AURORA
ENERGY RESEARCH

Optimal Dispatch Strategy and Contracted Revenues in the Italian Battery Market

Public Report

Our researchers

Matteo Coriglioni
Head of Italy

Maddalena Cerreto
Senior Associate

Christopher Coates
Senior Analyst

For more information on the Italian battery market, please contact:

Foteini Kakavia,
Commercial Associate
foteini.kakavia@auroraer.com

Deborah Scaggion,
Senior Commercial Associate
deborah.scaggion@auroraer.com

Sources: Aurora Energy Research

Agenda

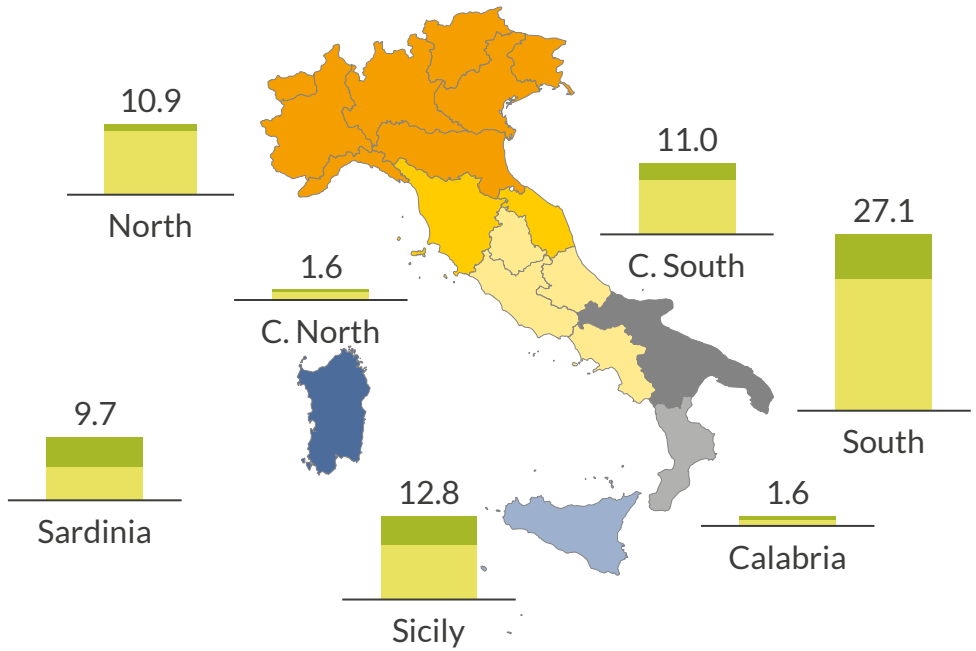
AURORA

1. Introduction
2. Dispatch-based business model – revenue stacking
3. Contracted revenues business model – MACSE auctions

More than 74GW of battery projects have requested grid connection, the majority of which in southern zones and Islands

Grid connection requests from battery storage assets[1]

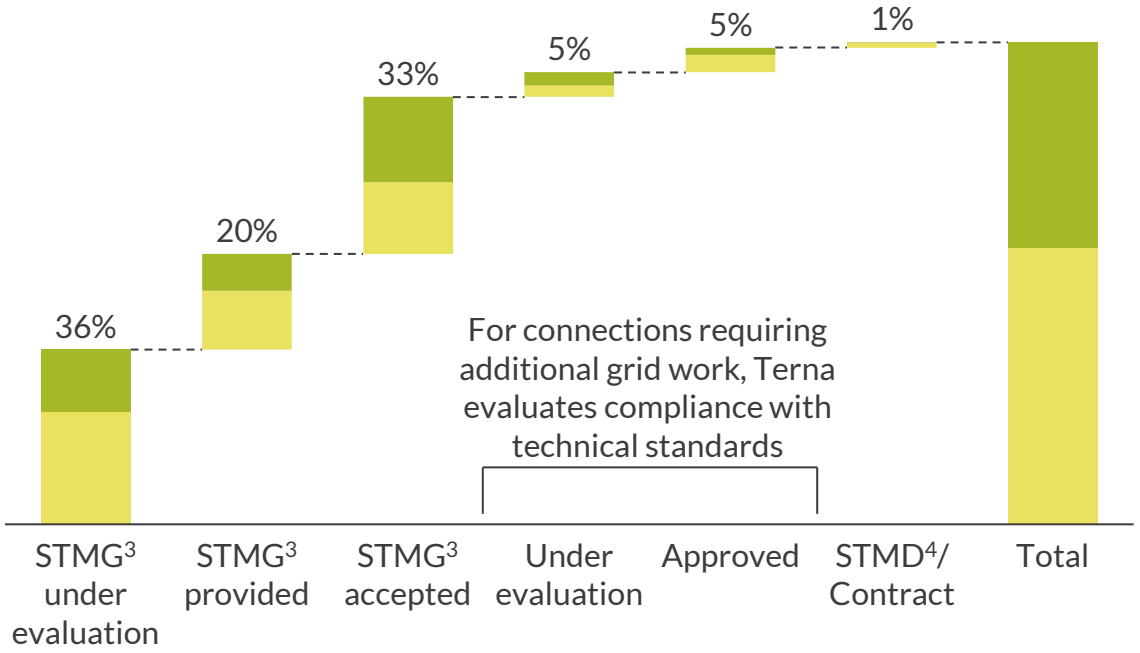
GW



- Out of a total of 74.3GW of grid connection requests received by Terna to June 2023, 27.1GW (36%) are in South, 12.8GW (17%) in Sicily and 11GW (15%) in Centre South.
- Zones C. North and Calabria are currently the least considered by battery developers, with only 3.2GW of requests in the two zones combined.

Grid connection requests by permitting stage[2]

GW



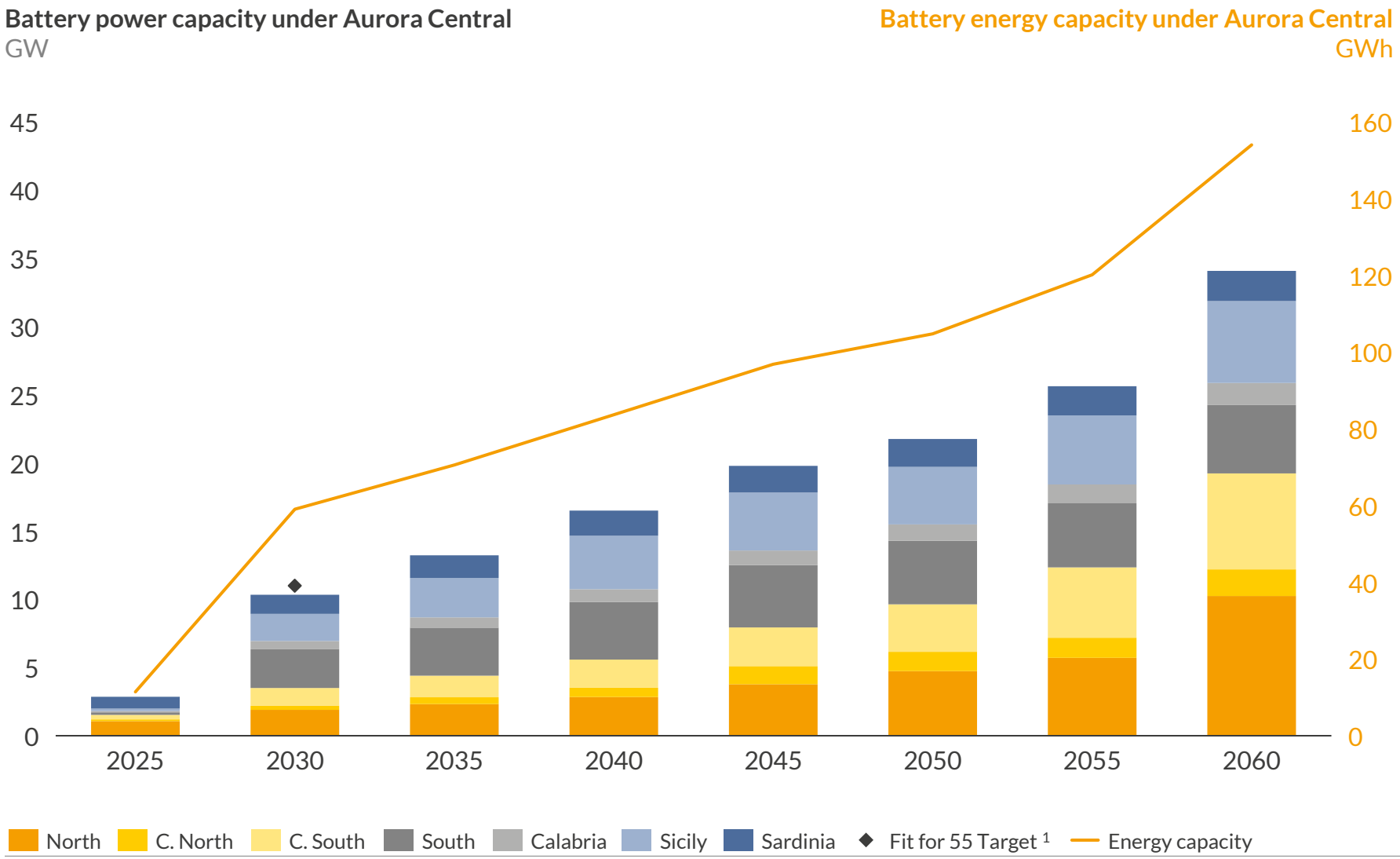
- Grid connection requests for stand-alone batteries amount to 57% of total grid connection requests.
- Most of the projects are at an early development stage, with only 1% of projects that already accepted/obtained the STMD[3].

Stand-alone Co-located

1)Received by Terna, until June 2023; 2) Received by Terna until December 2022; 3) "*Soluzione Tecnica Minima Generale*", the preliminary grid connection solution; 4) "*Soluzione Tecnica Minima di Dettaglio*", the final grid connection solution.

Sources: Aurora Energy Research, Terna

Battery capacity could reach around 10GW/60GWh by 2030, thanks to both merchant economics and auctions for contracted revenues



1) Utility scale target published by Terna and Snam to reach the Fit-For-55 decarbonization targets in Italy. Our battery timeline does not include behind-the-meter capacity.

Sources: Aurora Energy Research, Terna

AURORA

Outlook for battery capacity

- We expect battery capacity to develop mainly in the Southern zones and Islands in the medium term, where it can exploit higher RES penetration. Conversely, in 2060, 30% of total battery capacity is expected to be installed in zone North, as high power demand, retiring conventional capacity and increasing RES generation lead to increasingly favourable conditions.
- In 2030, Aurora outlook for battery capacity is slightly below the target[1] required by Terna to reach the Fit-For-55 decarbonization targets in Italy.
- The high average energy/power ratio is indicative of the better economics for longer duration batteries in Italy.

Batteries in the Italian market can access several business opportunities

Dispatch-based business model (revenue stacking)

Wholesale Market and Ancillary Services Market (MSD – *Mercato dei Servizi di Dispacciamento*)	▪ Arbitrage trading to exploit price volatility in the wholesale market and ancillary services market (MSD) ▪ In July 2023 participation in the MSD has been extended to new categories of resources on a voluntary basis, including battery storage systems. ▪ A structural reform of dispatch procurement will be applied after 2025 (TIDE), potentially opening up new market-based services.
Capacity Market (Ministerial Decree 28/06/2019)	▪ Capacity-based remuneration: 15-year contract for new capacity, 1-year contract for existing capacity. ▪ Obligation to participate in wholesale market and MSD.

Contracted revenues business model (MACSE auctions)

Auction scheme for storage (MACSE – *Meccanismo di Approvvigionamento di Capacità di Stoccaggio Elettrico)*	▪ Proposed auction scheme for the procurement of storage capacity. ▪ Capacity-based payments for the entire investment horizon in exchange for the obligation to make the capacity available to third-parties through a centralized "time-shifting products" platform, managed by the Energy Markets Manager (GME), and to Terna for use in the MSD market.

Sources: Aurora Energy Research, ARERA, Terna

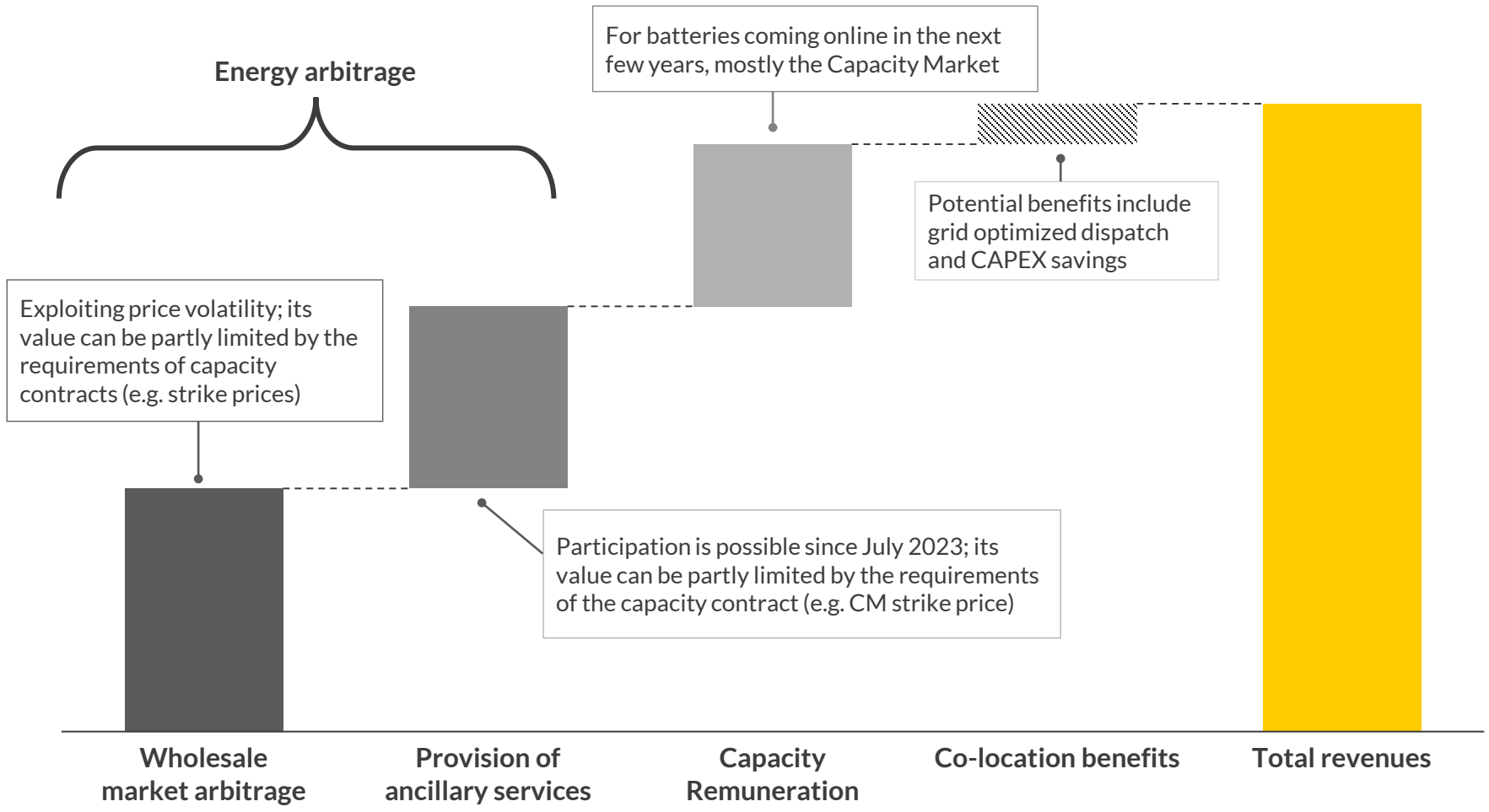
Agenda

AURORA

1. Introduction
2. Dispatch-based business model – revenue stacking
3. Contracted revenues business model – MACSE auctions

Batteries dispatch-based investment case depends on the revenue stacking opportunities in the different markets they can access

Revenue stacking opportunities for batteries
€/kW



1) New auctions for the Fast Reserve pilot project are not expected, so this capacity remuneration is accessible to the already awarded batteries for the delivery period 2023-2027.

Sources: Aurora Energy Research

AURORA

Potential for revenue stacking

- Batteries can participate to different extents in the energy markets.
- Several capacity mechanisms have been accessible to batteries in the Italian power market with different requirements and remuneration scheme.
- Co-location with RES plants unlocks further revenues and cost savings.

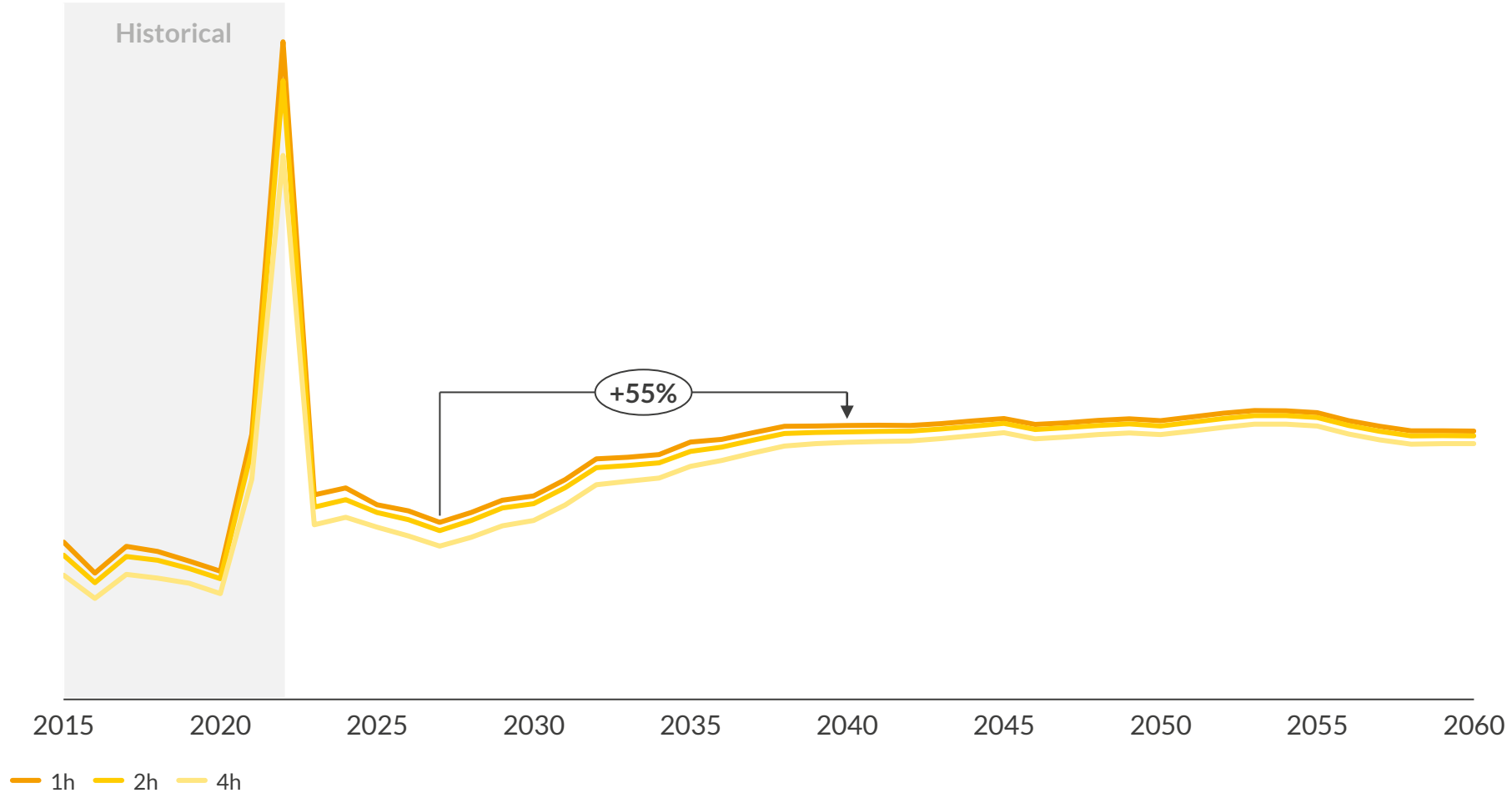
Do not miss out on the different revenue streams and markets for battery investment:

Get in touch with Foteini Kakavia, Commercial Associate

foteini.kakavia@auroraer.com

Growing long-term price volatility impacts daily price spreads, increasing the opportunities for arbitrage in the wholesale market

Average daily spreads[1] (PUN)
€/MWh (real 2022)



1) Defined as the average difference between the most expensive 1, 2, 4 hours and the cheapest 1, 2, 4 hours in a day.

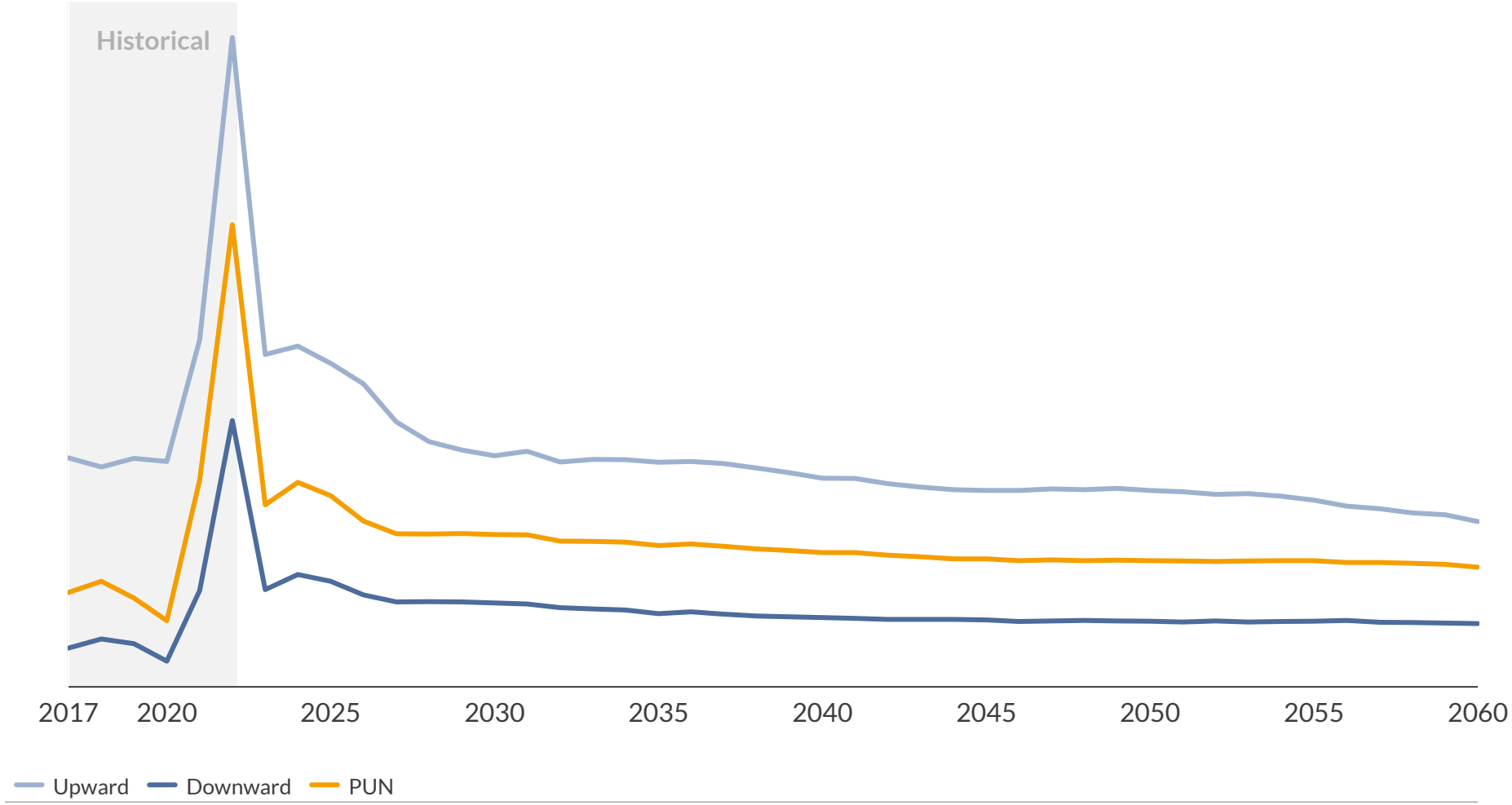
Sources: Aurora Energy Research, GME

Outlook for daily spreads

- After the normalization of power prices in the short term, average daily spreads increase until 2039: 1-hour, 2-hour and 4-hour daily spreads grow respectively 55%, 59% and 68% between 2027 and 2040.
- The increase of daily spreads leads to greater long-term opportunities for energy arbitrage in the wholesale market.
- After 2040, the average spreads stabilize due to the increased penetration of flexible technologies and demand (batteries, electrolysers, smart-charging EVs, etc.).

Batteries will lead to increased convergence of MSD prices to the day-ahead prices

MSD prices[1]
€/MWh (real 2022)



1) Volume-weighted average MSD prices.

Sources: Aurora Energy Research, GME

AURORA

Outlook for MSD prices

- In the short term, MSD prices continue to feel the effects of the spike in commodity prices, remaining above historical averages.
- In the medium term, even though volumes are expected to increase due to higher RES imbalance, the increasing participation of batteries leads to decreasing MSD upward prices.
- MSD downward prices decrease in the short term driven by the drop in baseload prices.
- By 2060, MSD premiums versus the PUN decrease to around 30 €/MWh for upward and around 40€/MWh for downward regulation.

The Capacity Market (CM) is an auction scheme set to procure capacity for system adequacy

AURORA

Market description

The CM is a mechanism used to procure capacity to ensure that total generation in the system is sufficient to meet security of supply standards, i.e. maximum 3 hours of Loss of Load Expectation (LOLE) per year at any given meteorological or demand conditions.

Therefore, demand curves for available capacity (CDP[1]) are drawn for each of the seven Italian market zones.

Prospective capacity providers from both Italian zones and Virtual Foreign areas can bid into the market to secure remuneration for keeping capacity available in the system.

Capacity Market contracts can be closed through three competitive auctions:

- Mother (T-4) auction, up to 4 years ahead of delivery
- Adjustment (T-3) auction, up to 3 years ahead of delivery
- Secondary market for the renegotiation of monthly positions, held a few days before delivery

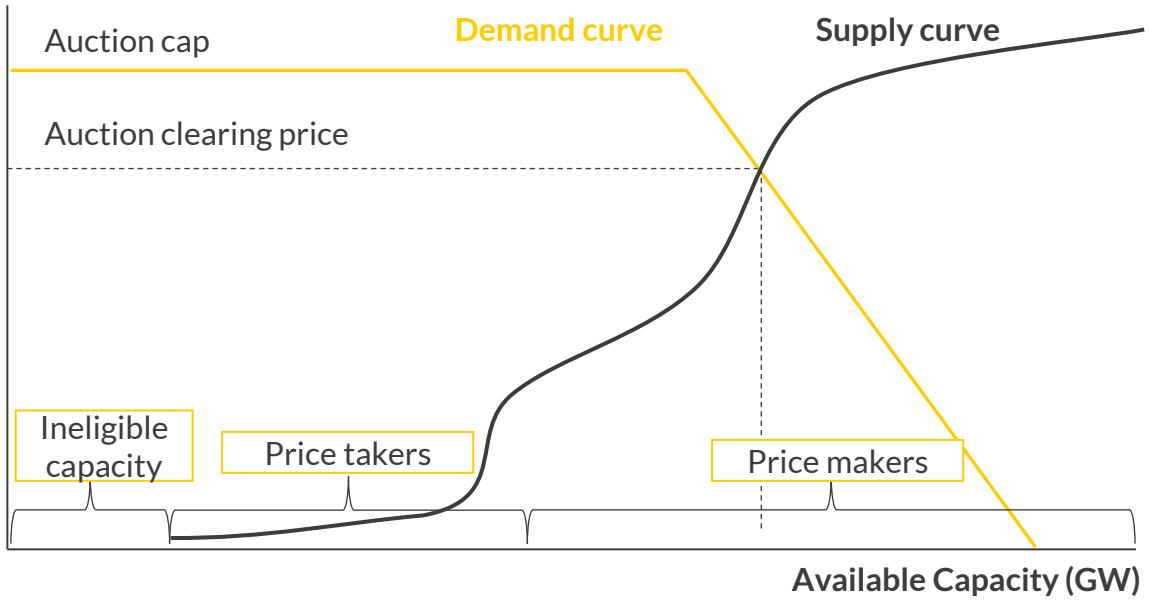
CM payments to capacity providers depend on the auction clearing price and technology-specific de-rating factors that reflect the availability of technologies and their potential contribution to security of supply.

CM contracts are awarded with durations of 1 and 15-years for existing and new-builds, respectively.

Every plant in the capacity market has a duty to participate in wholesale markets[2].

Supply and demand in the Capacity Market

€/MW



Auction caps for mother auctions were:

- 33 €/kW/year for existing plants
- 75 €/kW/year for new plants and delivery years 2022/23; 70 €/kW/year for new plants and delivery years 2024/25

An existing plant can request to be considered a new plant if a minimum investment threshold is reached, equal to 40% of the average CAPEX of an OCGT plant. For delivery years 2024/25, this is equal to 214 €/kW.

1) Capacitá disponibile in Probabilitá; 2) Day-ahead (MGP), intraday (MI) and ancillary services (MSD) markets.

Sources: Aurora Energy Research, Terna, Arera

Chronos delivers Aurora's state-of-the art battery investment case analysis with unmatched ease of use and speed

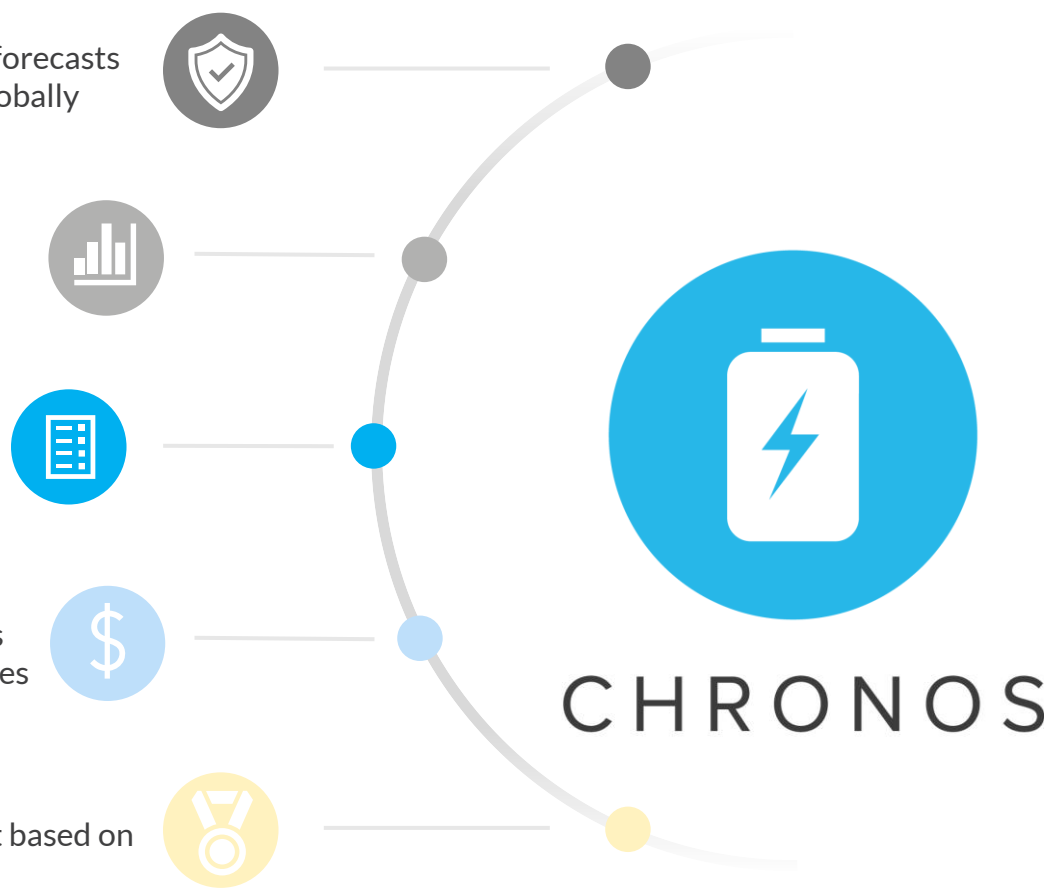
Aurora's trusted data
Underpinned by Aurora's bankable market forecasts used by and relied on by 350+ companies globally

Simple, intuitive, user-centric
User-friendly, and simple, requiring minimal training and no sophisticated in-house modelling capabilities

Exact same state-of-the-art model we use ourselves
Asset dispatch model integrated with our fundamental market forecast which structurally accounts for imperfect foresight

Cost-effective
Our simplicity and unique cloud-based SaaS architecture means large cost savings on set up, maintenance and licenses themselves

Always up-to-date
Easily update your portfolio's value forecast based on Aurora's latest market forecast



Chronos is the most advanced, feature-rich solution on the market

1 **Input your site settings**

Up-to-date locational benefits & charges: Chronos allows you to access a comprehensive database of the latest applicable network charges

Co-location support (upcoming): Chronos supports the co-location of solar & wind asset with your battery with different coupling schemes

Locational system balancing: Aurora's fundamental model allows Chronos to capture location-specific value from system redispatch actions

2 **Input your technology settings**

Customisable degradation: Capture battery degradation as it is defined exactly in your supplier's performance warranty

User-centric work flow: Chronos allows user to save, manage, and easily reuse different type of input data

Fundamental-driven forecast: Chronos is directly integrated with Aurora's long price forecast underpinned by market fundamentals

3 **Select your market scenario**

Realistic foresight: Chronos dispatch capture the imperfect foresight that battery operators have over future prices

Origin integration (upcoming): Value assets against your own market scenario by exporting scenarios created in Origin to Chronos

4 **Analyse results**

Bankable valuation on-demand: We can provide reliance on analysis run using Chronos

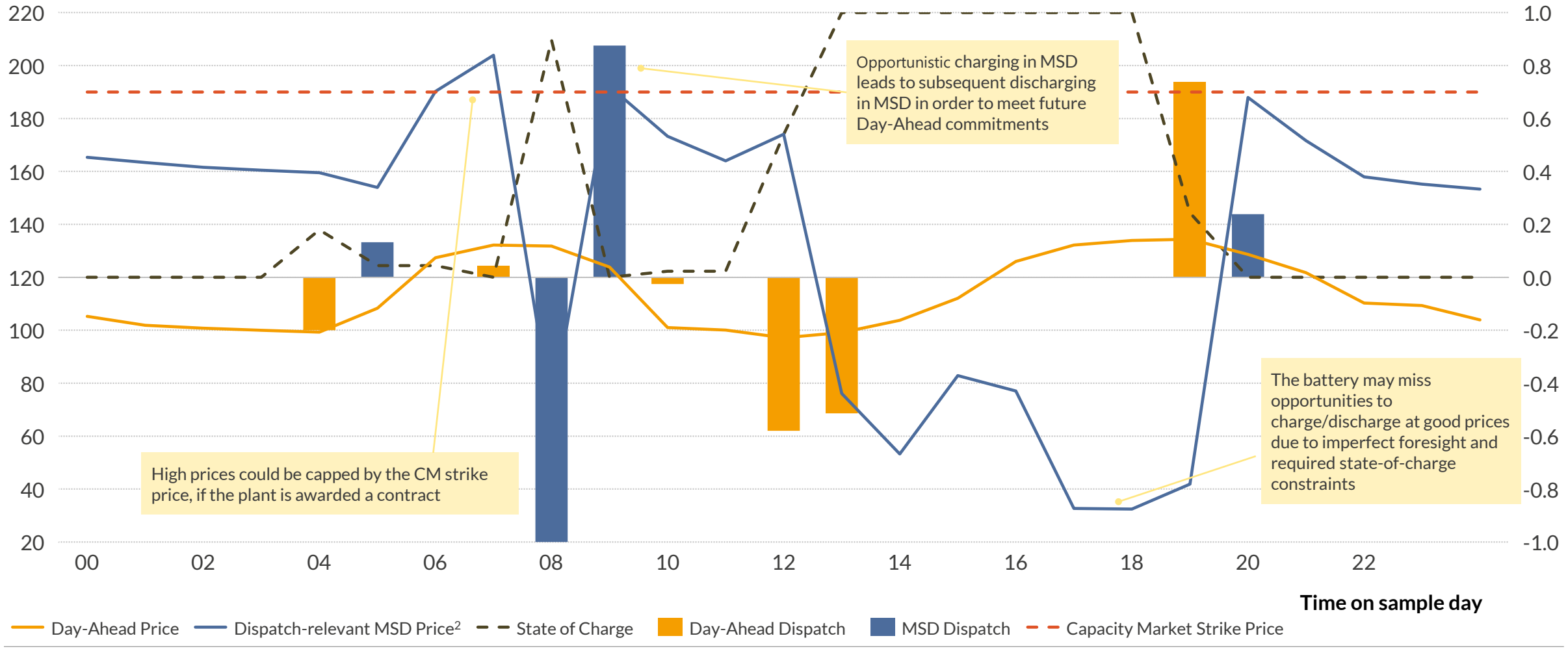
API: Integrate Chronos directly with your software or automated workflow for large scale computations

Example of modelled battery: asset is optimising to price movements, but could miss out on some prices due to imperfect foresight

AURORA

Day-Ahead and MSD prices
€/MWh, line chart

State of charge and battery dispatch[1] for a 1MW, 1h battery
MWh, bar chart



1) Discharging/export actions are shown as positive, while charging/import actions are shown as negative; 2) Defined as the MSD price in the prevailing (i.e. highest-volume) direction of the regulation in the relevant hour.

Source: Aurora Energy Research

Capacity Market contracts favour longer-duration batteries, while higher price volatility favours Southern regions

COD: 2027

Revenues

Capacity payment

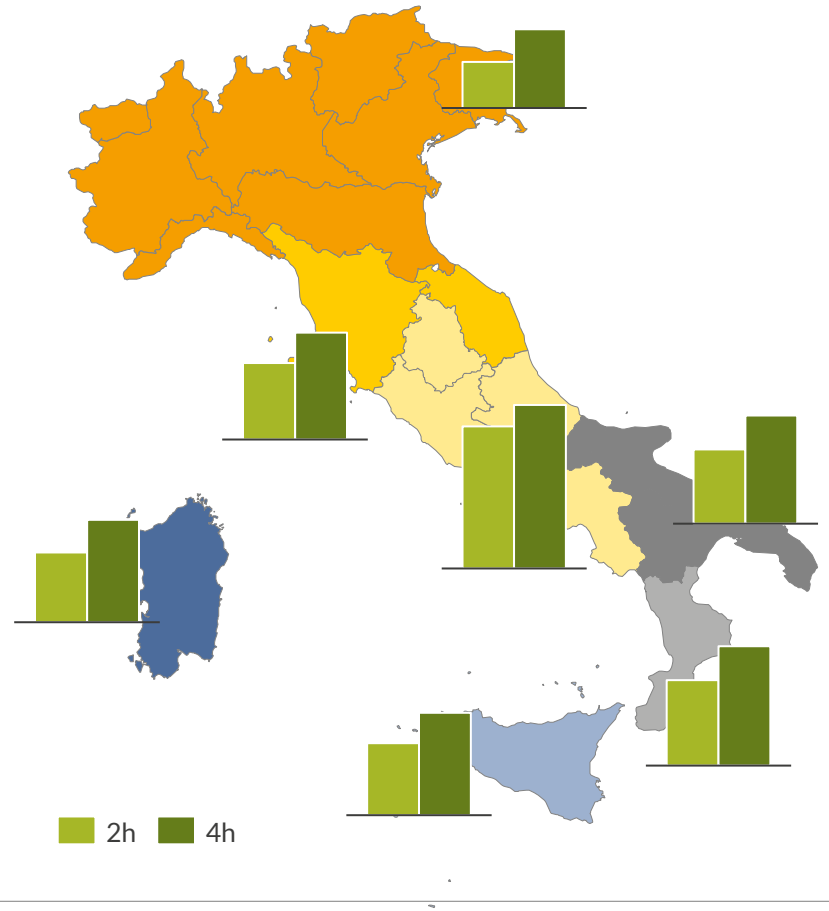
- Capacity Market contract for new capacity between 2027-2041, de-rating factor dependent on duration: 44% for 2-hour batteries; 67% for 4-hour batteries
- Yearly Capacity Market contract for existing capacity from 2042, de-rating factor dependent on duration

Energy arbitrage

- Energy arbitrage between day-ahead market and MSD
- Revenues capped at the CM strike price (calculated based on marginal costs of an OCGT)

IRR by zone and duration

%



Sources: Aurora Energy Research

AURORA

2027 Capacity Market scenarios

- The Capacity Market de-rating factors favour 4-hour batteries and, together with greater energy arbitrage opportunities, allow them to achieve higher returns than 2-hour assets.
- An increase in renewable generation and price volatility in the medium term leads to higher IRRs for batteries coming in Southern regions, compared to Northern zones that exhibit lower renewable penetration.
- Profitability in C. South is driven by favorable energy arbitrage opportunities in the MSD, particularly in the short term.

Agenda

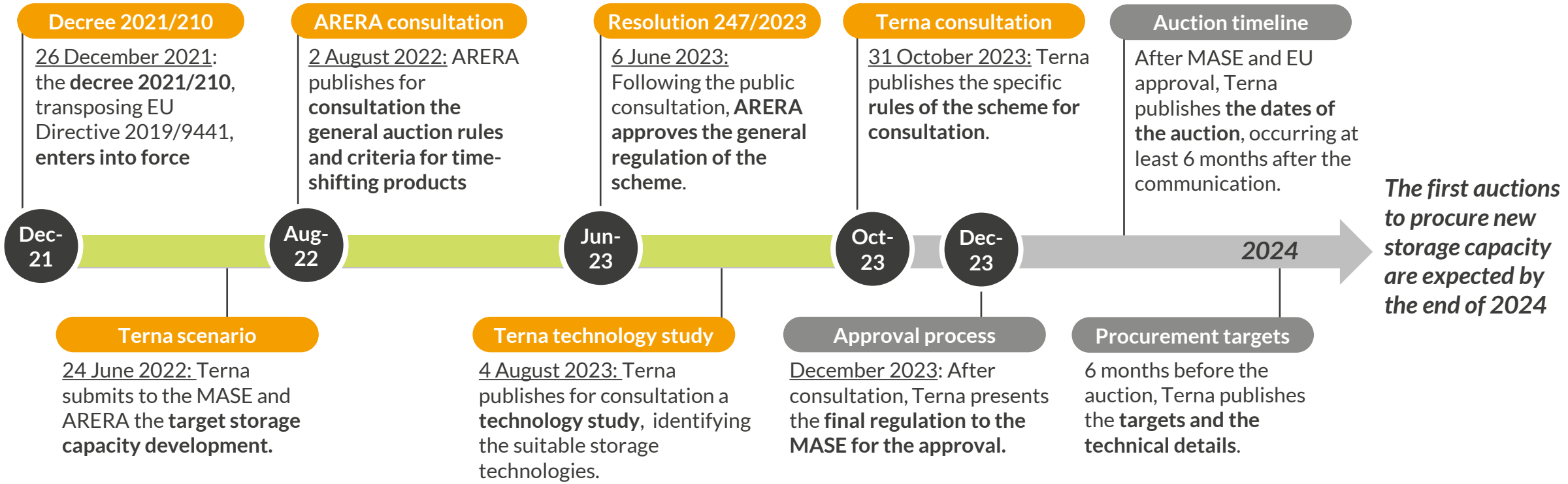
AURORA

1. Introduction
2. Dispatch-based business model – revenue stacking
3. Contracted revenues business model – MACSE auctions

The MACSE auction scheme for the procurement of storage will create a new support mechanism for battery investments in Italy

- The decree 2021/210 defined the next steps for storage development in Italy, including dedicated auctions, which will take place through the MACSE scheme.
- The MACSE scheme centers around **competitive auctions providing long-term payments**, in exchange for the obligations of making the asset capacity available to third-parties through a centralized "time-shifting products" platform, managed by the Energy Markets Manager (GME), and to Terna for use in the MSD market.

Steps in the development of MACSE



Sources: Aurora Energy Research, Terna

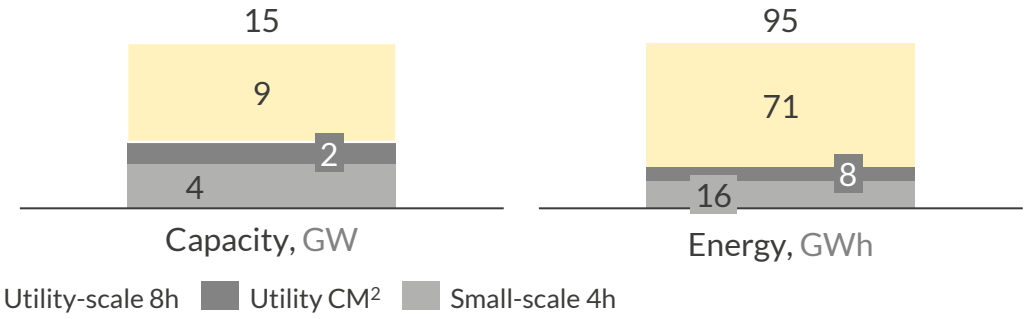
Terna estimates that procurement targets for the MACSE should be 9GW of storage capacity by 2030, with average duration of 8 hours

AURORA

Storage penetration

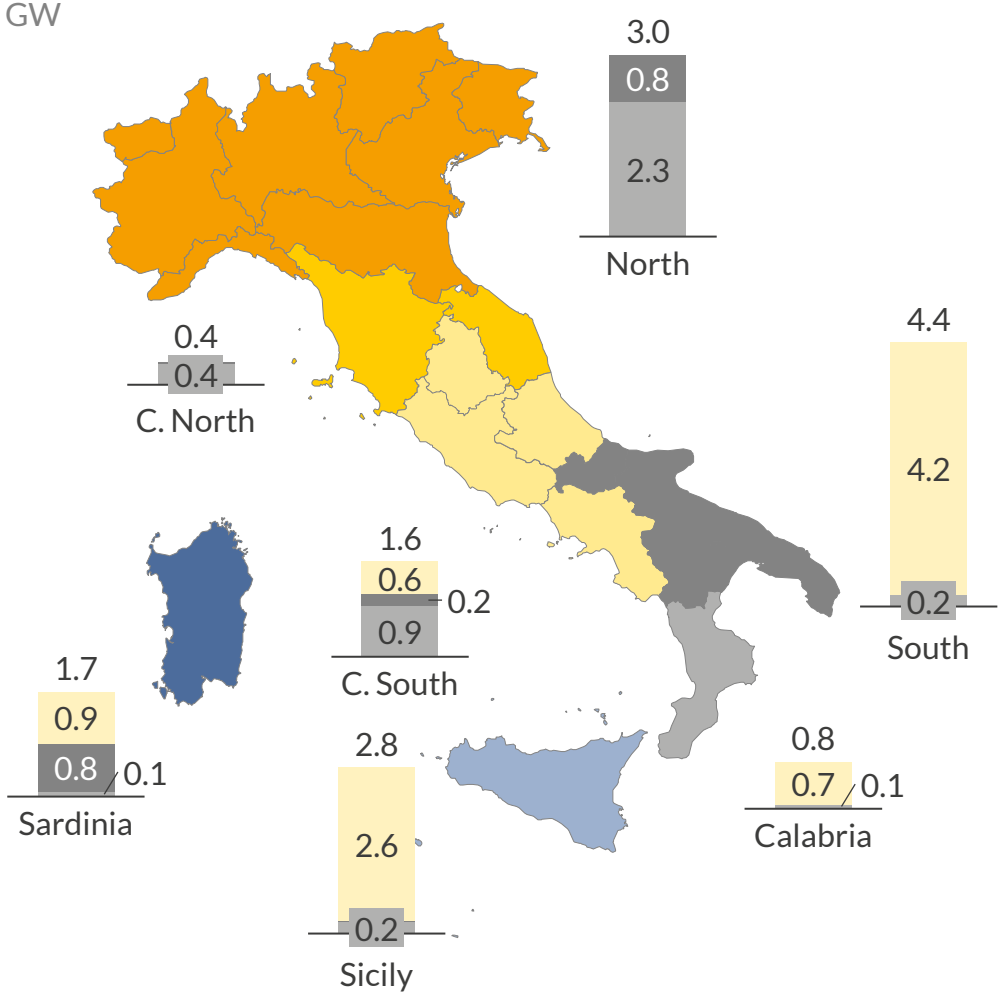
- Terna and Snam jointly developed a scenario where they map the development of the infrastructure, including storage capacity, required to reach the Fit-For-55 decarbonization targets in Italy.
- They identified the need for 15GW/95GWh of storage capacity, split into three categories:
  - Utility scale batteries that were awarded a Capacity Market contract
  - New small-scale behind-the-meter batteries with an average duration of 4 hours
  - New utility-scale storage with an average duration of 8 hours
- The indicated need for utility-scale assets with average duration of 8 hours, mostly concentrated in zones South and Sicily, will be the base for the definition of MACSE target capacity.

Storage requirements by 2030[1]



Storage capacity requirements by 2030[1]

GW



1) Capacities do not include existing pumped storage; 2) Batteries with Capacity Market contracts, mostly with duration of 4h.

Sources: Aurora Energy Research, Terna, Snam

In the draft technology study, Terna identifies lithium-ion batteries and pumped storage as reference technologies for MACSE scheme

AURORA

- With Resolution 247/2023, ARERA assigned Terna the task of preparing a **technology study aimed at identifying, the technologies best suited to fulfill the storage needs of the Italian power system**.
- Terna identifies **two reference technologies**, with proven technological and commercial maturity:
  - **Lithium-ion batteries**
  - **Pumped storage systems**
- For such technologies, in the draft technology study Terna analysed and determined the standard technical and economic parameters.
- The final study has been sent to ARERA and not yet published.

Standard technical parameters for reference technologies

- **Duration**: up to 8 hours
- **Lifetime**: 12 – 14 years for li-ion battery, > 50 for pumped storage
- **Number of cycles**: 4500 – 5000 for li-ion battery, > 50000 for pumped storage
- **Optimal SoC[1] range**: 15% – 100% for li-ion battery, 0% – 100% for pumped storage
- **Degradation**: 1% – 3% yearly for li-ion battery, negligible for pumped storage
- **Construction period**: 1 – 3 years for li-ion battery, 5 – 7 years for pumped storage

Standard economic parameters for reference technologies

	8-hour lithium-ion batteries		Pumped storage systems	
CAPEX *k€/MWh*	207 – 228		213 – 363	
Power-related CAPEX *k€/MW*	133 – 147		1300 – 1700	
Energy-related CAPEX *k€/MWh*	190 – 210		50 – 150	
OPEX *k€/MWh/year*	2.1 – 2.8		1.4 – 4.5	
WACC *%*	6		8	
Minimum SoC *%*	17		–	
Lifetime *year*	12	14	30	50
CONE[2] *k€/MWh/year*	31 – 35	29 – 32	20 – 37	19 – 34

The findings of the technology study will be used to determine the obligations under MACSE standard contracts

1) State of Charge; 2) Cost of New Entry, depending on assumed CAPEX, OPEX, lifetime, WACC and usable energy, so the minimum state of charge of the technology.

Sources: Aurora Energy Research, Terna, Snam

Awarded capacity receives fixed payments aiming to cover all capital and operational costs, including the remuneration of invested capital

In October 2023, Terna published the specific rules of the scheme for consultation.

1 Requirements for participation

Only **authorized new-build capacity** (also repowering capacity in case of pumped storage) can participate if:

- round-trip efficiency (RTE) is above the the minimum value identified for the relevant reference technology
- capacity is not contracted under Capacity Market or Fast Reserve schemes

Asset that do not belong to the reference technologies can participate if RTE is above the minimum value identified for 8-hour li-ion batteries.

Requests for participation must be submitted 120 days before the auction.

2 Auction mechanism

The first procedure will consist of **two auctions**: **one for li-ion batteries** (and other technologies[1] that satisfy the minimum required RTE) and **one for pumped storage**.

3 Supply curve

To produce the final supply curve Terna will apply coefficients to each participant's bid to account for:

- **different performance in terms of capacity** ("**extra-performance coefficients**"), to ensure comparability bids across different durations[2]
- **different geographical location**, to consider different value of storage location

4 Remuneration

Pay-as-bid mechanism. Participants receive their bid without the supply curve coefficients adjustment. The awarded capacity receives **monthly fixed payments** (1/12 of the yearly premium in €/MWh/year) for the entire contract period. The **payment is updated monthly based on a percentage of inflation**.[3]

1) Up to 10% of auction volumes for li-ion batteries can be assigned to these technologies; 2) The product of participant's bid price and coefficient must be lower than the auction's maximum premium; 3) The consultation indicates this percentage as "Opex quota" and it sets it at 10%.

Sources: Aurora Energy Research, ARERA

In return for the payment, storage capacity is made available to third parties for wholesale market and to Terna for use in the MSD market

Auction winners will have an availability obligation: for the entire contract period, the same level of maximum and minimum capacity as declared in the qualification phase must be guaranteed[1]. Maximum available energy and round-trip efficiency can decrease over time based on the reference degradation.[1]

Auction winners will have an **obligation** to provide:

Time-shifting products

- Terna will make the contracted storage capacity available to third parties by *pooling* it into time-shifting products, based on reference technology type, duration and efficiency and aggregating them at a zonal level so they are not linked to individual storage plants.
- Time-shifting products will have different validity periods: multi-year (3 years), yearly, monthly and daily.
- Time-shifting products can be purchased on a platform, hosted and maintained by the GME, and buyers will be able to profit from wholesale market arbitrage within the contract period.
- Products can be sold on to a new player on a secondary market.
- Buyers will have the right to close bilateral contracts, as well as trading on the wholesale markets.

Ancillary services

- Participation in the MSD market is managed by the storage asset owners, as it requires live knowledge of plant availability and status, and thus this will not be made available to third parties.
- Each month Terna calculated the asset's MSD margins, as the difference between MSD upward and downward payment to and from the asset.
- 95% of monthly MSD margins must be paid back to Terna. In the unlikely event that MSD margins were negative, the cost is left with the asset owner, which recovers it through positive MSD margins in the following months.
- Bids placed on the MSD market will be capped at daily values:
  - Maximum Upward bid: max (hourly MGP zonal price) · 120% / RTE[2]
  - Minimum Downward bid: min (hourly MGP zonal price) · 80%

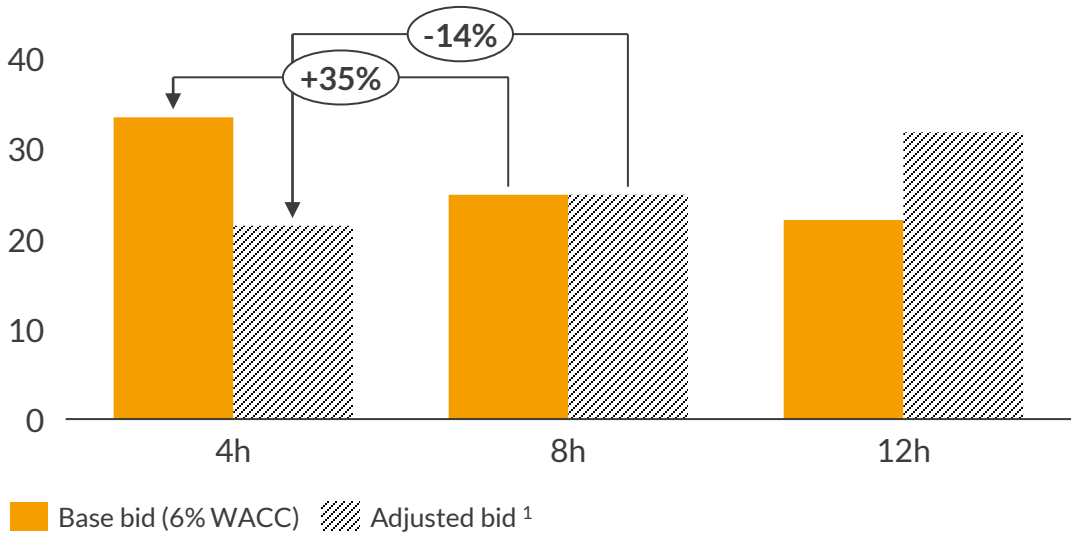
1) Unavailability is not penalised if within the standard availability defined in the Technical Report. Unavailability must be communicated to Terna 5 days prior to the daily time-shifting product auction. Penalties are foreseen for unavailability over the standard one or if this is not communicated within the 5 days; 2) The standard de-rating coefficient will be published in the Technical Report 6 months before the auction; 3) Round-trip efficiency defined in the Technical Report for the reference technology.

Sources: Aurora Energy Research, ARERA

The level set for the *extra-performance coefficients* risks overcorrecting the expected economies of scale and favor specific battery durations

AURORA

Adjusted bids with Terna's exemplary coefficients – COD 2026
€/kWh (real 2022)[2]



Extra-performance coefficients to uniformize adjusted bids

Battery import duration	*Battery export duration*	*Terna's Extra-performance coefficient*	*Indifference coefficient*
4h	**4h**	0.64	0.74
8h	**8h**	1	1
12h	**12h**	1.44	1.13

- A 4-hour battery entering the scheme in 2026 would require premiums that are, on average, 35% higher than those of an 8-hour battery, due to higher CAPEX per unit of generation.
- In order to make the assets compete on an equal scale in the auctions given the expected economies of scale, Terna multiplies submitted bid prices by a duration-specific coefficient ("extra-performance coefficient").
- Applying an extra-performance coefficient of 0.64 to the bid of a 4-hour battery would allow it to outbid the reference duration of 8 hours
- Given the assumed costs and economies of scale, we calculated the extra-performance coefficients that would equate all battery duration annual premiums ("indifference coefficients").
- The indifference coefficients range from 0.74 for 4-hour batteries to 1.13 for 12-hour batteries.
- In case the economies of scale between battery durations are less strong, the coefficients should be further closer to 1 to avoid distorting the auction outcomes and favor specific durations.

1) The adjusted bid is used only to determine the merit-order in the supply curve, and it is calculated as the product of the submitted bid and Terna's extra-performance coefficients.

Sources: Aurora Energy Research

Access detailed power market analysis and investment case data for batteries with our Italian Flexible Energy Add-On

AURORA

Flexible Energy Add-On

Forecast Reports & Data

Technology and market development reports

- Overview of regulatory framework for batteries
- Revenue stacking models for batteries
- Projections for battery CAPEX and OPEX by delivery year
- Reports and datasets follow the same format with content tailored to specific markets

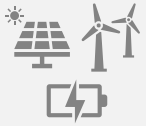
Forecast Data

- Central case forecast prices provided at hourly granularity until 2050
  - Wholesale market arbitrage
  - Capacity remuneration scheme
  - Ancillary Services Market (MSD)

Investment Cases

Standalone battery

- Multiple investment cases per country or zone including:
  - Arbitrage of wholesale market and balancing market
  - Focused participation in frequency control market (if applicable)
- Annual project margins to 2050. IRR and NPV for multiple entry years



Co-location

- Analyses of co-location benefits

Get in touch to find out more:

Foteini Kakavia, Commercial Associate
foteini.kakavia@auroraer.com

Deborah Scaggion, Senior Commercial Associate
deborah.scaggion@auroraer.com

Join key players from across the Italian power sector at our subscriber-exclusive Group Meetings

AURORA

Source: Aurora Energy Research


AURORA
ENERGY RESEARCH