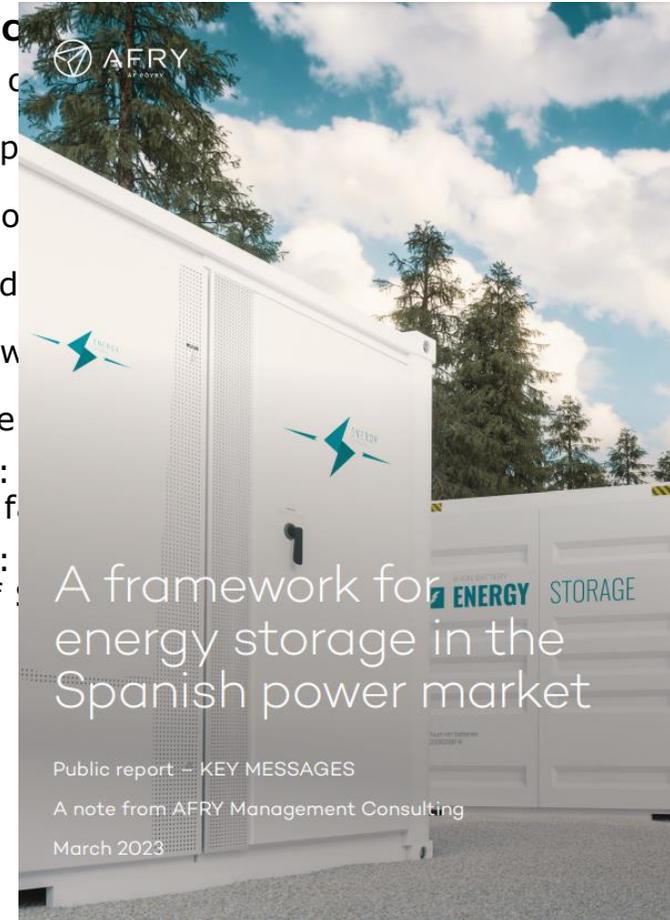
Octubre 2023

<https://www.entsoe.eu/outlooks/eraa/2023/eraa-downloads/>

https://www.ree.es/sites/default/files/01_ACTIVIDADES/DOCUMENTOS/informe_os_nov23.pdf

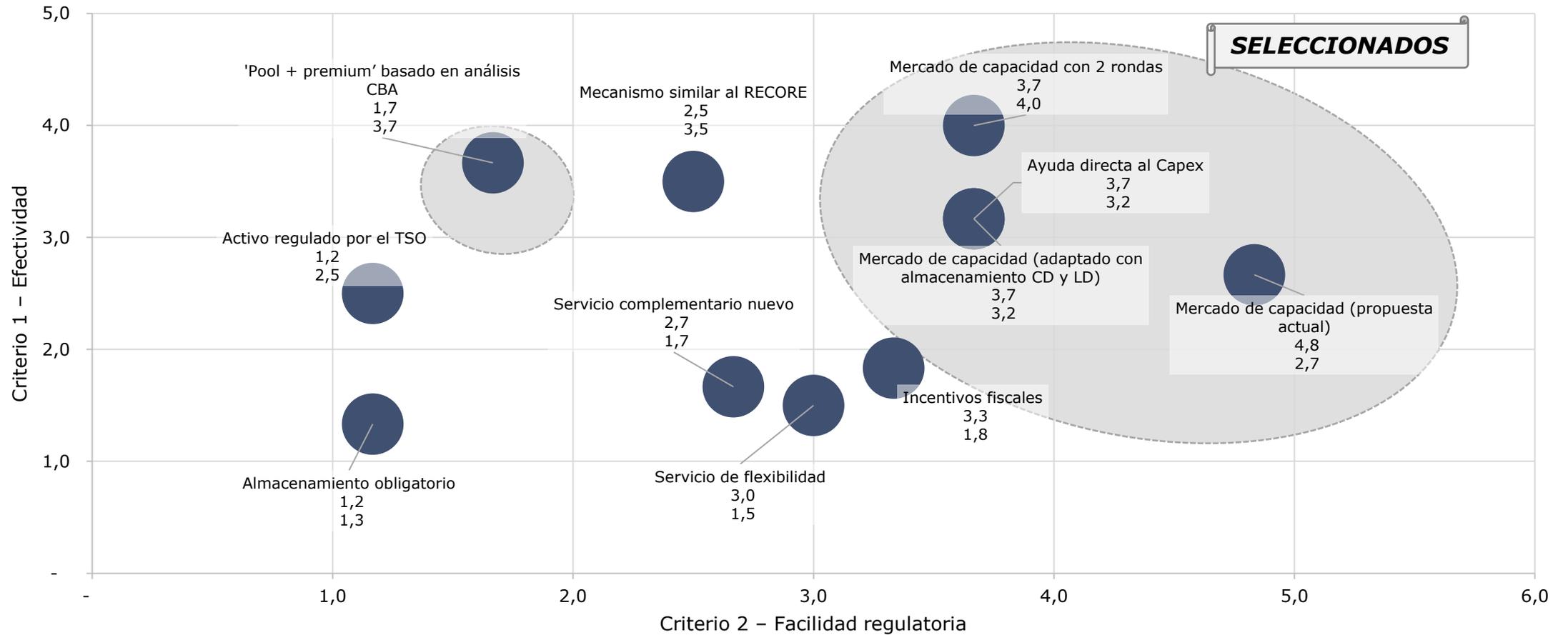
STILL MANY UNCLEAR

- Assumptions of capacity
- Additional capacity
- Derating factors
- Available funding
- Any other new capacity
- AFRY Multicliente
- Proposal A: or 'scaling factor'
- Proposal B: Security of supply

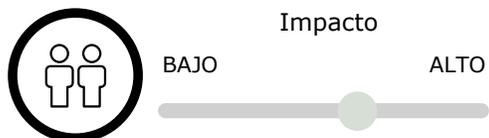


https://afry.com/sites/default/files/2023-03/afry_energy_storage_development_key_message_final.pdf

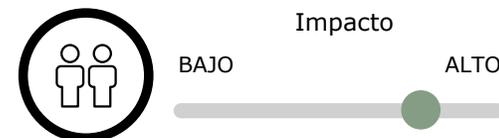
Se valoraron las propuestas por su 'facilidad regulatoria' y su 'eficacia' para atraer almacenamiento, y se seleccionaron las más prometedoras



La aplicación de las propuestas A o B podría tener un impacto tangible en el despliegue del almacenamiento en España



PROPUESTA A – ALMACENAMIENTO CD Y LD

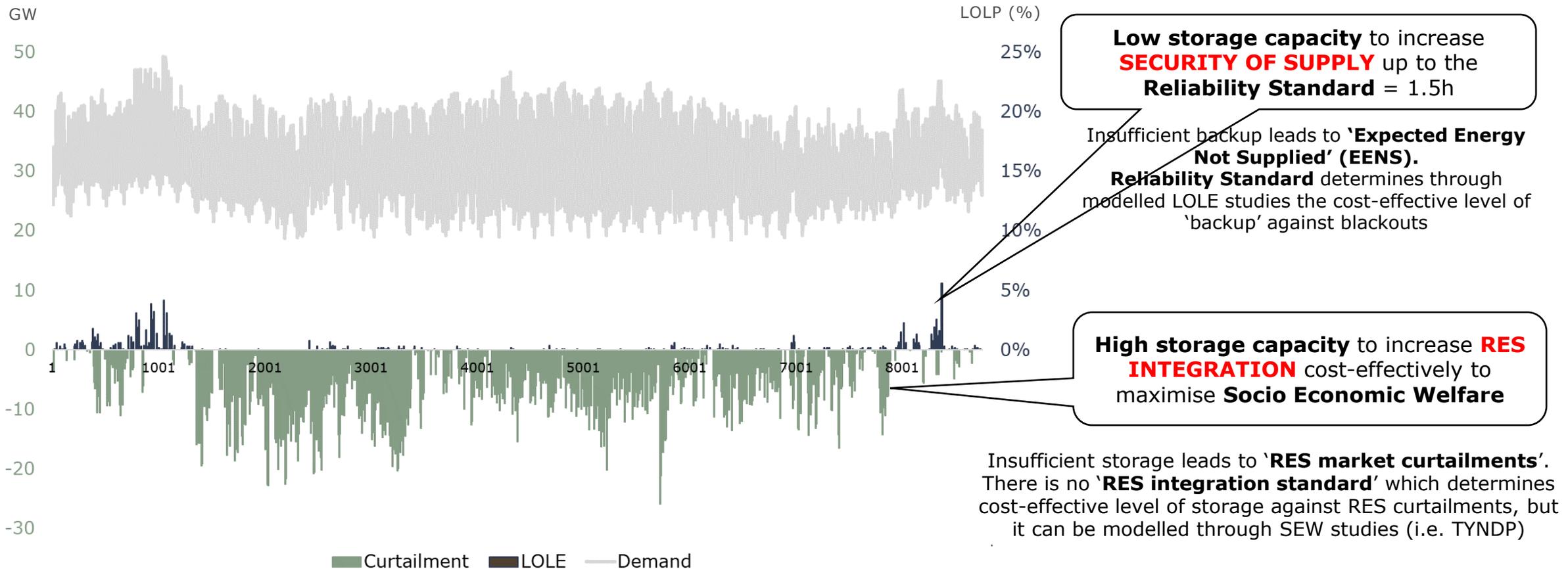


PROPUESTA B – MEC. CAPACIDAD 2 RONDAS

| | | |
|----------|---|---|
| <p>+</p> | <ul style="list-style-type: none"> – No implica cambios regulatorios importantes, basado en el Proyecto de Orden publicado. – Introduce 'factores de escalado' para reflejar otros beneficios del almacenamiento (tantos como deseado). – Permite la competencia entre tecnologías de almacenamiento. | <ul style="list-style-type: none"> – Solución integral, atraería un volumen de almacenamiento más allá de las necesidades de SdS. – Ya existen la mayoría de elementos (PNIEC, propuesta de subastas de capacidad) aunque deberían ampliar su contenido. – Permite considerar todos los beneficios a través del CBA basado en el PNIEC. – Permite la competencia entre tecnologías de almacenamiento. |
| <p>–</p> | <ul style="list-style-type: none"> – Volumen insuficiente, relacionado con las necesidades de seguridad de suministro. – El cálculo de los 'factores de escalado' debe seguir una metodología clara y transparente. – DSR e integración transfronteriza pendientes de desarrollo, como el Proyecto de Orden publicado. | <ul style="list-style-type: none"> – Necesaria la justificación de la ayuda según requisitos de las CEEAG. – Cálculo de los 'factores de escalado', desarrollo participación DSR a integración transfronteriza, como en A – Modelización de los impactos para la factura final (CBA) |

Should the market and the Regulator size storage for Security of Supply or for efficient RES integration?

HOURLY LOSS OF LOAD EXPECTATION (% LOLP) VS RES CURTAILMENTS (GW)



Storage is a key instrument to enable further RES integration, at the very beginning of a strong deployment. But it will likely not come alone...

01



SPANISH MARKET APPROACHING TIPPING POINT FOR MERCHANT RES

- relevant curtailments threaten merchant RES (and auctions)
- Storage is the key enabler to keep rising RES integration and provide future backup

02



MERCHANT STORAGE UNLIKELY (but not impossible)

- Capex reductions? First mover? Technical Constraints?
- Cannibalisation of arbitrage and Ancillary Services

03



REQUIRED REGULATORY INCENTIVES

- Capacity Market, Flexibility markets?
- Capex grants

04



VALUE BEYOND SECURITY OF SUPPLY?

- Efficient RES integration, positive SEW
- PSH: local materials, longer life, low import dependency
- Requires new European and National regulation

Contacts



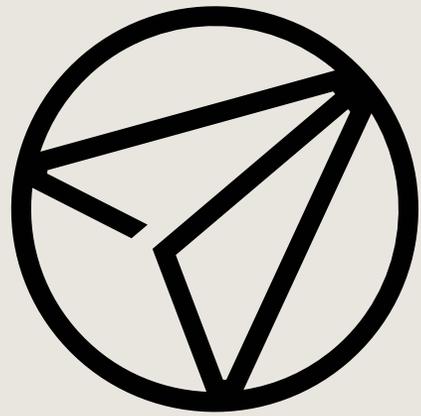
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Making Future



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