Almacenamiento de electricidad: transición energética, estabilidad del sistema, mercados y rentabilidad

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ESS: EUDER STORAGE SYSTEMS

DEVELOPMENT OF BATTERY ENERGY STORAGE SYSTEMS

ESS: Key facts

Aim

- Development of power storage plants
- Standalone and co-located (with third parties)
- Geographical scope: Spain and Portugal – by now.

Highlights

- Part of Euder Energy Group. JV with Terranova Iniciativas.
- Team with strong development capabilities and solid technical, regulatory and financial background.
- Proven track record.
- Already developing storage plants.
- **Early movers**: Capture **since 2022** opportunities in the emerging storage market

Expertise in the whole value chain

Integral project development: Greenfield, 3rd party M&A

RTB sale or Financial Structuring

Construction Commission

O&M Markets+PPA management

M&A Project sale @ COD + X

ELECTRICITY STORAGE

STATE OF THE ART OF A NEW POWER ACTIVITY: REQUIREMENT (WHY), TECHNOLOGY (WHAT), MARKETS (HOW)

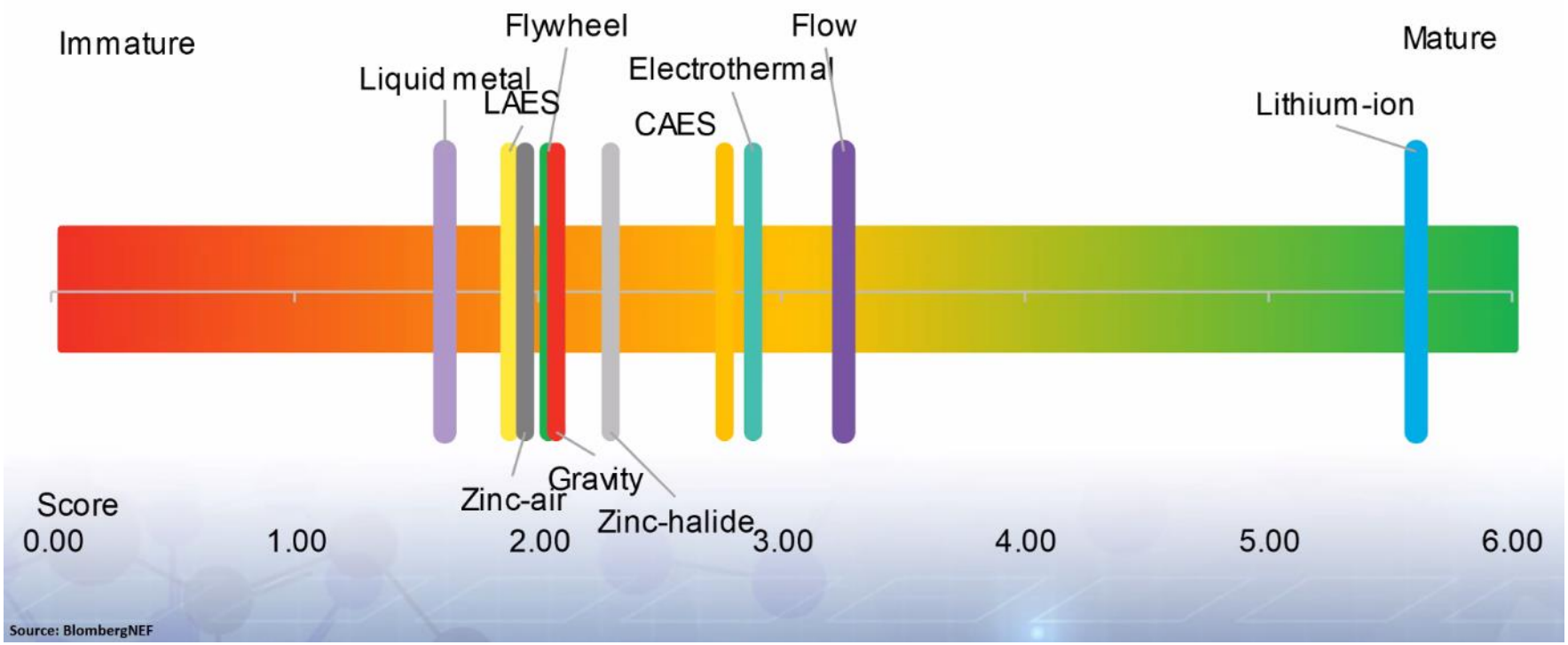
Storage: Key to energy transition

A reality that has become mainstream worldwide. Keys:

- 100% renewable sourced, which are generally not “manageable”.
- It is required capacity guarantee -> produced energy to be stored to match generation and demand.
- Electrification of energy, especially transport (EV), domestic and tertiary sector -> significant increase in power demand.
- Non-electrifiable uses (industry, aviation, shipping, …) -> Hydrogen -> even more demand.
- Grid requirements with reduced synchronous generation -> management and control.

Comply with increasingly restrictive requirements due to new grid codes and regulation.

Maturity of storage technologies



Lithium (electrochemical) is the most mature technology short-term, further to pumped hydro (mainly). BESS are extremely compact, with scarce impact on terrain and environment.

Regulatory framework of storage in Spain

The mandate of Directive 2019/944 is clear and MANDATORY (transposition in Spain within 2023 – new market actors: storage and demand aggregators). **Installation and operation of storage basically already regulated**:

- RD-Law 23/2020: Modifies Law 24/2013 introducing storage as an actor of the electrical market.
- RD-Law 6/2022: Modifies RD 1955/2000 (regulation of power activities and permitting) assimilating storage to generation whenever there is no more specific regulation -> enables standalone storage.
- RD-Law 14/2022: Modifies RD 413/2014 (RES power production) establishing specific retributive provisions -> enables market trading.
- RD 1183/2020: Storage is assimilated to generation; hybrid plants are enabled.
- CNMC 3/2020 and R.D. 148/2021: Energy from the grid for storage is excluded from grid charges.

Detail regulation still being developed:

- Operation procedures (grid codes) still being developed for grid access conditions (P.O.12,2) and participation in non-frequency services and resolution of technical constraints (recognized by Resolution CNMC 8-9-22), and integration of hybrid plants in programming process (P.O. 3.1; P.O. 3.2; P.O. 3.7; P.O. 3.8; P.O. 3.11; P.O. 9.2; P.O. 9.3; P.O. 14.1; P.O. 14.4; and P.O. 14.8.).
- New NTS 3.x (plant certification including storage)

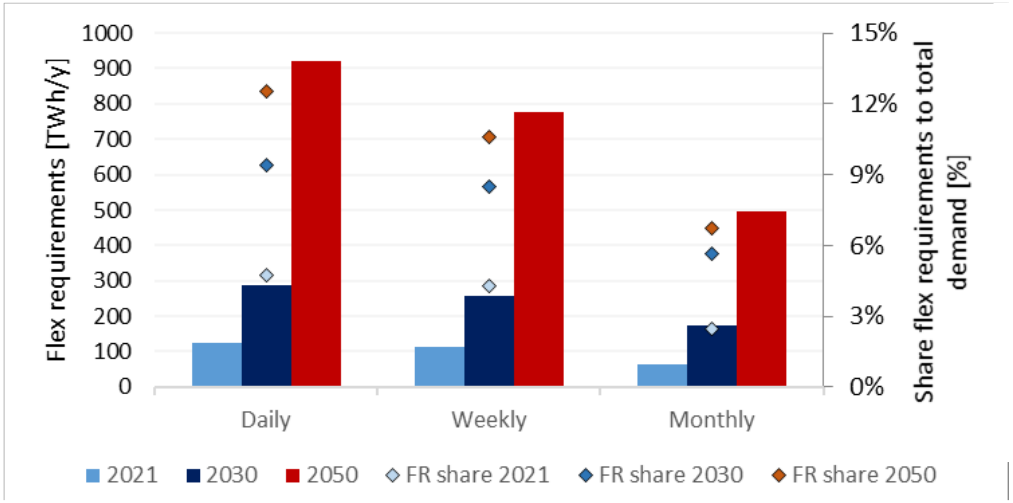
New additional regulation expected: Transposition of storage and demand aggregation as actors in the power sector, additional support provisions (RepowerEU, etc.), capacity markets, specific storage tenders, grid codes for DC measurement and grid forming operation, black start?, grid capacity tenders?

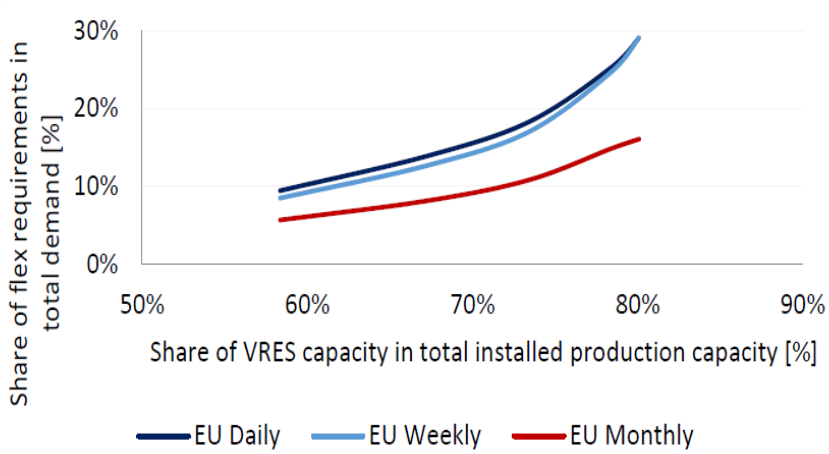
EUDER STORAGE SYSTEMS is actively involved in the Regulatory Framework development with MITERD and REE

The Spanish administrative environment at a glance

Bloque	Tema	MITECO	REE	CNMC	IDAE	OMIE	CE
1.Acceso y Conexión	Acceso ALM stand-alone		X	X			
	PO 12.2		X	X			
	Grid Forming		X	X			
	Concursos de acceso	X	X	X			
2. Tramitación	Varios	X (+ CCAA)					
3. Medio ambiente	Varios	X (+ CCAA)					
4. Tramitación urbanística	Varios	X (+ CCAA)					
5. Participación en mercado	Gestionabilidad y PPOO	X	X	X			
6. Peajes, cargos e impuestos	Varios	X	X	X			
7. Marco retributivo	Participación en mercado	X	X	X			
8. Ingresos	Mecanismo de capacidad	X	X				X
	Otros ingresos	X	X	X	X	X	X
	Reforma de mercado CE	X	X	X			X
9. Ayudas	Convocatorias PERTE	X			X		X

‘Strongest legislative treatment yet’ in new EC Electricity Market Design

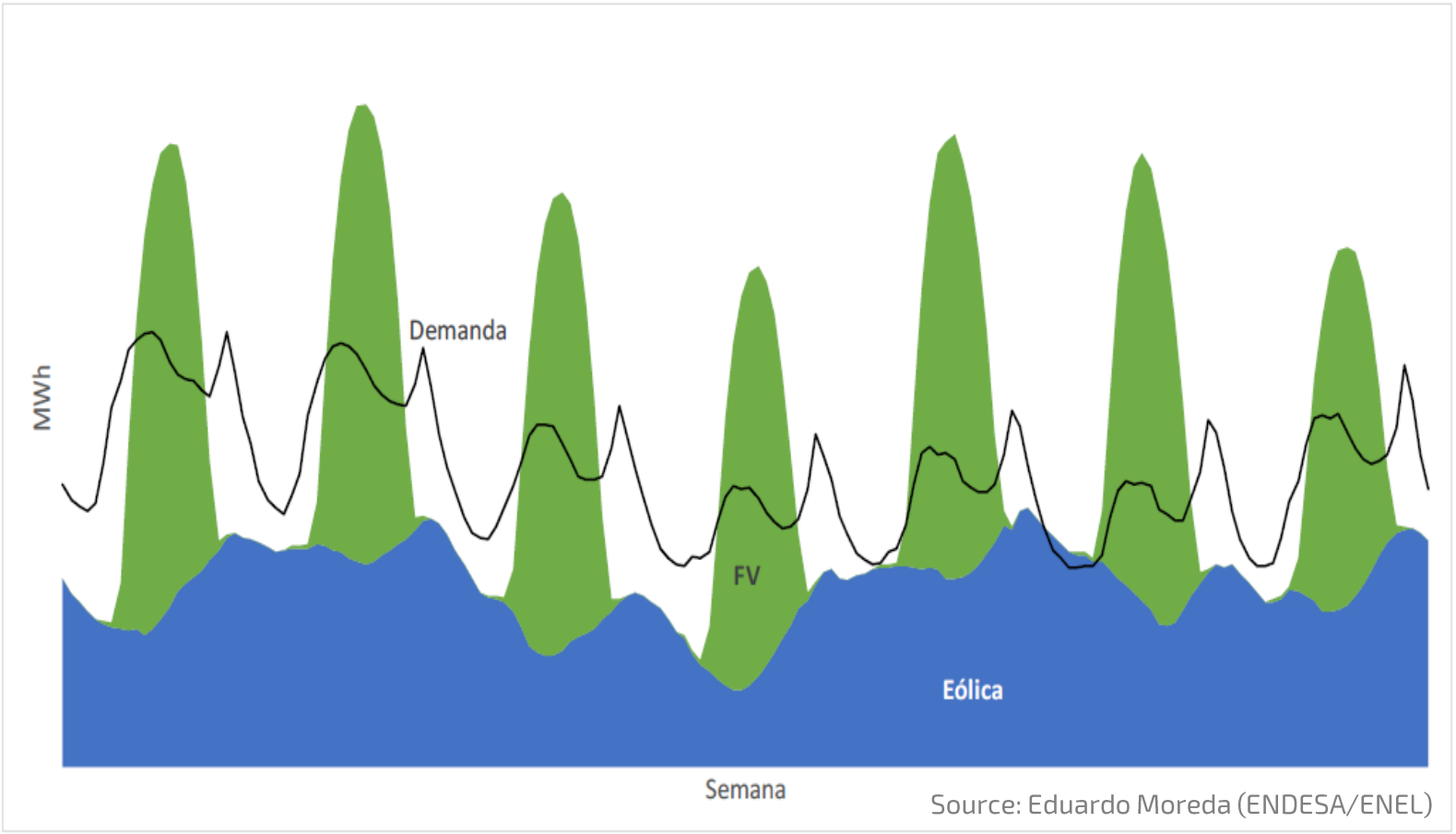




Source: JRC Flexibility requirements and the role of storage in future European power systems, 2022

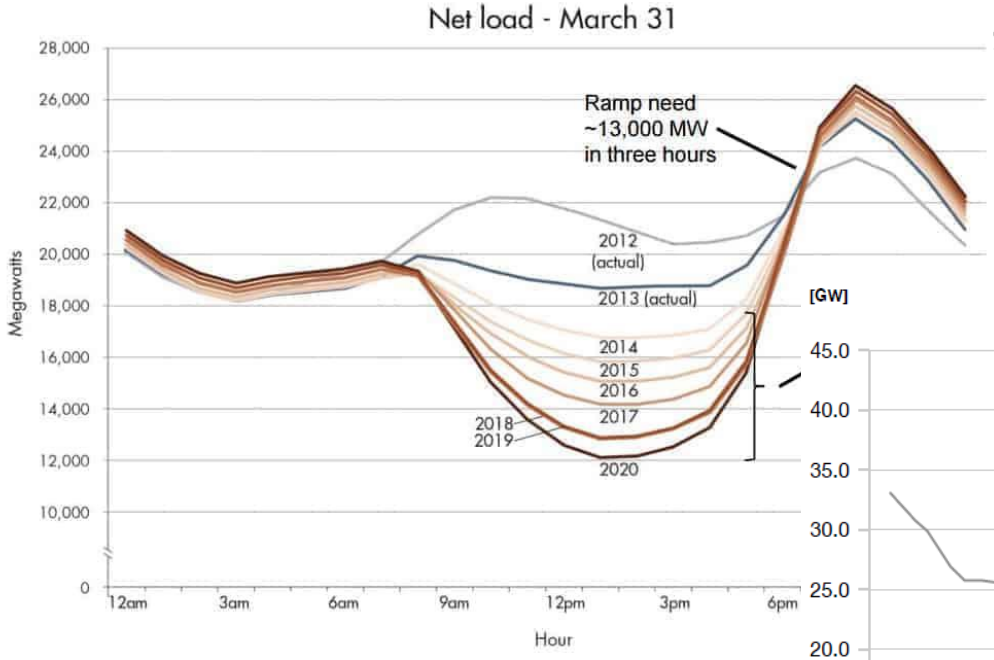
- EC wants advancement of storage, with a bigger role to play in short-term electricity markets and competing with natural gas in short-term balancing.
- Member States to produce reports on needs for **flexibility** (at least five years), assessing how much flexibility is needed to integrate the projected growth of renewables and how storage and demand response step in at both transmission and distribution level.
- Member States should define national objectives for the use of flexibility resources like storage and encourage a wider participation of energy storage in capacity markets.

The problem: Matching Generation and Demand

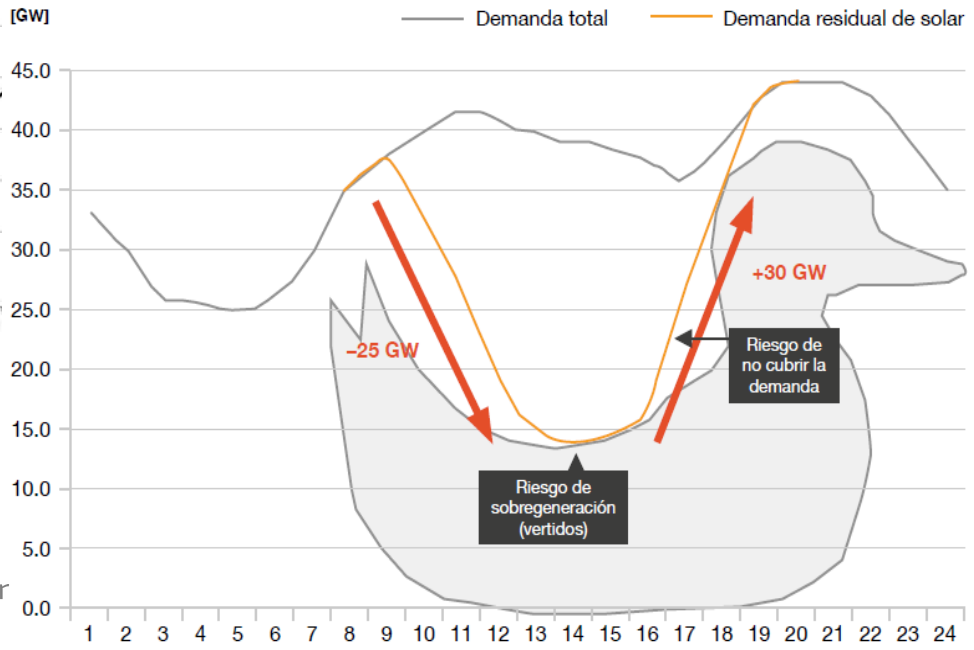


Source: Eduardo Moreda (ENDESA/ENEL)

Scenarios California (actual 2012-2020) vs. Iberia (foreseen 2030)

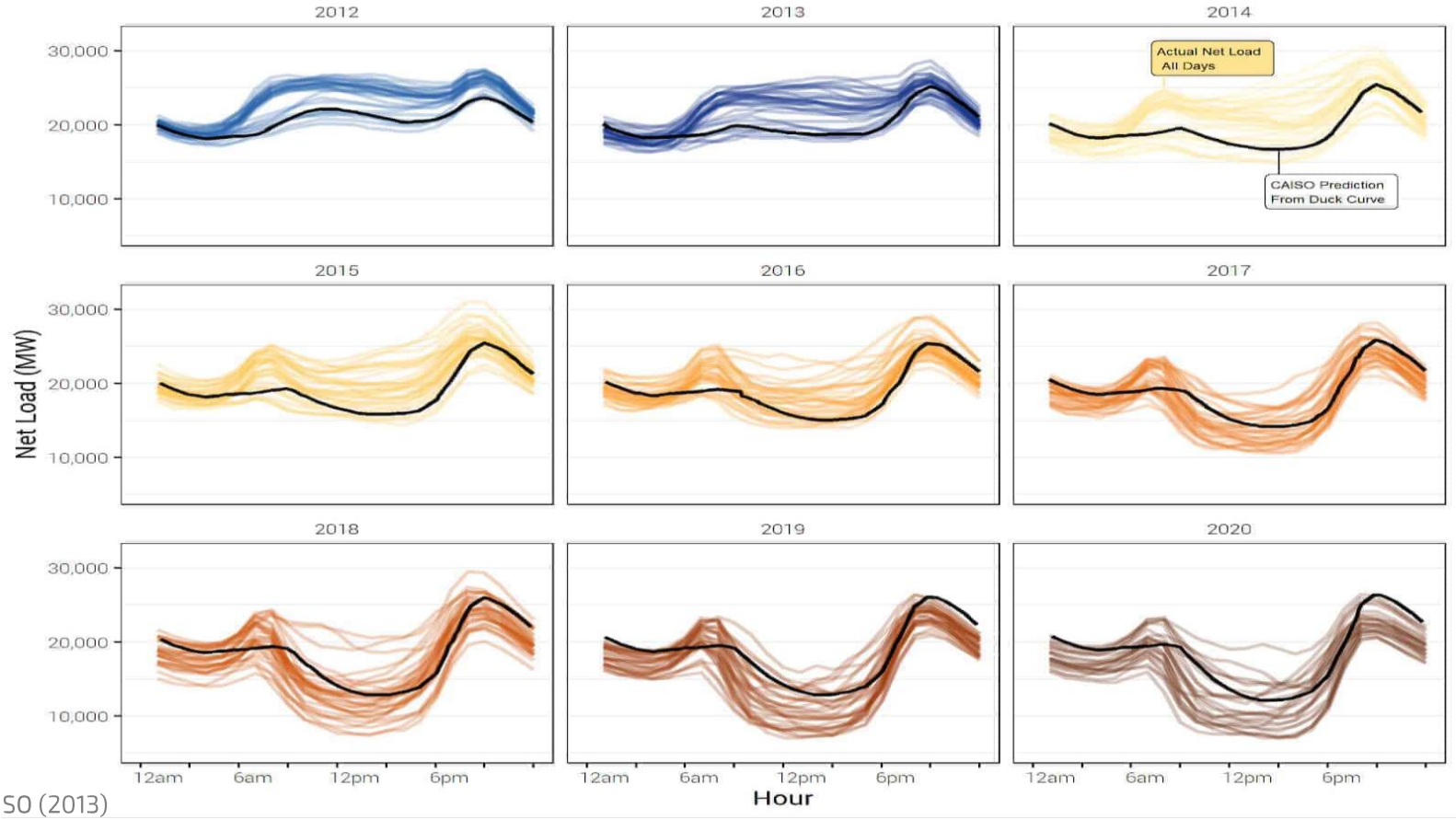


Source: CAISO (2013)



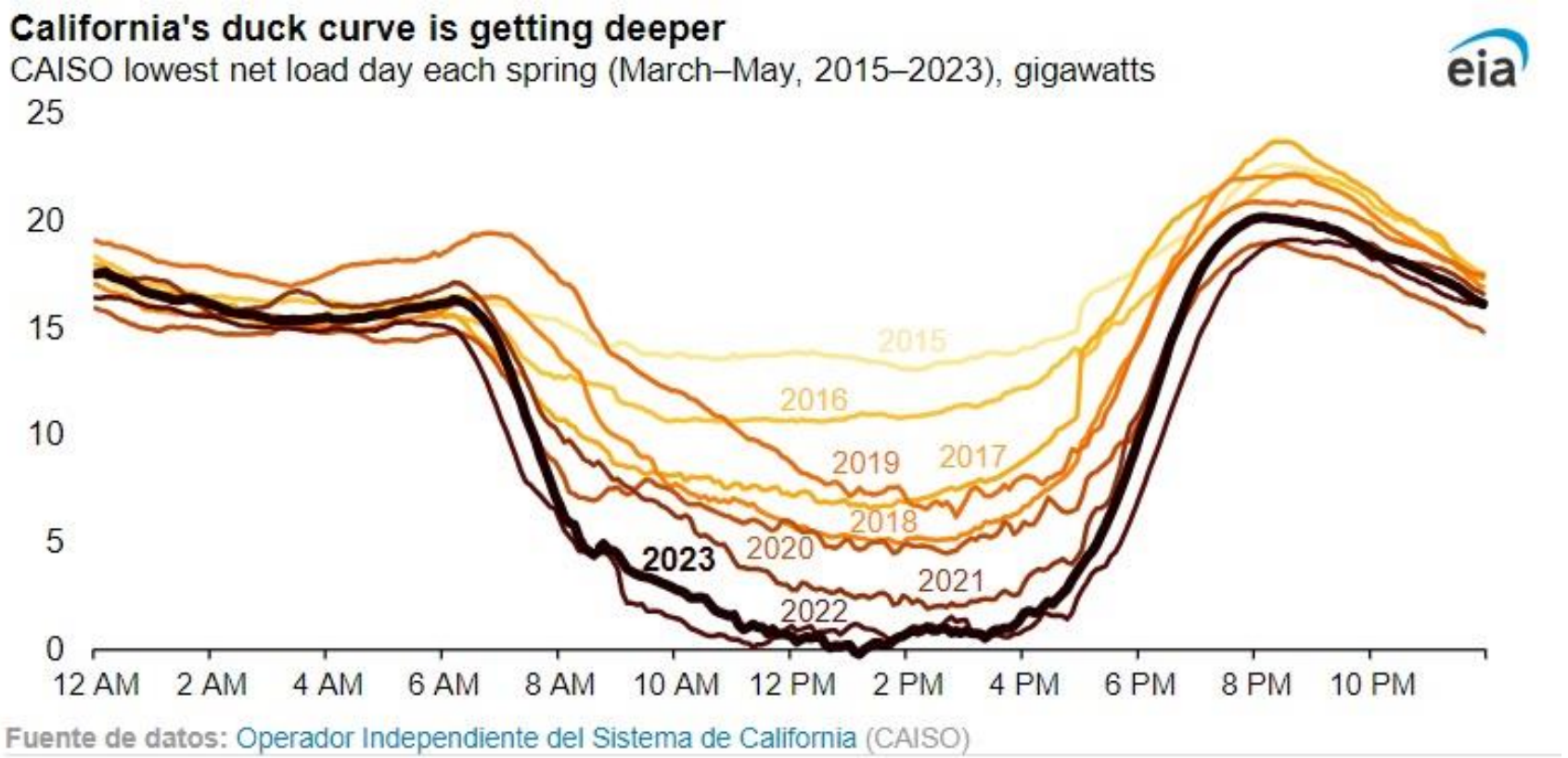
Source: PwC and REE (2021 - foreseen for 2030) – Report of Naturgy Foundation

The experience in California



Source: CAISO (2013)

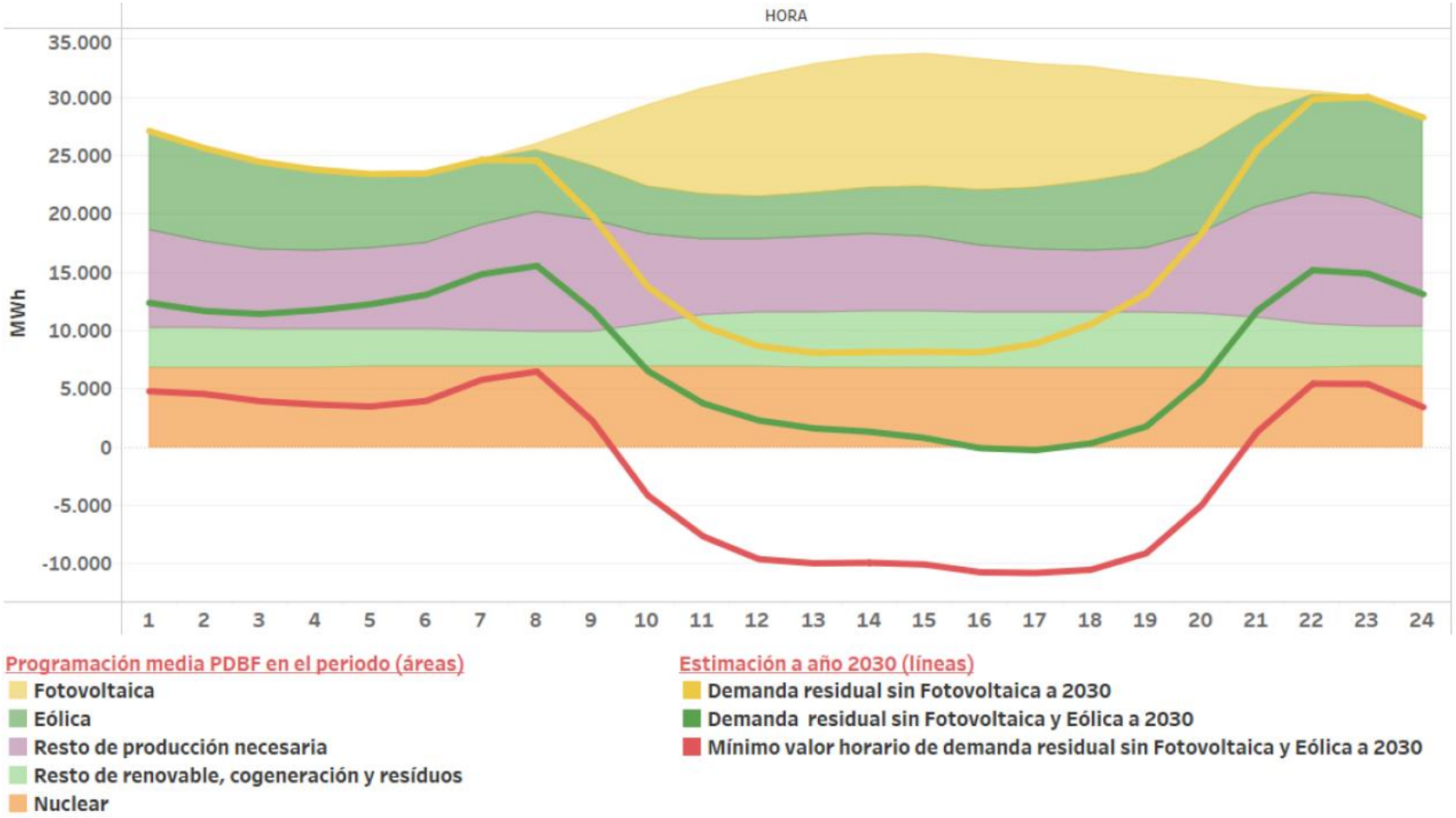
California: Actually deeper, and worse



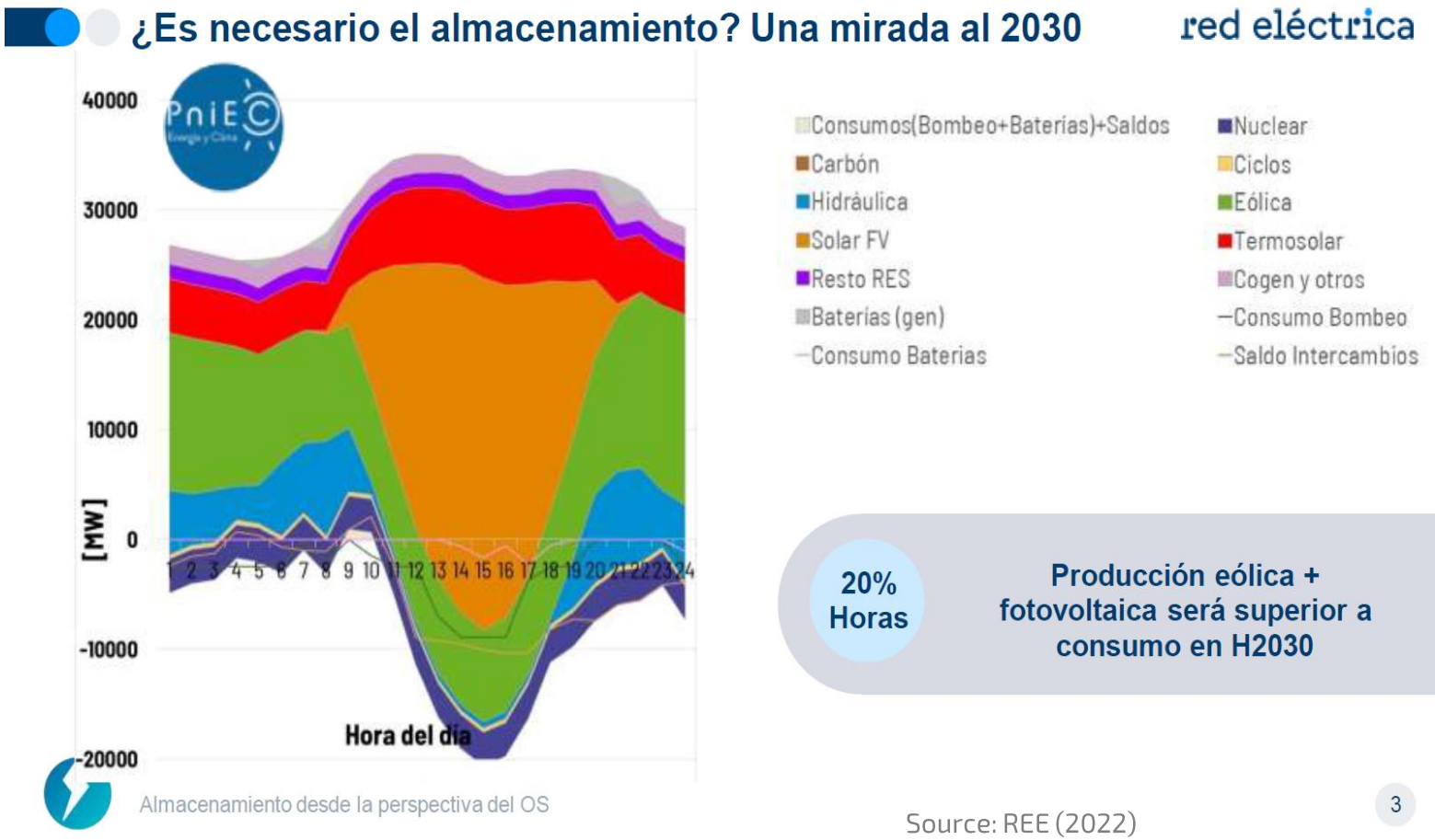
Source: CAISO (2023)

The “duck curve” in Iberia (2030)

Source: OMIE



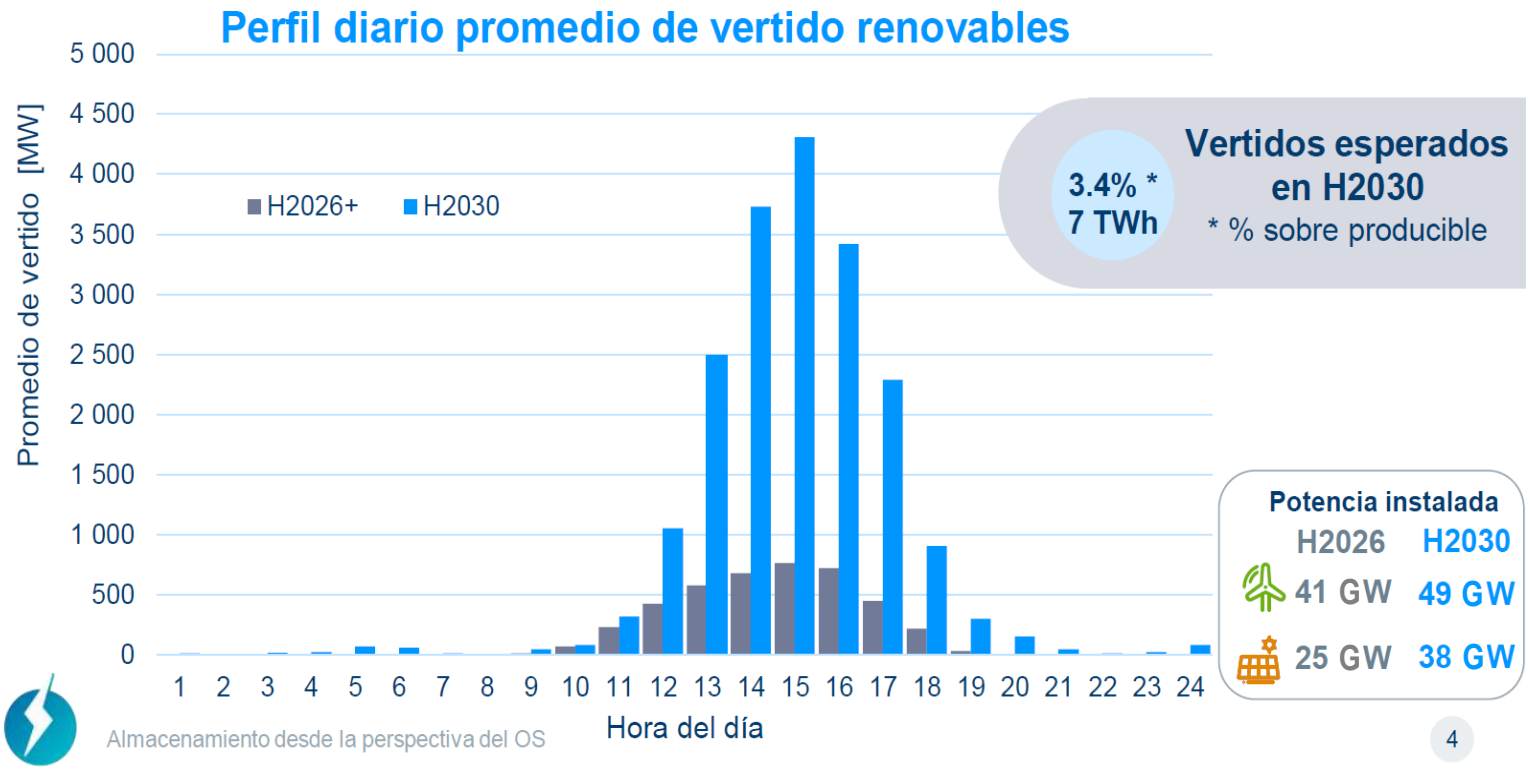
REE (grid operator – exp. 2030)



Source: REE (2022)

REE expected curtailment (2030)

Vertidos de producción renovables por balance. Península red eléctrica



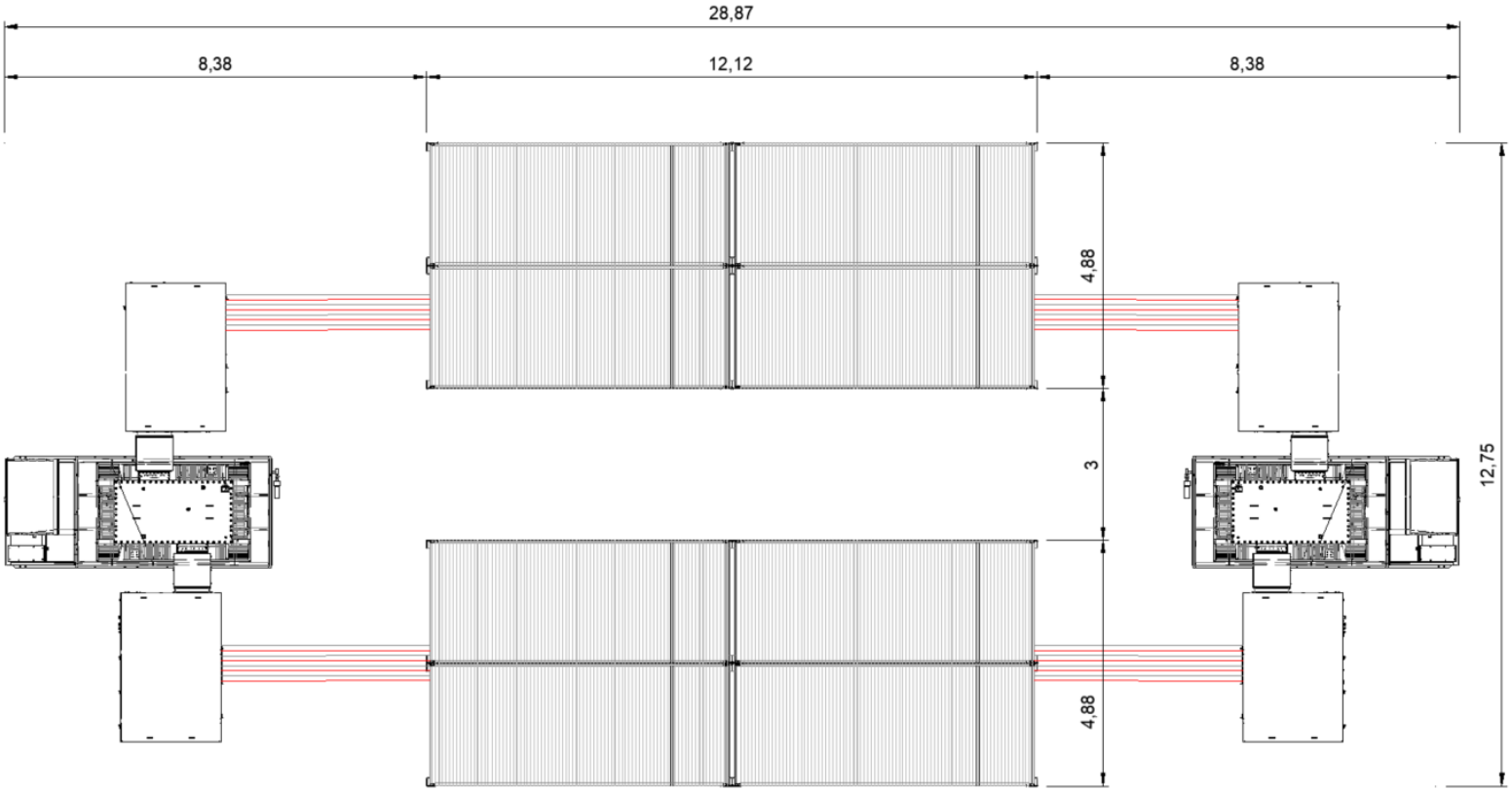
Source: REE (2022)

CAPEX and LCOS

50 MW 100 MWh (UK)

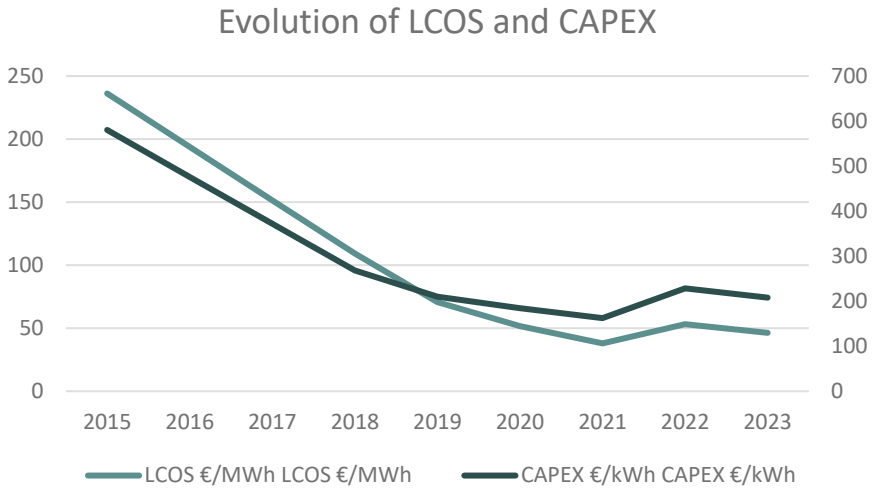
7,5 MW 15 MWh (Australia)

CAPEX: BESS getting compact

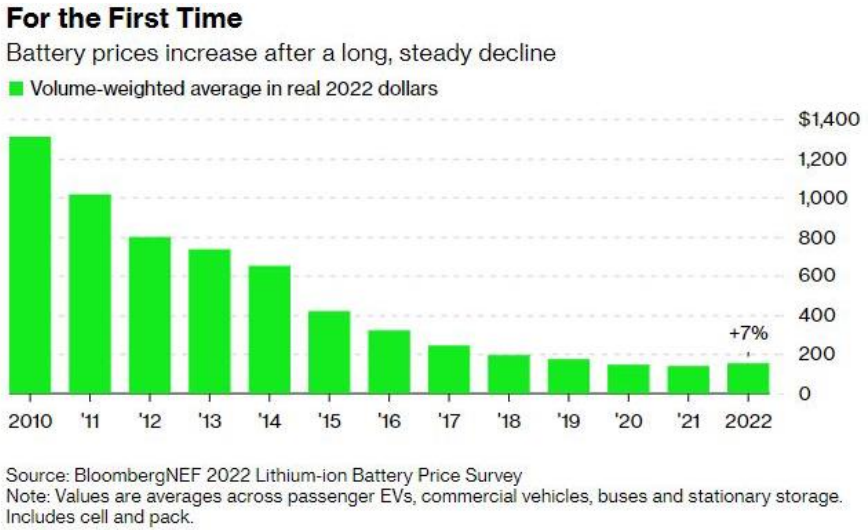


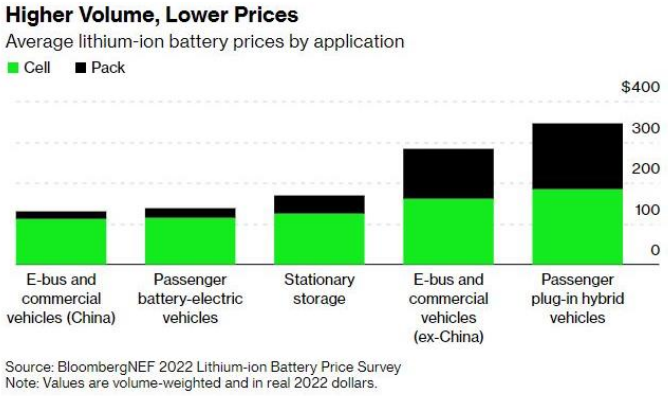
COMPACT (exp. 2025): 20 MW, 81,6 MWh, 30 kV (own design, two 20’ HQ container levels): 4,5 m²/MWh

CAPEX and LCOS of BESS



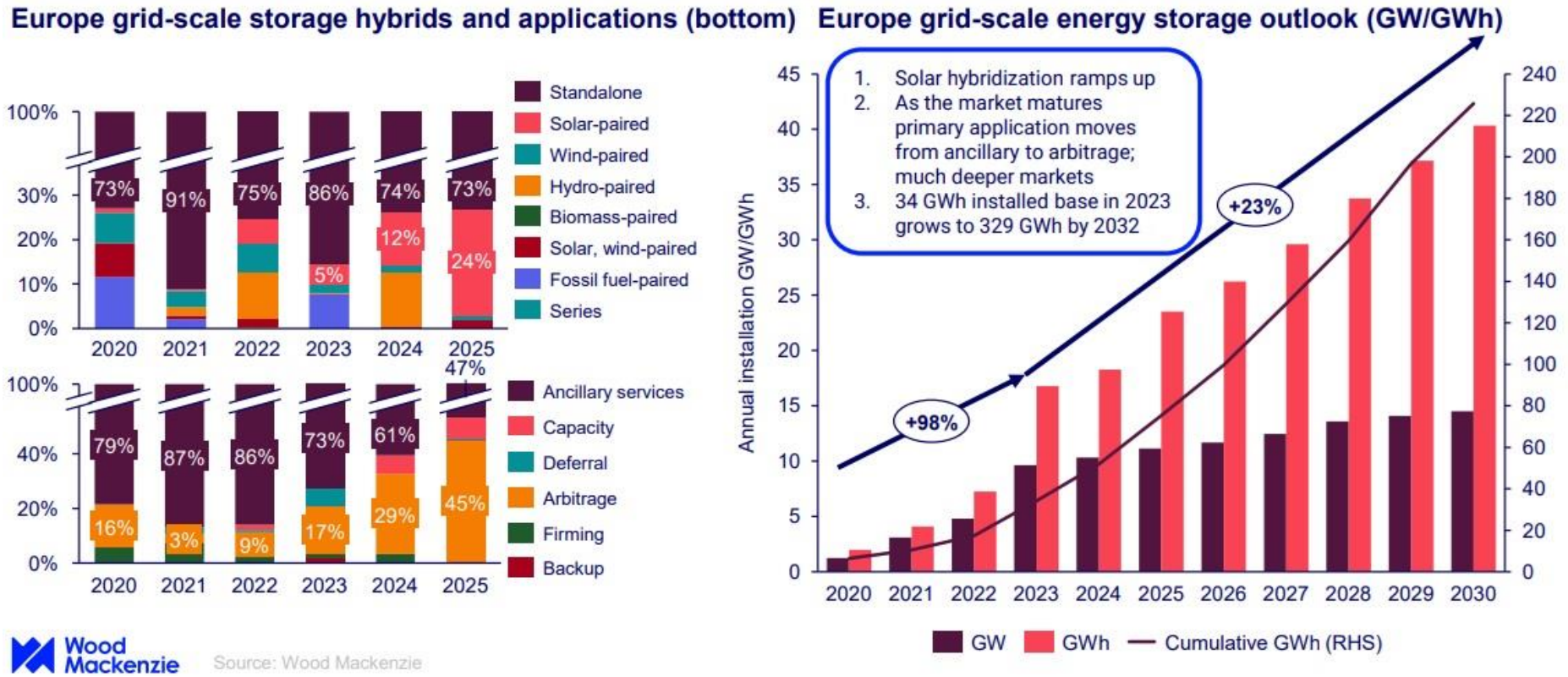
Source: ESS (own)





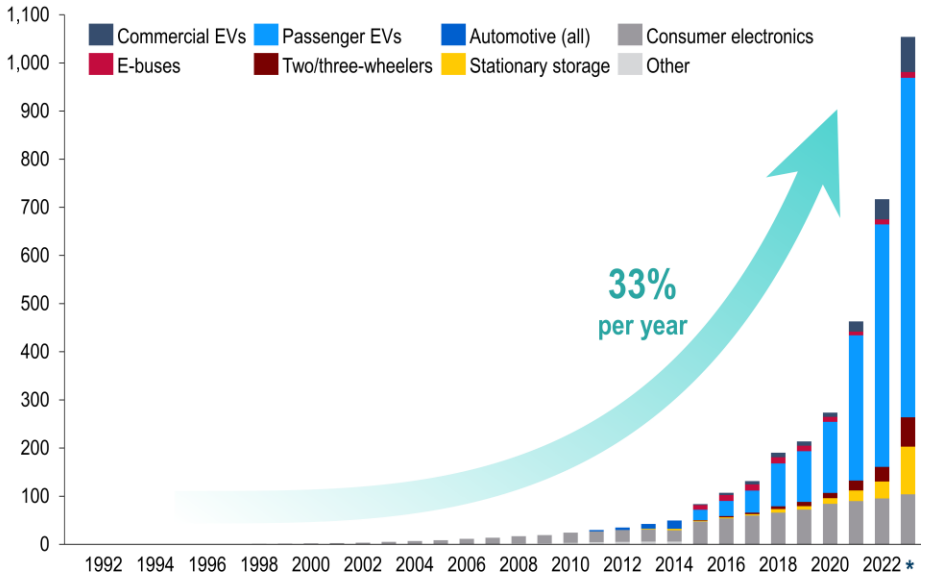
Source: BNEF

Installed battery capacity to increase tenfold 2023-2032



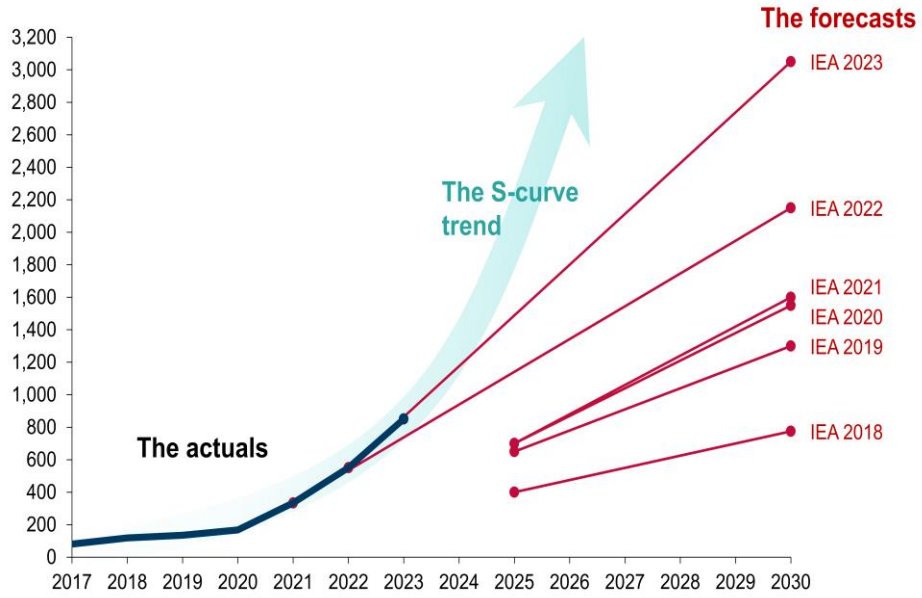
Source: Wood Mackenzie report *"2023: the year the European renewables bubble burst and reasons for optimism in 2024"*

Battery sales: S-curves



Global battery sales by sector, GWh/y

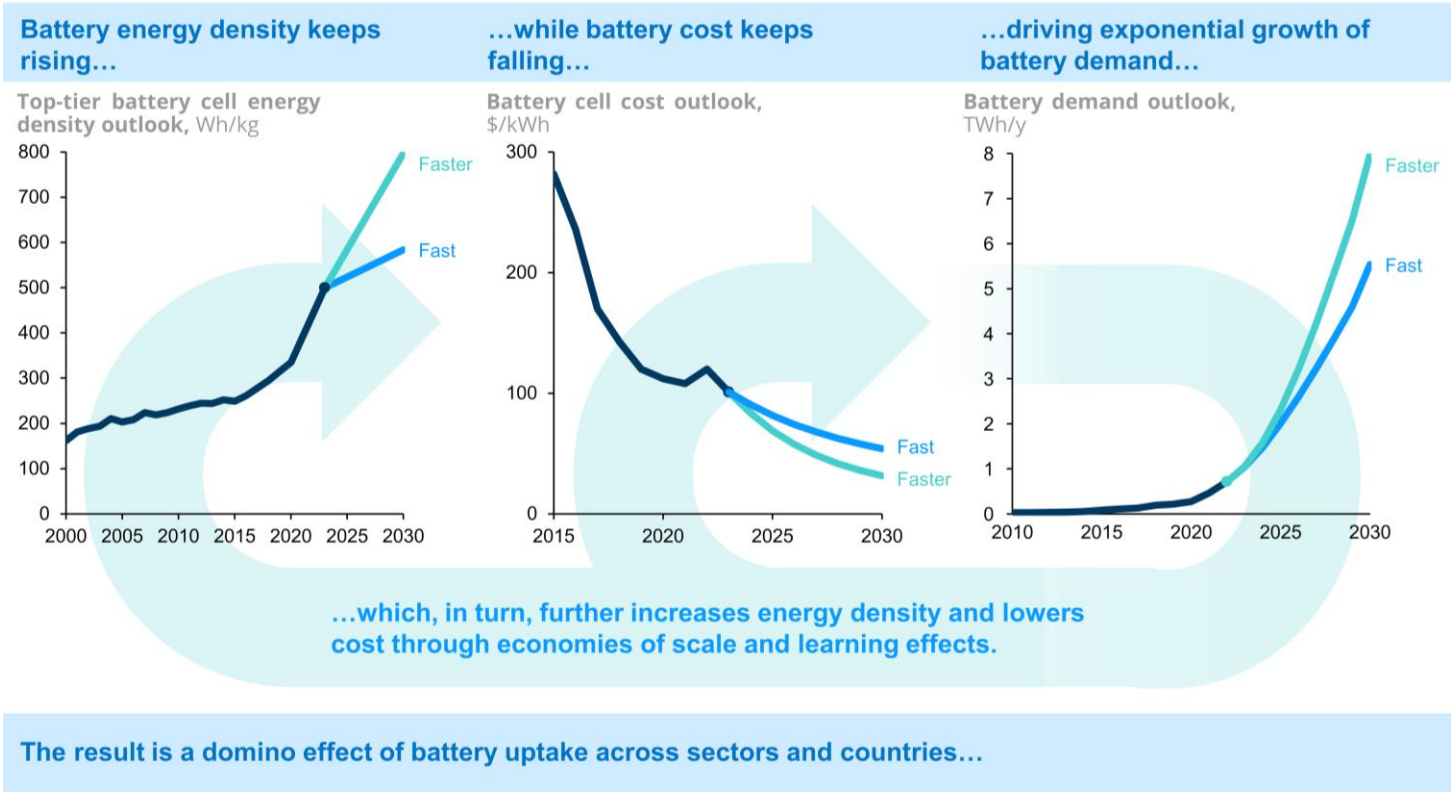
Source: Ziegler and Trancik (2021), Placke et al. (2017) for 1991-2014; BNEF Long-Term Electric Vehicle Outlook (2023) for 2015-2022 and the latest outlook for 2023 (*) from the BNEF Lithium-Ion Battery Price Survey (2023)



Automotive lithium-ion battery demand, IEA forecast vs. actuals, GWh/y

Source: IEA Global EV Outlook (2018-2023) current policy scenarios and actuals; BNEF Long-Term Electric Vehicle Outlook (2023) for 2023 estimate

CAPEX: Virtuous circle of technology - cost - volume

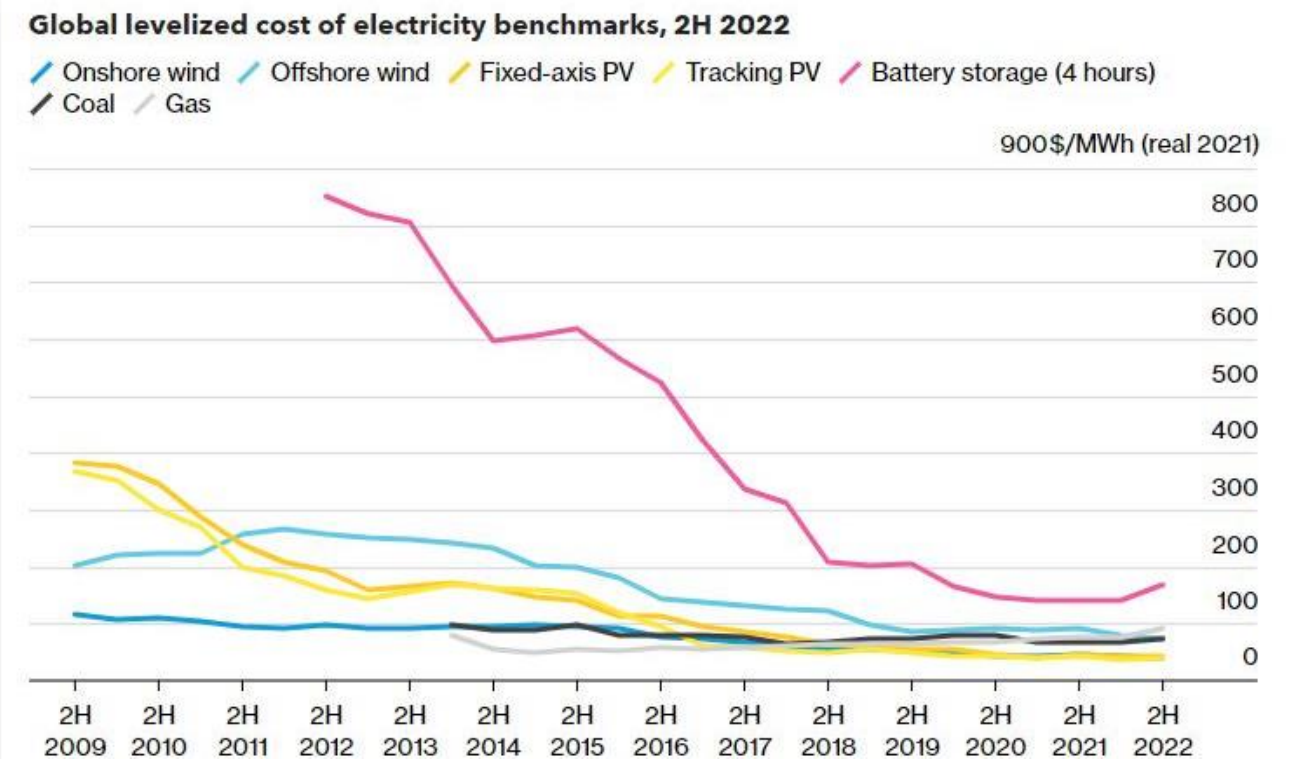


Source: BNEF & Rocky Mountain Institute.

Battery cells to reach by 2030 a cost of 32-54 $/kWh and an energy density of 600-800 Wh/Kg

LCOE of BESS

20% Increase in debt costs for newly-financed projects since 1H 2022



Source: BNEF

LCOE of storage includes purchase cost of electricity – 2023 sees a sharp reduction after the increase of 2022

CAPEX and LCOS of BESS

$$LCOS = \frac{Inv + \sum O\&M_{VAN}}{Nc \cdot DoD \cdot \eta c \cdot \eta d}$$

$$LCOE_{tot} = LCOE + fstorage \cdot LCOS$$

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023
CAPEX €/kWh	**580**	**476**	**372**	**268**	**210**	**184**	**162**	**228**	**208**
% contribution battery	86%	84%	80%	73%	70%	68%	65%	75%	74%
LCOS €/MWh	**236,0**	**193,6**	**151,4**	**109,1**	**70,6**	**51,6**	**37,9**	**53,2**	**46,2**
LCOE PV €/MWh	35,0	33,6	32,3	31,0	29,7	28,5	27,4	26,3	25,2
Total LCOE €/MWh	**153,0**	**130,4**	**107,9**	**85,5**	**65,0**	**54,4**	**46,3**	**52,9**	**48,3**

- EVs driving prices down at a fast pace, with temporal constraints in raw materials and supply chain.
- The contribution of battery cells to the total system cost is rapidly decreasing.
- Price reduction is not linear and accelerating (in spite of recent market spikes).
- Major factors are technological improvement (double effect: energy density and cycling capacity) and economies of scale.
- Cost of storage will end up being marginal as compared to generation.

Source: ESS (own development)

Expected CAPEX 2024

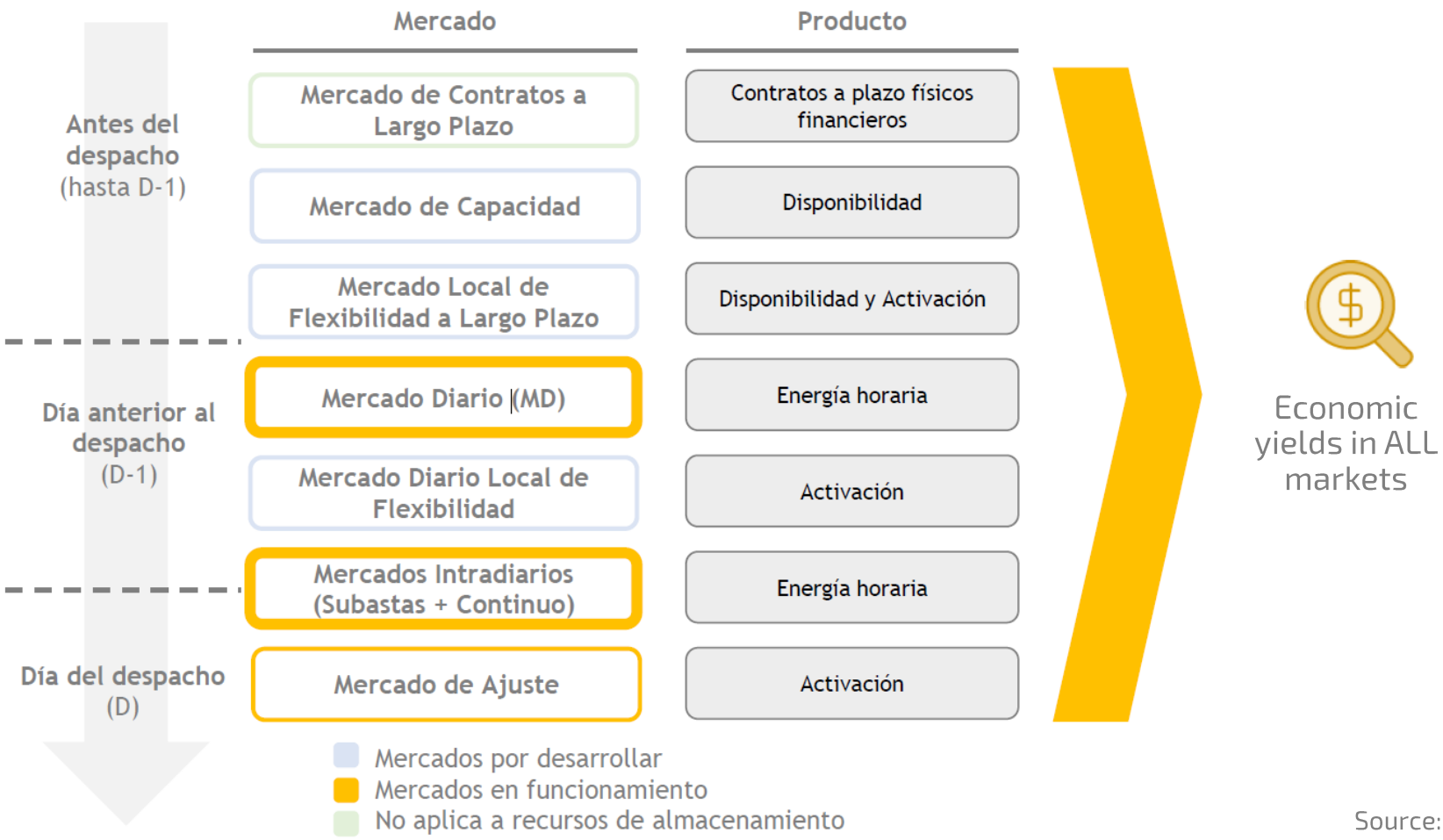
CAPEX	UNIT	AVERAGE
Capacity MWh	€/MWhn	125.000
Power MWn (incl. EMS + BoS)	€/MWn	50.000
Grid access	€/MWn	50.000

BESS: OPEX and income

20 MW 20 MWh
(Philippines)

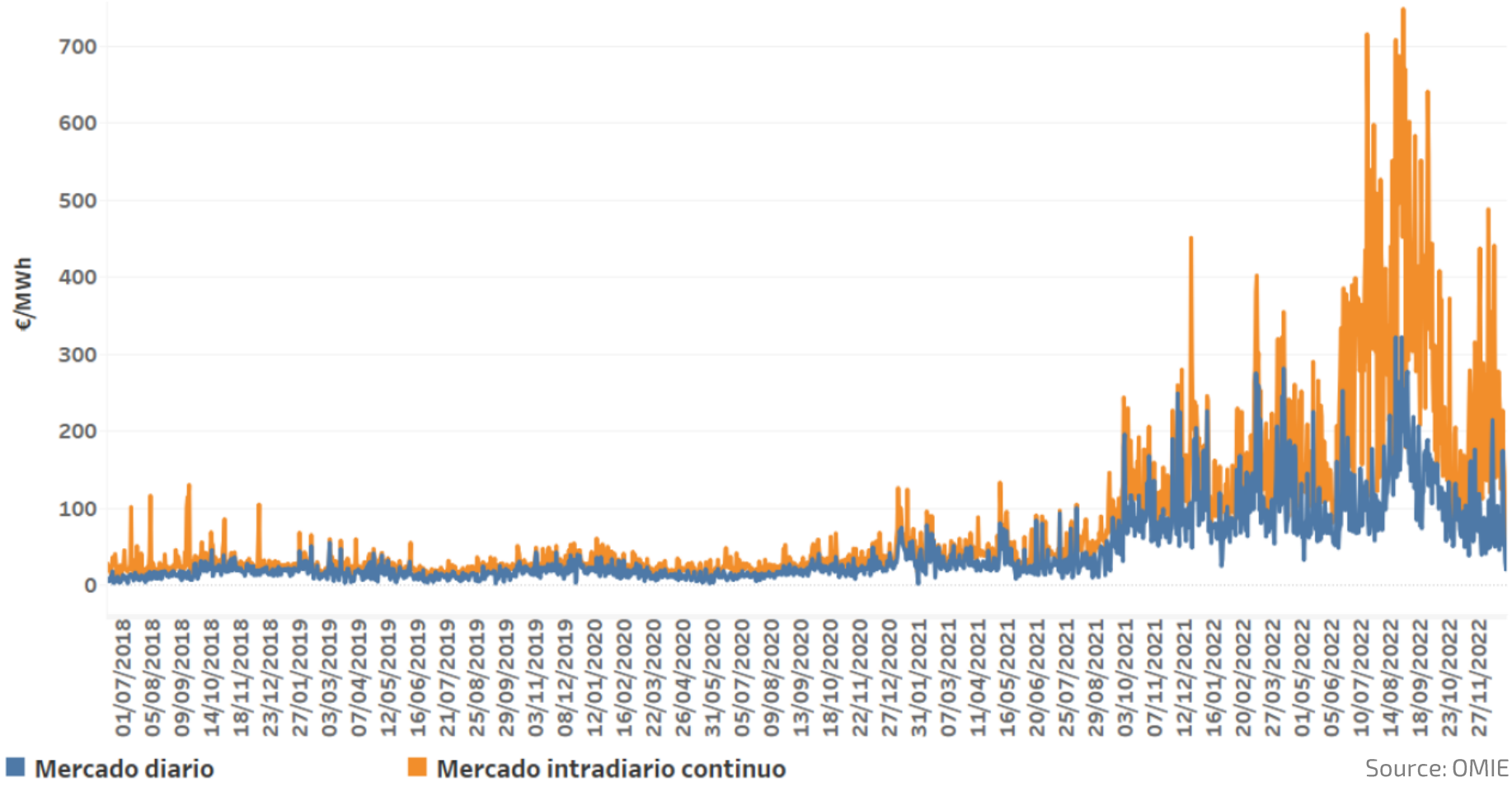
20 MW 20 MWh (Philippines)

Revenue stacking: optimizing participation in ALL markets



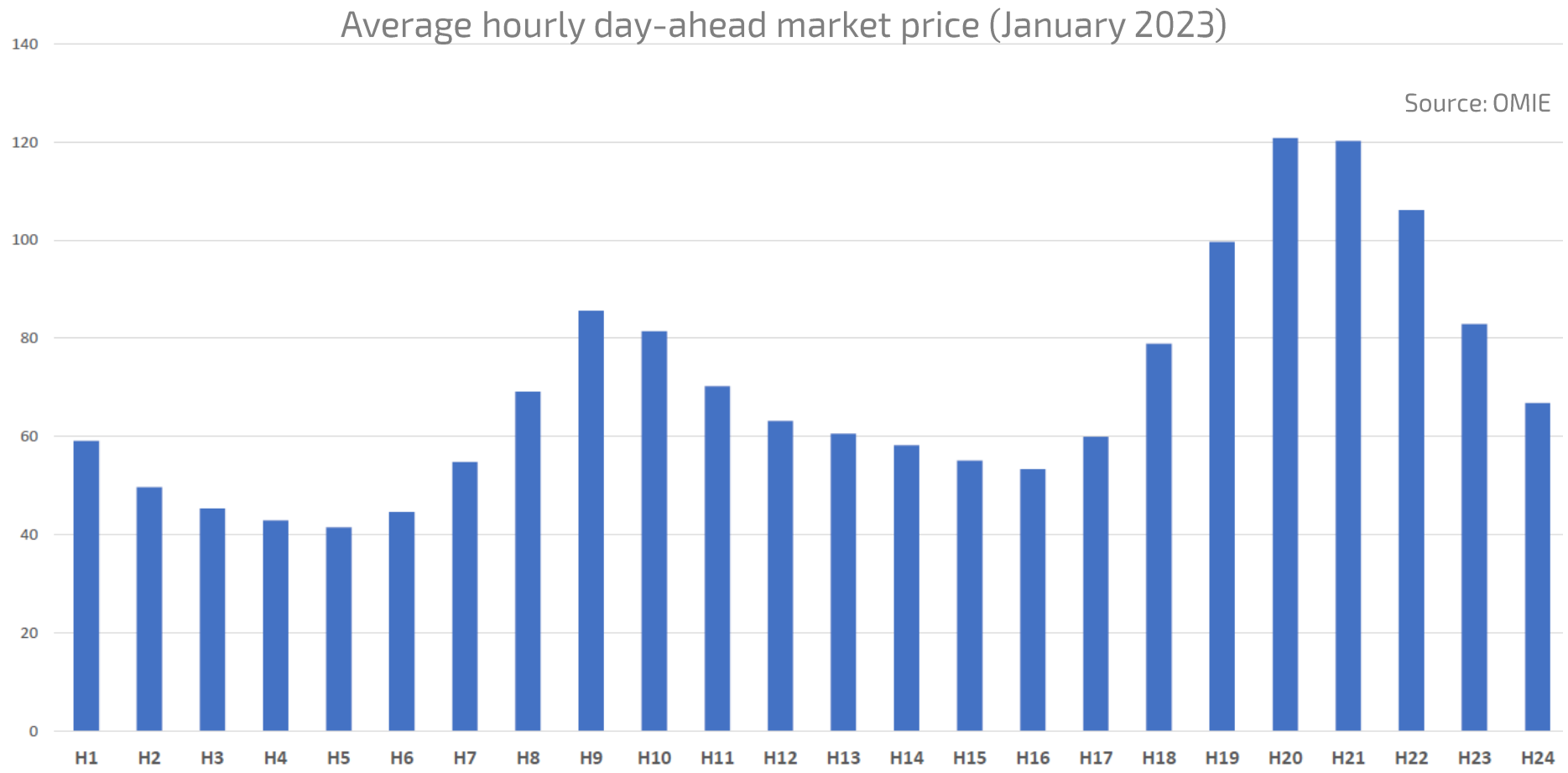
Source: OMIE

Spreads (revenues) increase with growing penetration of renewables



Source: OMIE

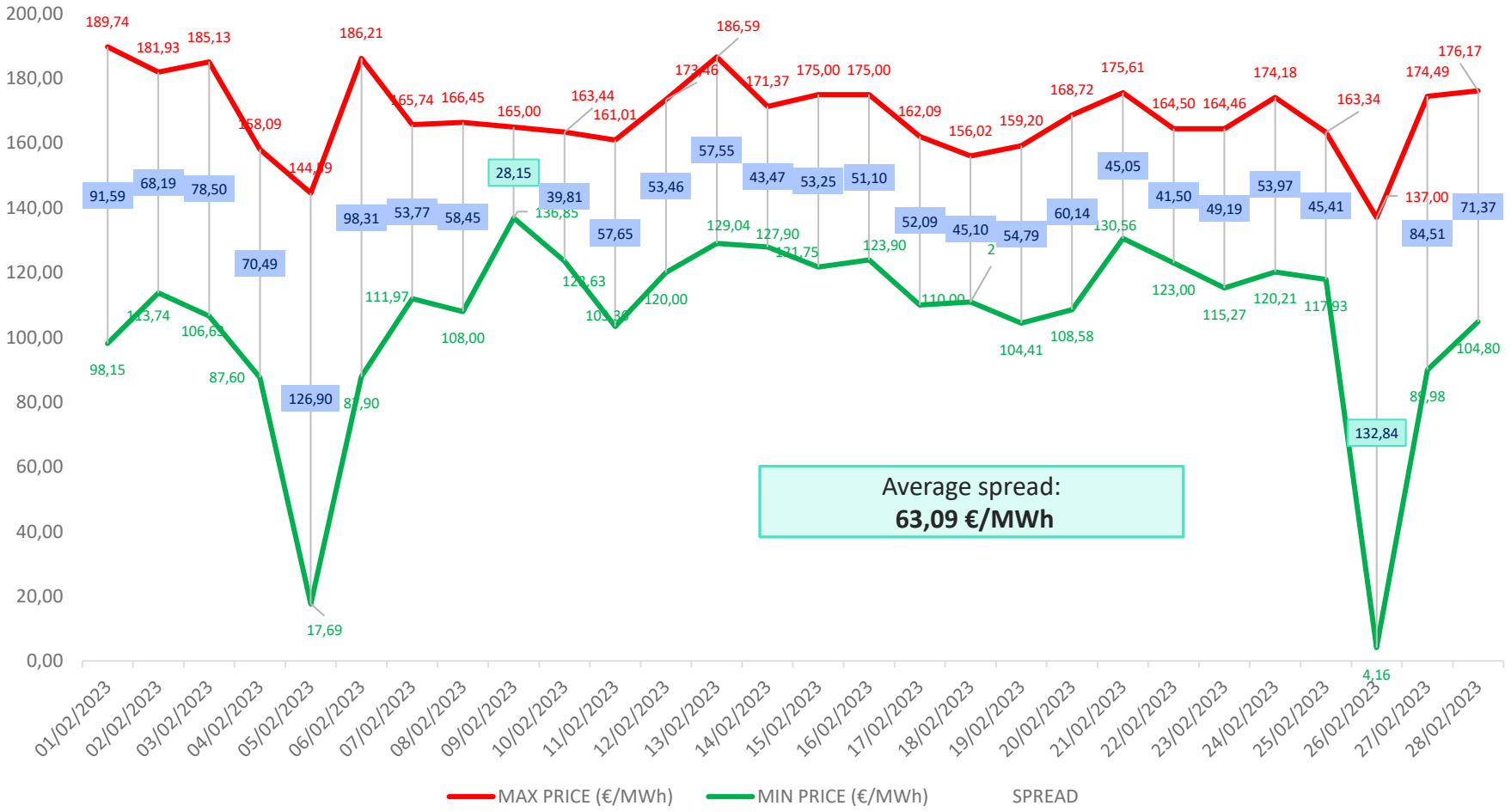
Prices and spreads increasingly reflect the “duck curve”



Growing price spreads

Lowest 1st Third 2023: SPREADS day-ahead market (February)

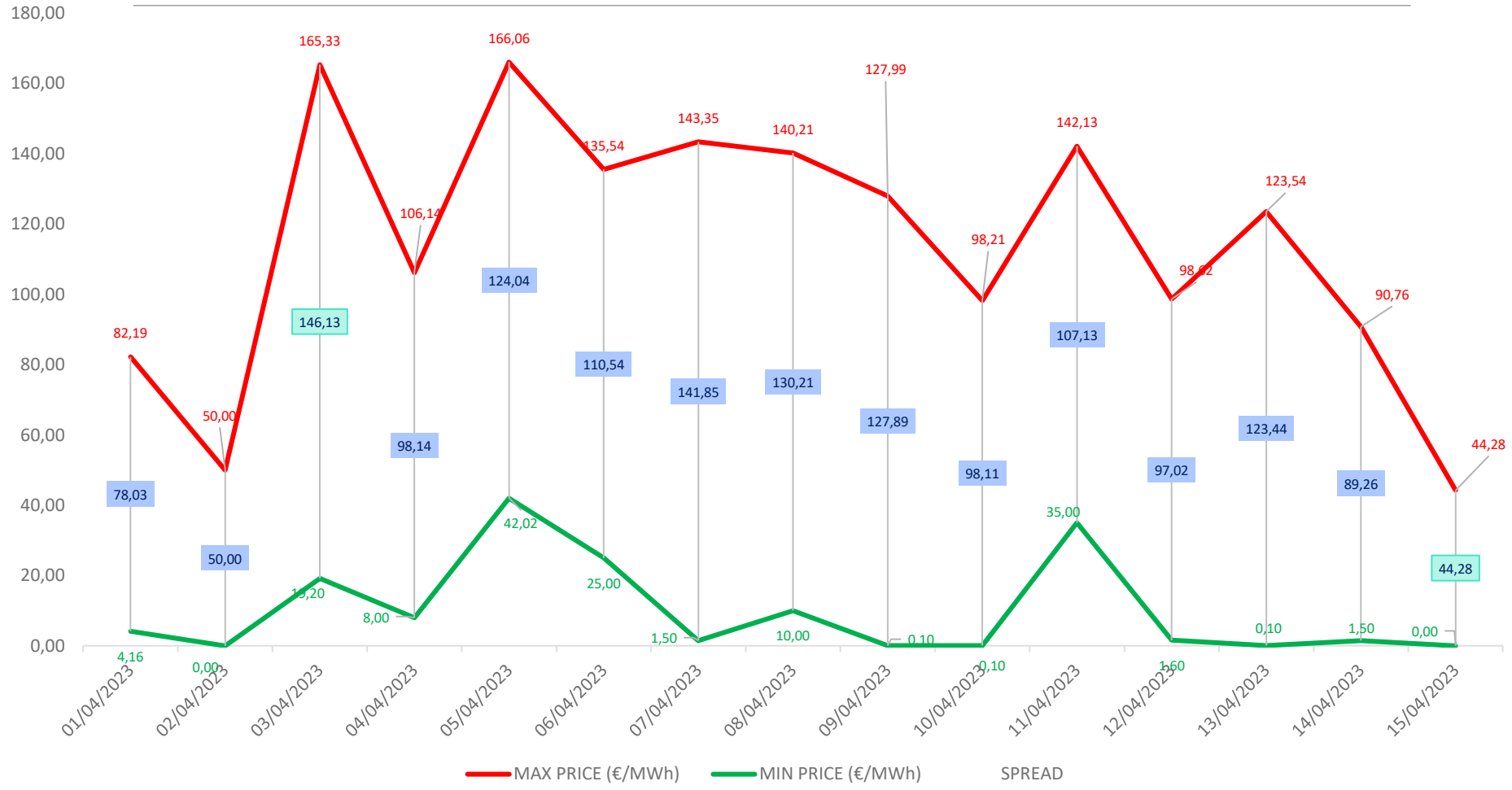
Source: OMIE



Growing price spreads

HIGHEST 1st Third 2023: SPREADS day-ahead market (April)

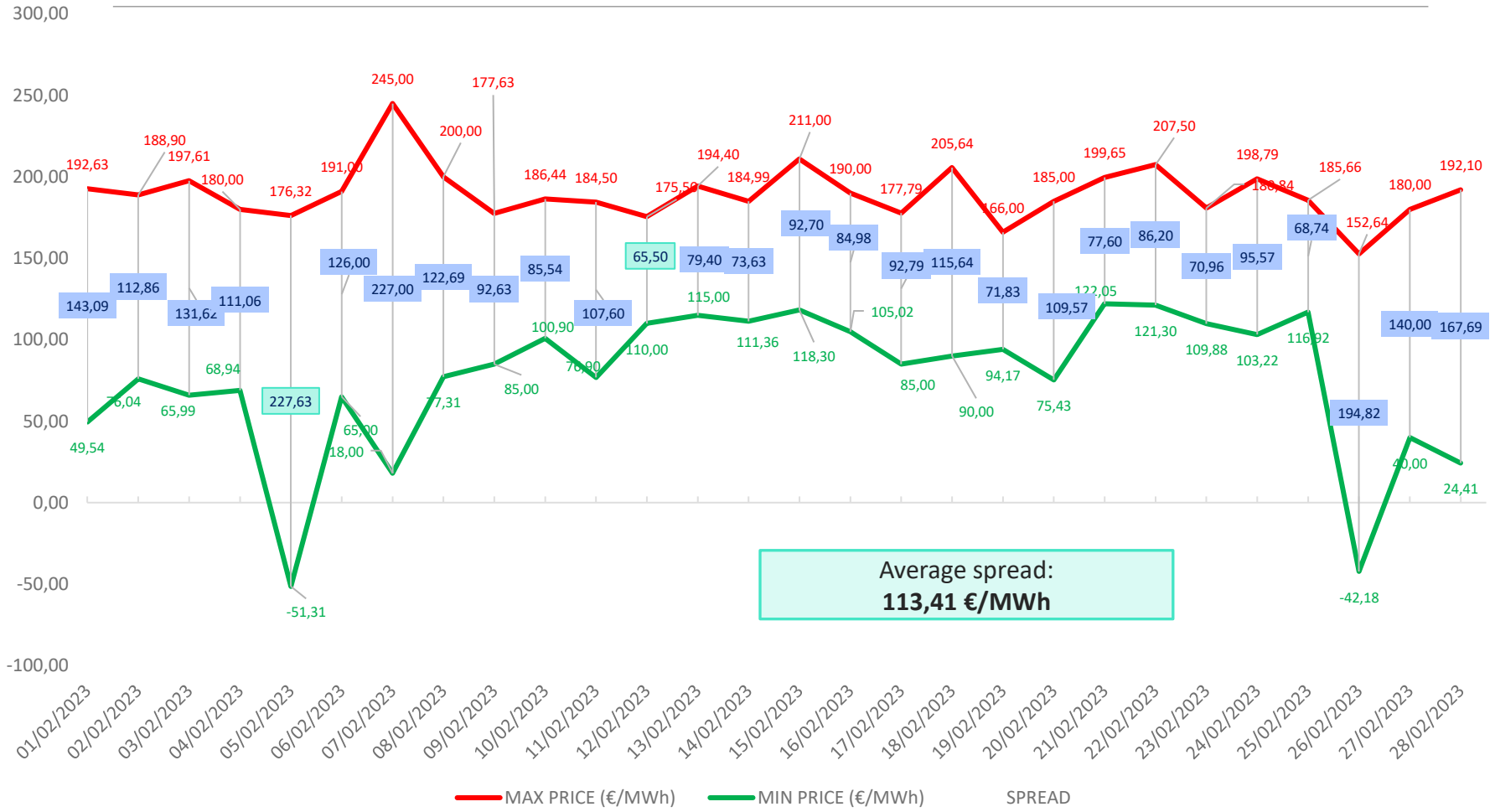
Source: OMIE



Growing price spreads

Lowest 1st Third 2023: SPREADS intraday market (February)

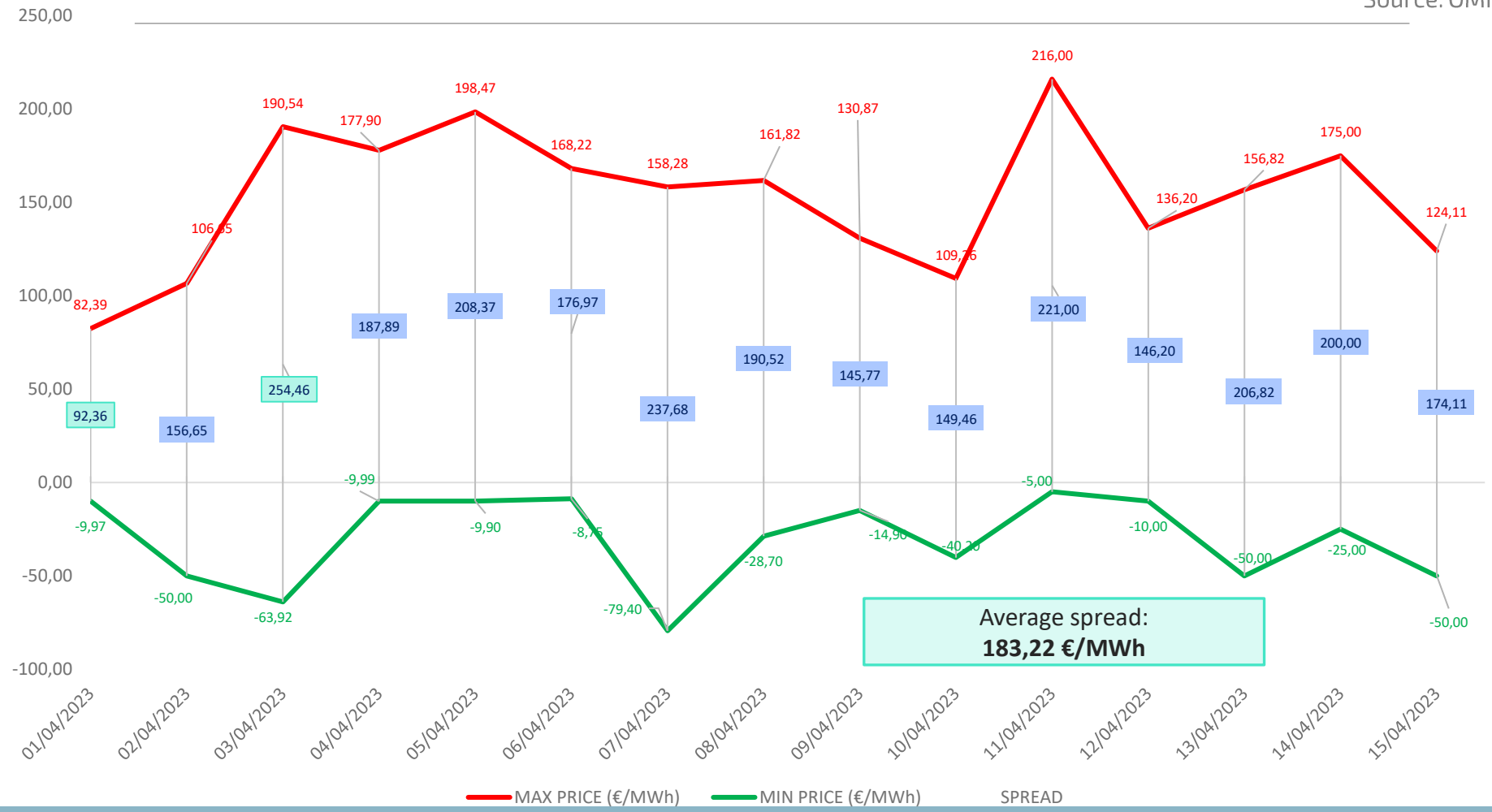
Source: OMIE



Recent price spreads

HIGHEST 1st Third 2023: SPREADS intraday market (April)

Source: OMIE



Average price spreads Jan-Apr 2023

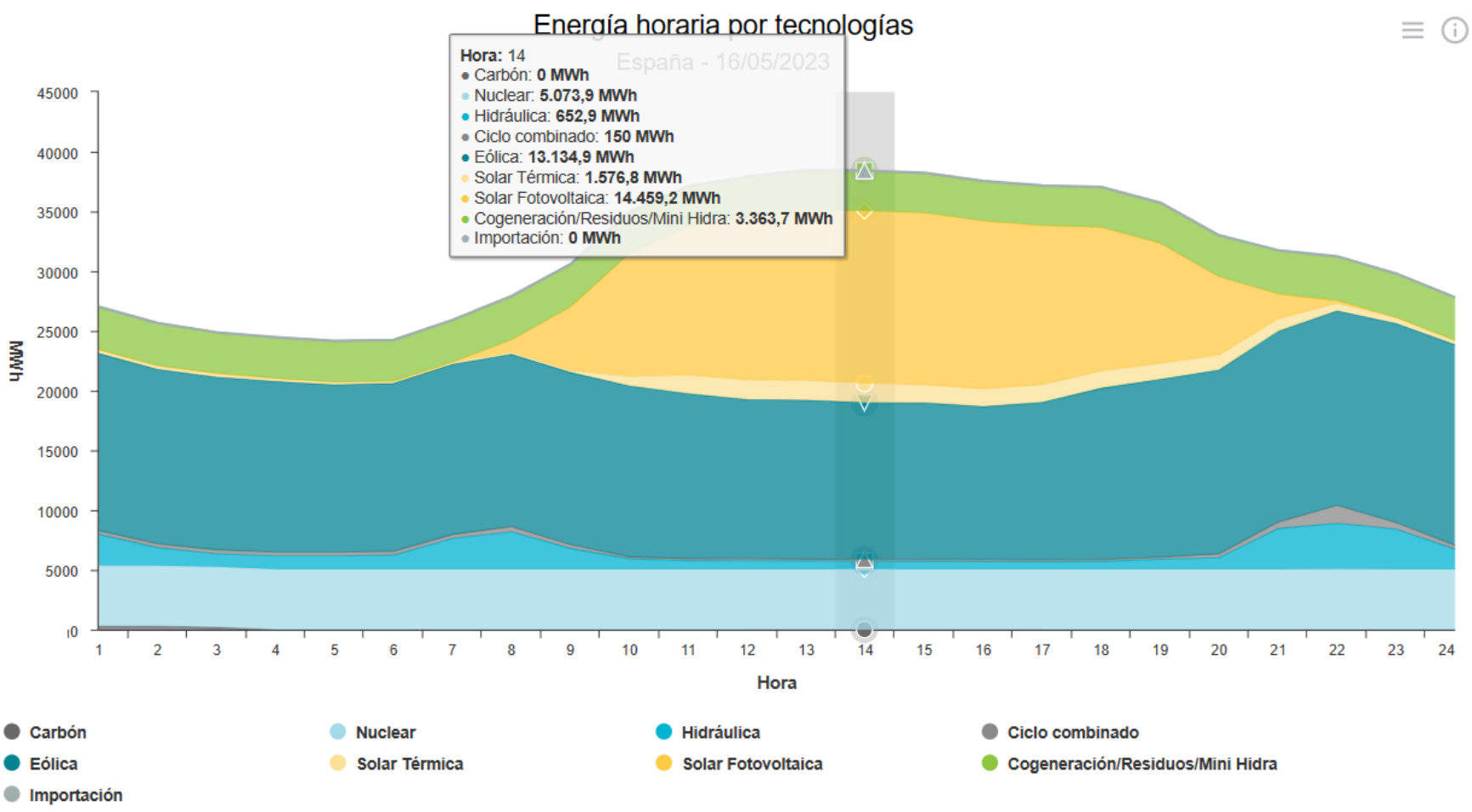
Source: OMIE

Average €/MWh 2023	Price Day-ahead	Spread Day-ahead	Spread Intraday
January	69,55	92,19	159,59
February	133,47	63,09	113,41
March	89,66	85,59	163,36
April	61,01	104,40	183,22

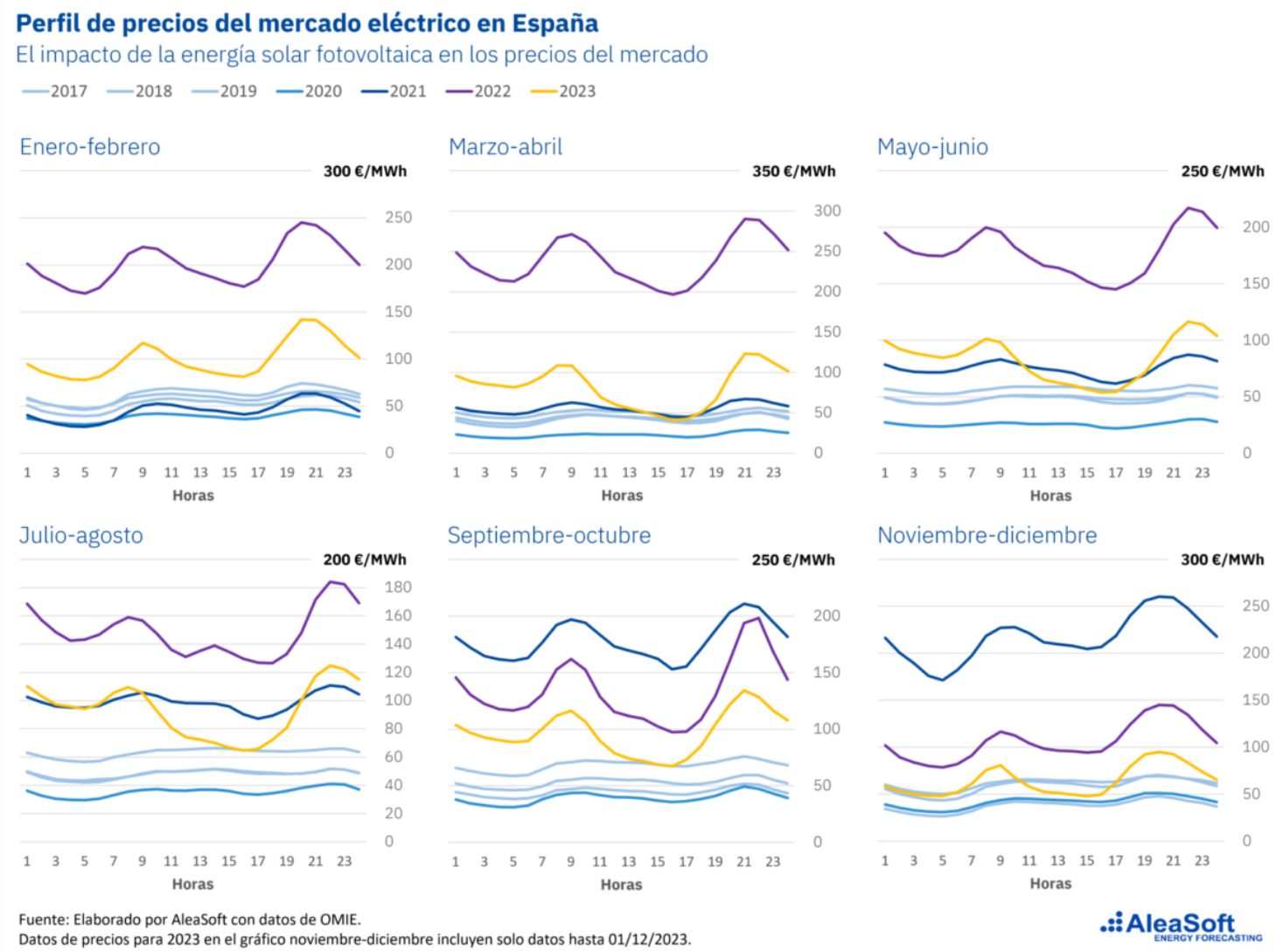
Record days becoming recurrent

8h 100% renewables + nuclear (16 May 2023 11-19 h)

Source: OMIE



Average prices evolution: 2023



Source: Aleasoft

Baseload and consumption profile PPAs offer higher revenues

PEXAPARK's EUROPEAN PPA MARKET OUTLOOK 2023:

- Baseload PPAs command a premium compared to Pay-as-Produced ("PAP") PPAs. Interestingly, sellers that master Baseload PPAs can handle the much discussed "24/7 Green Supply" agreements!
- There are corporates that by nature of their consumption profile are much more inclined to buy fixed profiles as foreseen under Baseload PPAs. In exchange of the higher risks, energy producers benefit from a pricing premium, compared to PAP.
- The business case for co-locating energy storage as an optimiser in assets under baseload PPAs is gaining traction.
- Volatility and the revenge of system costs will result in an increasing share of renewables + storage projects and will bring to the fore PPAs reflecting both the energy sale and storage elements. The system will demand 'smarter and more flexible' renewables, that will leverage the benefits of colocation with energy storage assets.

We are entering a new phase, where readiness, alertness and flexibility is the way forward.

Source: Pexapark

Capacity payments

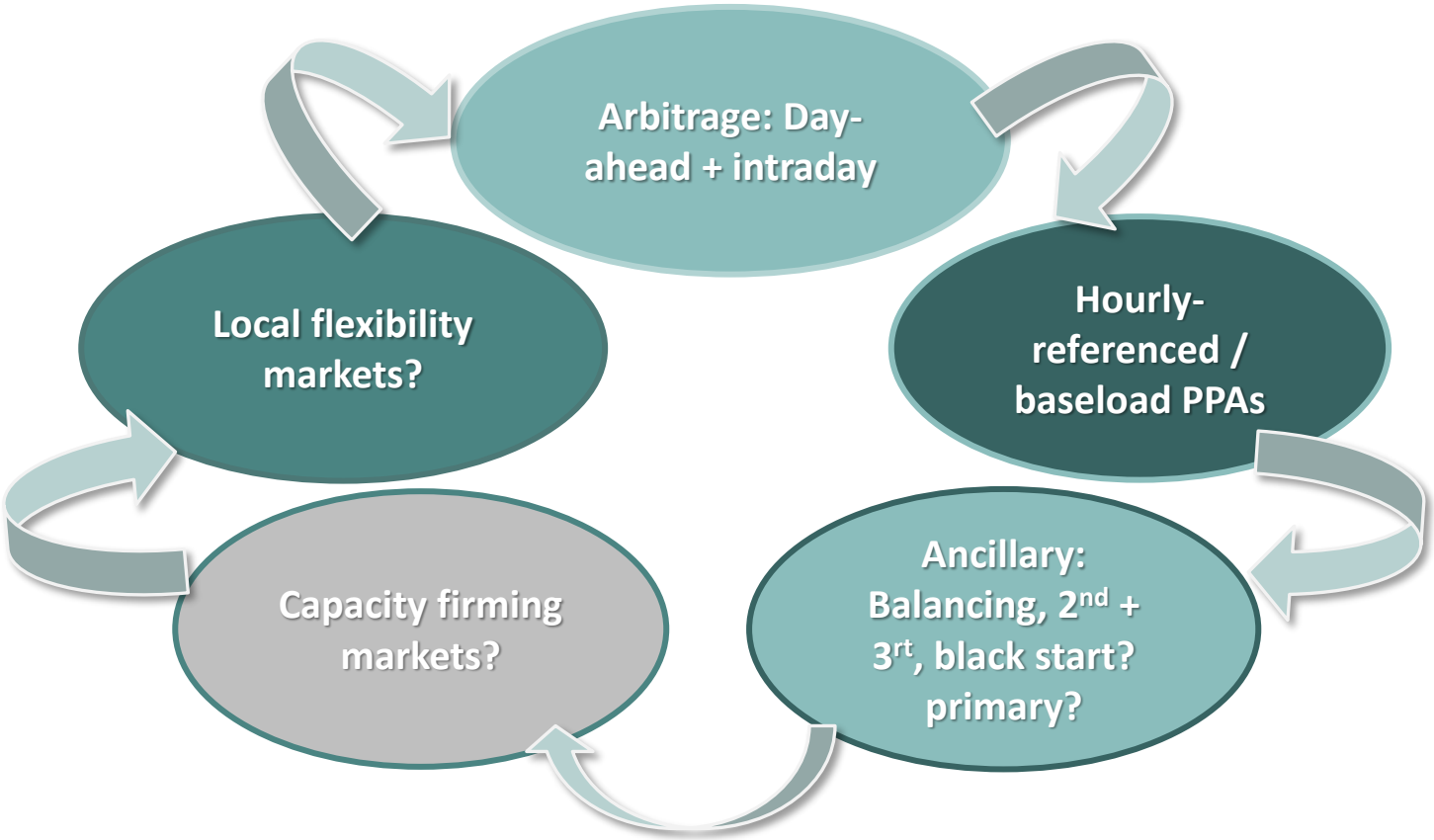
Derating factor in last UK tender for capacity payments:

- 1 h: 11,81%
- 1,5 h: 17,77%
- 2 h: 23,63%
- 2,5 h: 29,58%
- 4 h: 46,86%

Still unknown how it will work in the case of Spain (when/if launched).

Source: Pexapark

Revenue Stacking



BP: Operation & OPEX

OPERATION PARAMETERS		
Operative life	Yrs	15
DoD (operation)	%	95,0%
Average yearly cycles (over nominal capacity * DoD)	#/yr/MWh	621
Average daily cycles	#/day/MWh	1,7
Capacity year 1 (for linear estimation)	%	94,5%
Yearly degradation (over nominal capacity)	%	-1,9%
OPEX (yearly)		
Fixed O&M expenses (incl. land rent and surveillance)	€/MWhn	500
Fixed O&M expenses	€/MWn	1.900
Variable expenses (due to operation)	€/MWh	0,5
Yearly variation of expenses	%	1,7%
Other operation expenses (energy trader)	% of sales	0,40%
Expenses not subject to VAT (insurance, labour, etc.)	€/MWhn	800
Other known power sale and operation costs and taxes such as electricity tax, BICE, IAE, etc. not included		

Table of input data for BP results from running a 15-yr cycling model

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