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ENERGY RESEARCH

# Aurora Introduction to the Flexible Energy Market Service

To learn more about the service, contact Alan Jabbour (alan.jabbour@auroraer.com).

# Access detailed power market analysis and investment case data for batteries with our French Flexible Energy Market Service

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## Flexible Energy Market Service

### 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 until 2050:

- Hourly wholesale power prices
- Yearly capacity market prices
- 4-hourly FCR market prices
- Hourly aFRR (energy and capacity, upward and downward) prices (from March 2023)

+

### Investment Cases

#### Standalone battery

- Multiple investment cases per country or zone including:
  - Arbitrage of wholesale market and FRC and aFRR market
- Annual project margins to 2050; IRR and NPV for two entry years

### Workshops and Assistance

- 1h Workshop with our Market Experts
- Ongoing analyst support

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# Agenda



This report also includes:
- A granular databook with our input assumptions as well as our Central hourly wholesale and 4-hour blocks FCR prices
- An investment case databook with our input assumptions and standalone battery investment cases: considering entry in 2024 or 2025, 1-hour, 2-hour or 4-hour battery duration and either exclusive or simultaneous participation in day-ahead and FCR, aFRR markets

# Deployment of grid-scale battery storage in France is dominated by 1-hour batteries, reaching 430 MW total installed capacity

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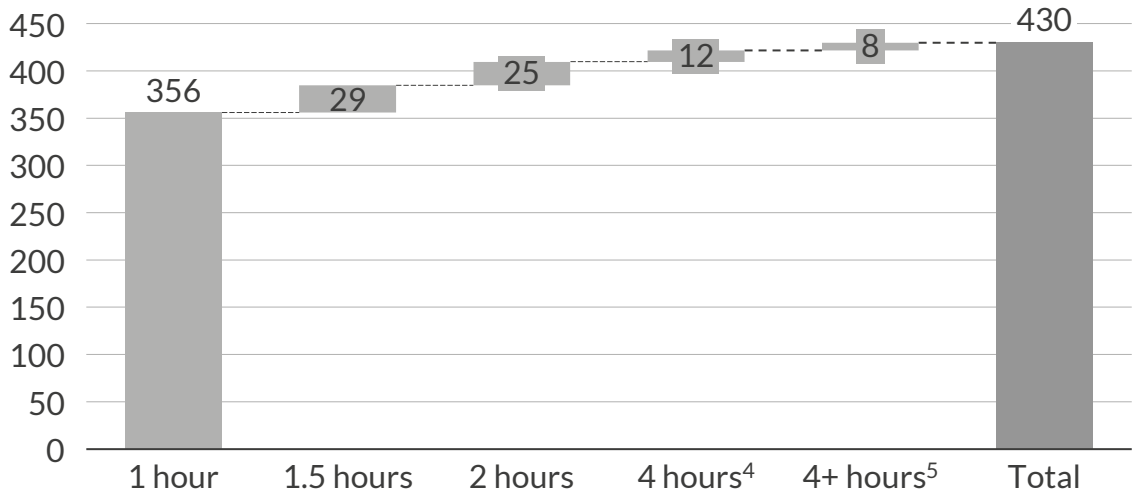
## Market context for batteries in France

- Grid-scale battery development started in 2020 in France, reaching 430 MW deployed in December 2022[1]
- 253 MW were awarded a contract in the 7-year capacity market auctions ("AOLT"[2]) for the 2021-2027 and 2022-2028 periods for 29 k€/MW/y and 28 k€/MW/y respectively
- RTE forecasts grid-scale battery deployment to reach 800 MW by the end of 2023[3]

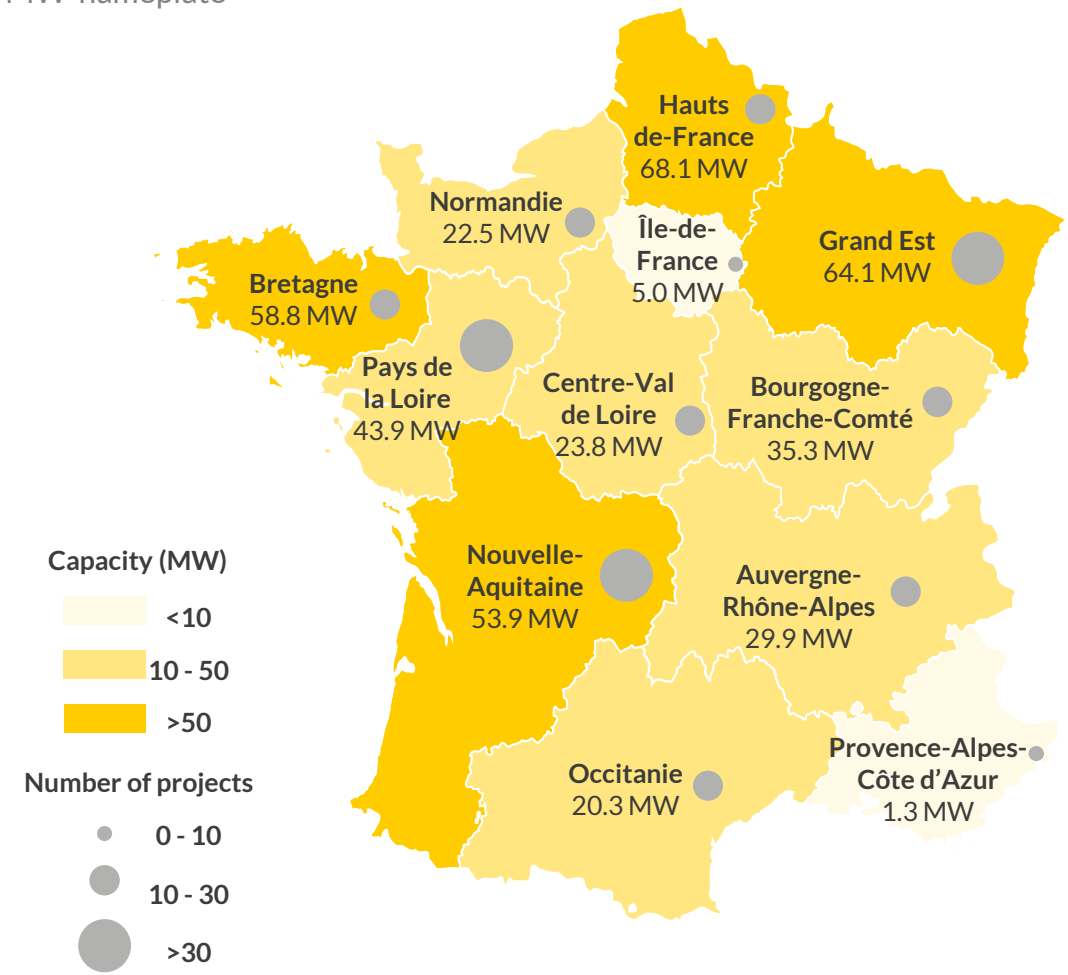
## Operational grid-scale battery capacity in France[1]

MW-nameplate




## Operational grid-scale battery capacity by region

MW-nameplate




1) Data published on 18/10/2022 on the Open Data Réseaux Energies "Registre national des installations de production et de stockage d'électricité website; 2) "Appel d'Offres Long-Terme"; 3) RTE "Atelier Stockage Electricité" (05/06/2022); 4) Ringo project in Fontenelle, Hauts-de-France; 5) Renault battery in Cuincy, Hauts-de-France.

Sources: Aurora Energy Research, RTE

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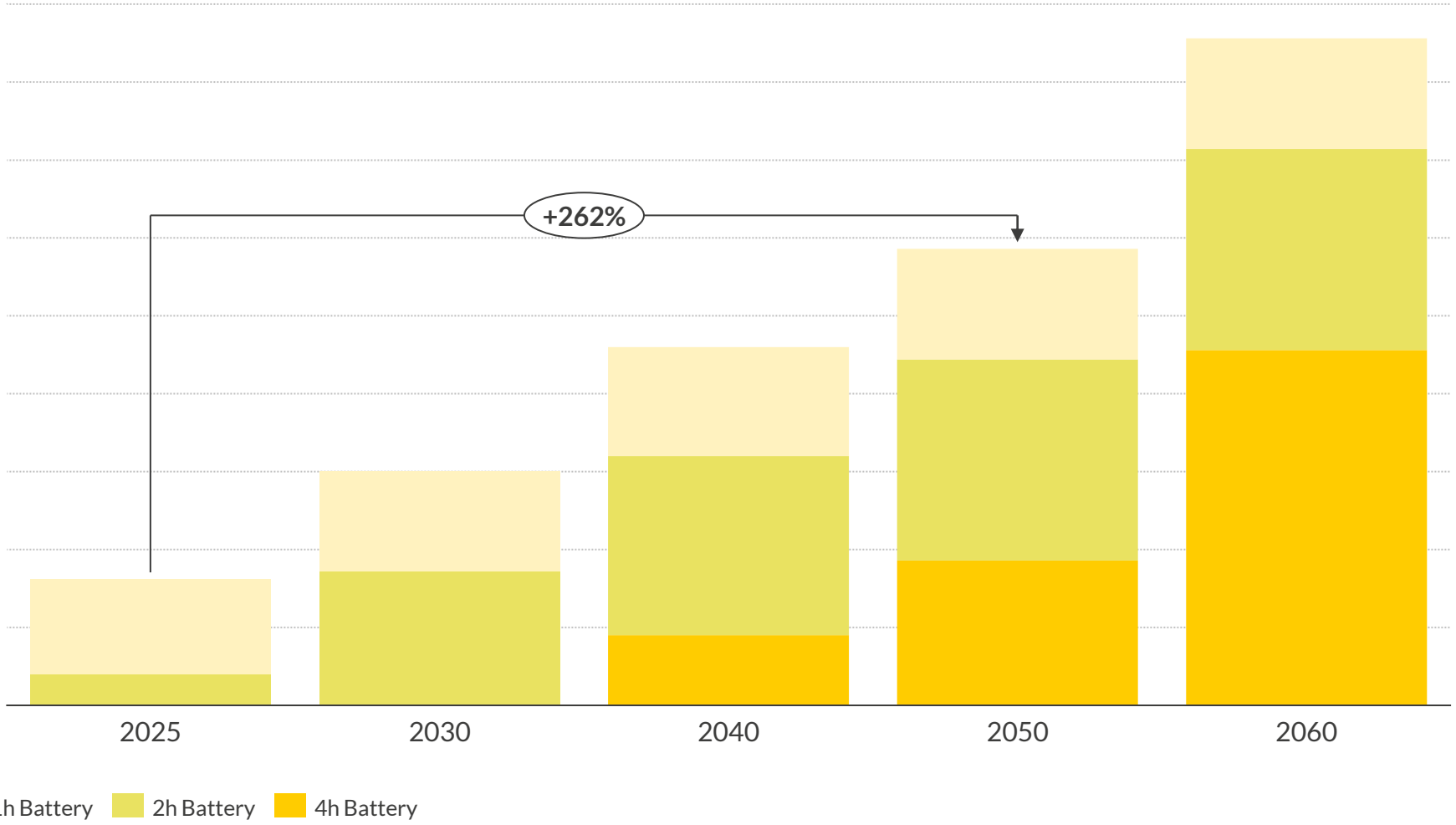
# In Aurora's Central scenario, battery capacity in France increases by 262% between 2025 and 2050

**Battery capacity in Aurora Central[1]**
GW




- We expect the majority of batteries entering the market at the beginning of the forecast to be 1 and 2-hour batteries, with business models relying mostly on ancillary services: FCR market and aFRR market once it is opened[2]
- 4-hour batteries will develop from 2031 participating in ancillary services and energy arbitrage while CAPEX of those systems decline

1) Aurora January 2023 Central Scenario; 2) According to the deliberation published on the 30th of June 2022, the Energy Regulation Commission (CRE) has granted RTE a derogation of up to 3 years for contractualisation of aFRR through the PICASSO platform.

Sources: Aurora Energy Research, CRE

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# Diverse revenues streams will be available for batteries, with ancillary services, wholesale and capacity markets as main sources

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**Response time** → **Delivery**

**Years** | **Hours** | **Minutes** | **Seconds**

## Capacity Market

- Ensures national security of supply by procuring a sufficient level of firm capacity to meet peak electricity demand
- Payments are made on a capacity basis in €/kW/year and are de-rated based on contribution to security of supply

### 1-yr CM market

- Aims to incentivise lower demand in peak periods and capacity investments

### 7-yr CM market

- Built-up against the 1y CM market to provide greater revenue certainty

## Wholesale Market

- The day-ahead market provides a platform to buy and sell power to meet demand every hour
- The intraday market procures continuous trading during the day
- Batteries can take advantage of arbitrage opportunities on both the day-ahead and the intraday markets

## Ancillary services[1]

### Frequency Containment Reserve ("Réserve Primaire")

- Maintains operational grid requirements and provides primary balancing through sub-second to minutes-long response
- Contracted at the European level the day before the service can be procured

### automatic Frequency Restoration Reserve ("Réserve Secondaire")

- Ensures balance is maintained in the power system in each half-hour trading period
- Participation is not yet allowed for batteries[2]

### Balancing markets ("mécanisme d'ajustement", mFRR and RR)

- The battery business cases for this application are very narrow: capacity revenues (RR-RC tender) for batteries are limited and energy activation rates are low

Available to batteries | Not yet available for batteries | Not available anymore | Revenue potential for batteries

1) Tertiary Reserves (mFRR and RR) are not relevant for batteries due to the required duration of these products: 120 minutes for the manual Frequency Restoration Reserve (mFRR) and 90 minutes for the Replacement Reserve (RR); 2) aFRR is not procured through a market yet in France and will be from July 2024.

Sources: Aurora Energy Research

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# 2-hour batteries achieve the highest IRRs when participating in a hybrid trading model, participating in wholesale market, FCR and aFRR

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**Battery Internal Rate of Return[1] (pre-tax real and unlevered), %**

| Entry Year | Scenario | Duration | IRR |
|---|---|---|---|
| 2024 | A<br>WM + FCR + CM[2] | 1 hour | |
| | | 2 hour | |
| 2025 | | 1 hour | |
| | | 2 hour | |
| 2025 | B<br>WM + FCR + aFRR + CM | 1 hour | |
| | | 2 hour | |
| | | 4 hour | |

- In the scenario A, 1-hour batteries are significantly more profitable than 2-hour batteries as the additional energy of a 2-hour battery only permit to have more arbitrage opportunities on the day-ahead market but do not increase FCR opportunities
- When batteries can participate in aFRR capacity and energy (scenario B), we observe much higher revenues and so IRRs
- Larger batteries benefit from greater revenues from aFRR capacity reservation and more energy arbitrage (although import costs due to TURPE reduce it)
- Lower duration batteries achieve higher IRRs as the increase in CAPEX is not compensated by the upside in gross margins

1) Representative 15-year battery project IRR with an availability of 99%, a round-trip efficiency of 87.5% and a degradation per cycle of 0.0048%; 2) Wholesale market + FCR market + Capacity market.

Sources: Aurora Energy Research

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# Batteries that can participate simultaneously on day-ahead, FCR and aFRR markets achieve higher gross margins

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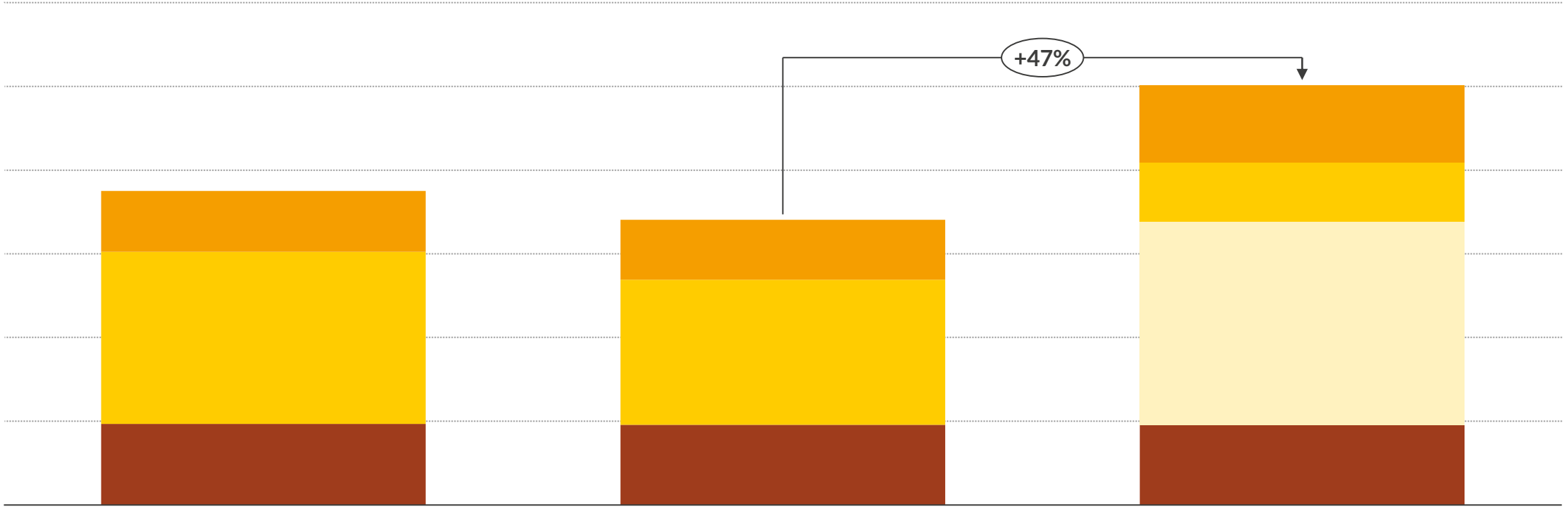
Scenario: WM + FCR + CM | WM + FCR + aFRR + CM

Entry year: 2024 | 2025

**Average total gross margins (including degradation) for a 2-hour battery**
€/kW/year (real 2021)




Energy Arbitrage[2] | FCR market | aFRR Capacity market | Capacity market

1) Represents a 15 year IRR for the battery. Does not assume repowering; 2) Refers to Wholesale market and aFRR energy trades.

Source: Aurora Energy Research

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