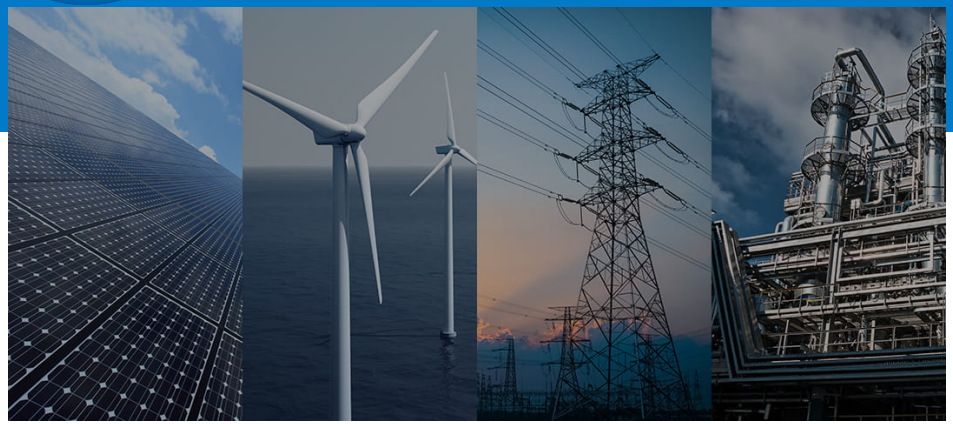
CLEANHORIZON

The Energy Storage Experts



Energy Storage Digital Series

Energy Storage Leaderboard: Top Countries, Top Players

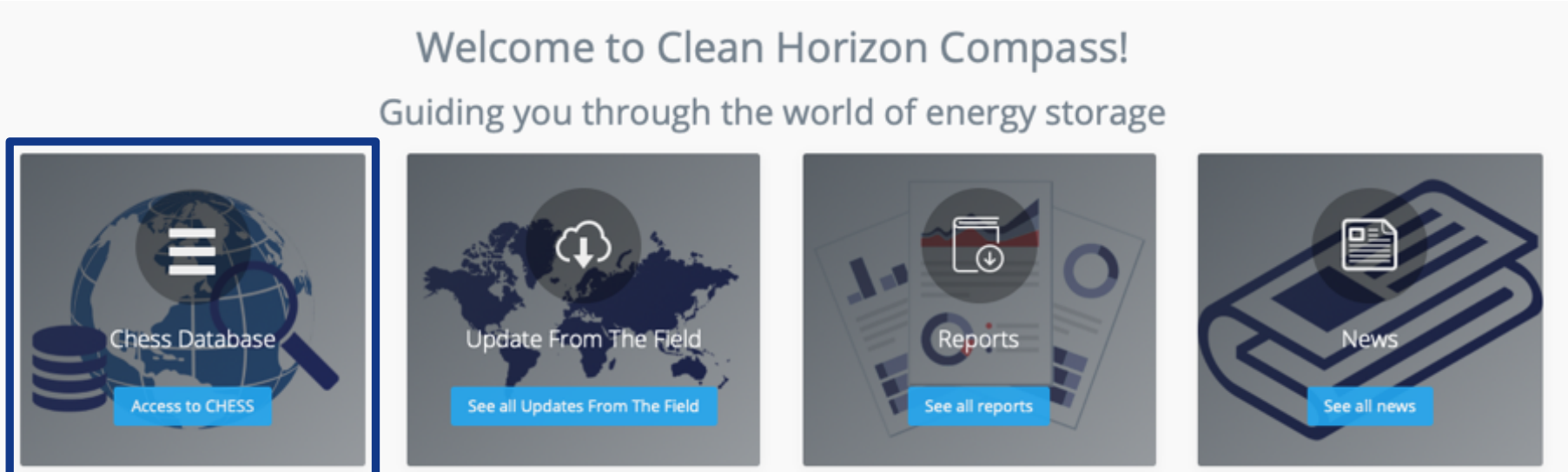
May 12th 2020

Energy Storage Digital Series

Energy Storage Leaderboard: Top Countries, Top Players

First, where does our data come from
(and why the numbers in our leaderboard vastly differ with what vendors say…)

We use our CHESS database



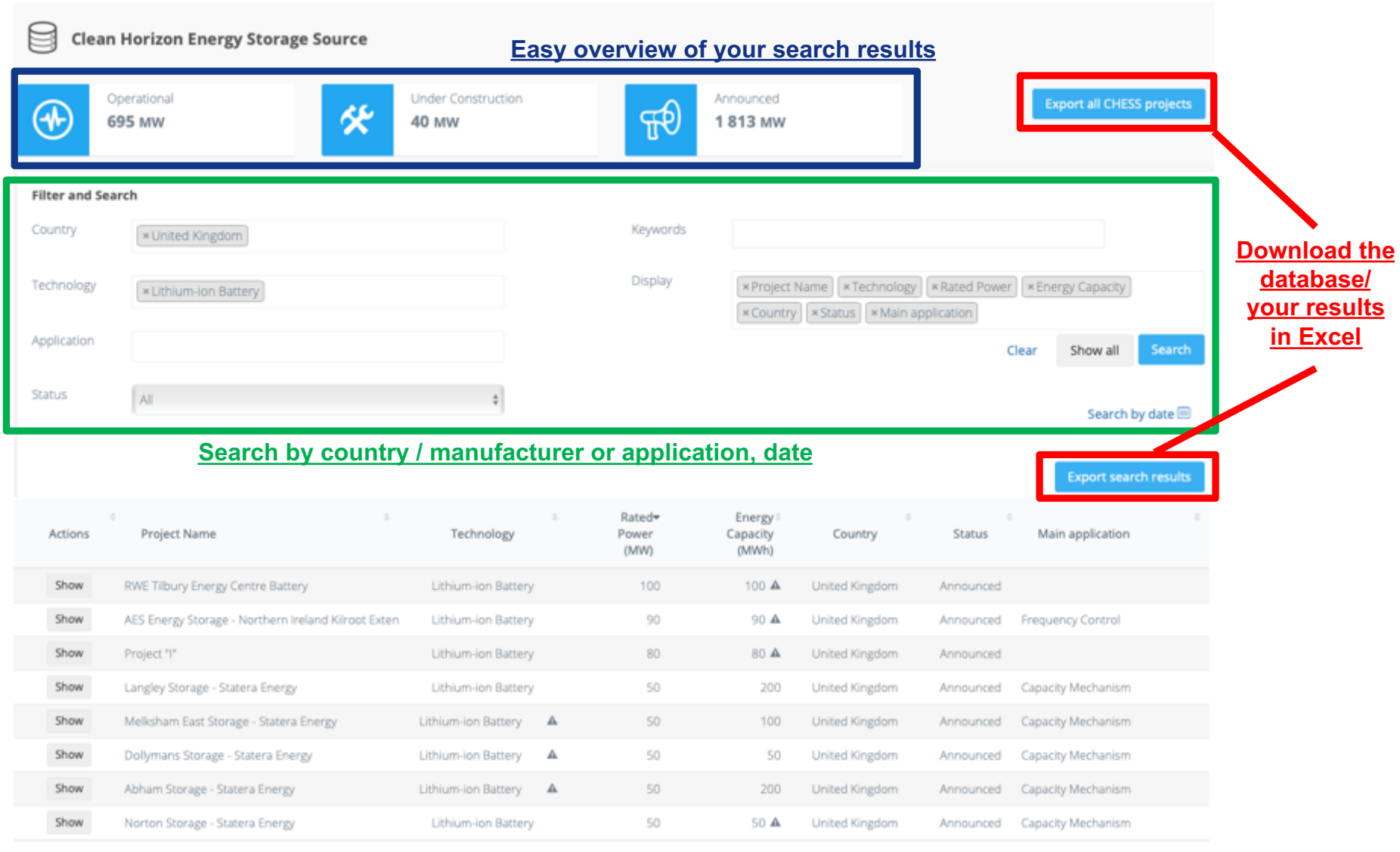
1. Clean Horizon Energy Storage Source (CHESS)
A worldwide database of all storage projects larger than 500kW can be tracked with this tool

2. Update From The Field (UFTF)
- Our monthly analysis note on the energy storage market
- **Latest calls for tenders** (and history of tenders flagged by Clean Horizon)

3. Other reports
All our on-the-shelf report are available here

4. News
All our TOP 5 weekly news can be tracked here

We use our CHESS database



And CHESS as one characteristic: we use cross-checkable data

CHESS indeed relies on 1200+ MW-level global projects where:

- A precise **site** is known (ie a project in a “confidential Asian country”, or “ a 2 GWh pipeline” are **not** included)
- The data is sourced/public, meaning:
  - It is findable online, or
  - It has been disclosed publicly at a conference, or
  - It has been communicated to, and verified by, Clean Horizon in a **non-confidential manner**

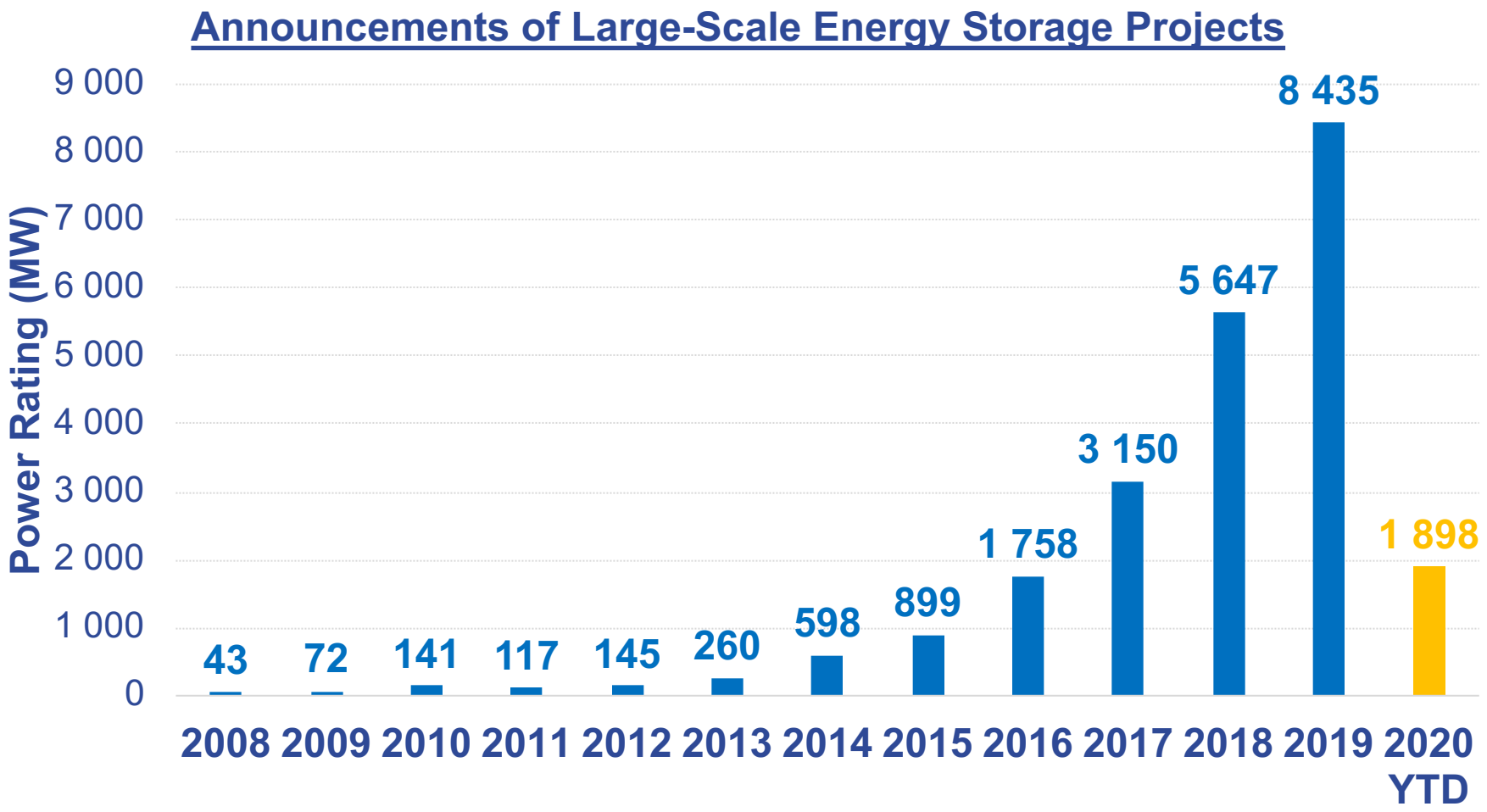
Agenda

1. Global market size

2. Energy storage leaderboard: top players

3. Energy storage leaderboard: top countries

Global Large-Scale Energy Storage Project Announcements
(~120 GW of pumped-hydro excluded)

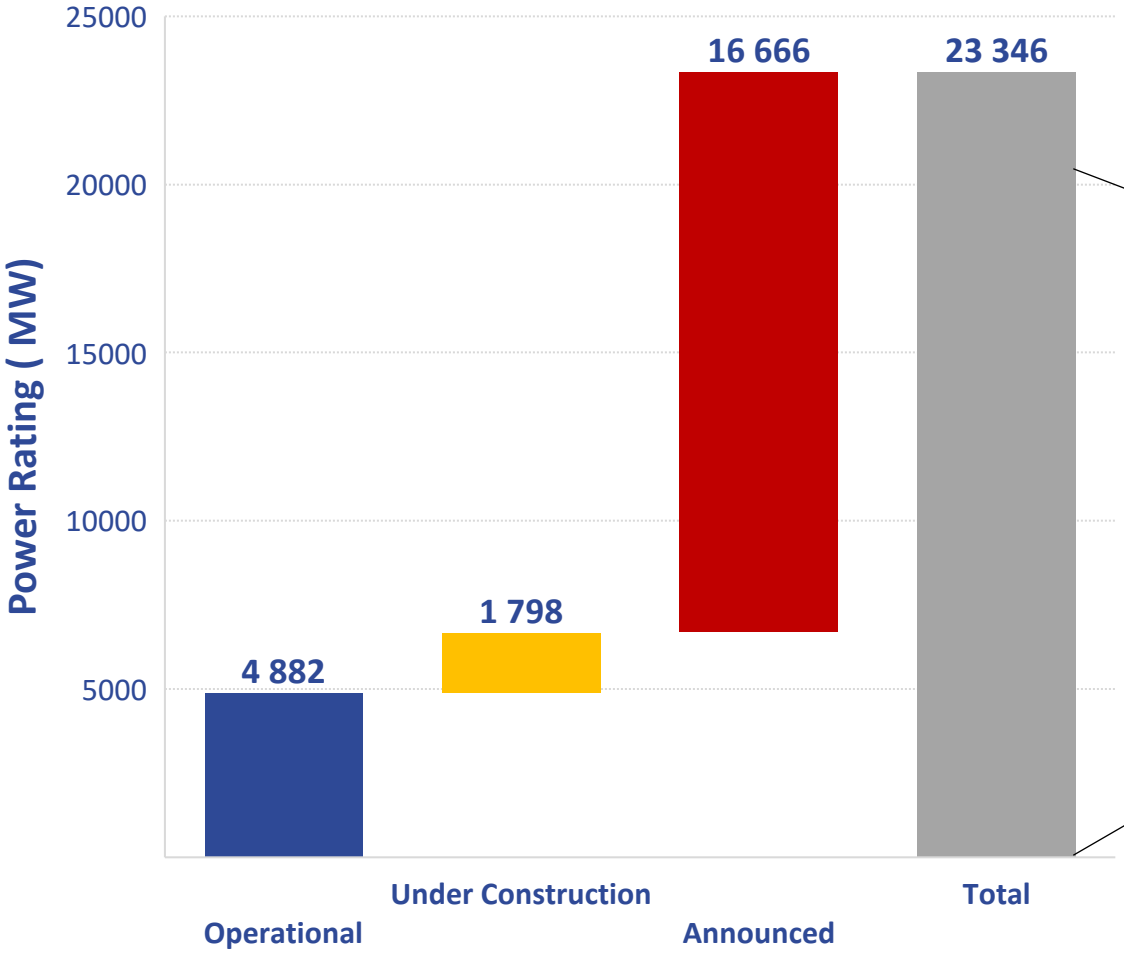


Finally, energy storage is growing exponentially!

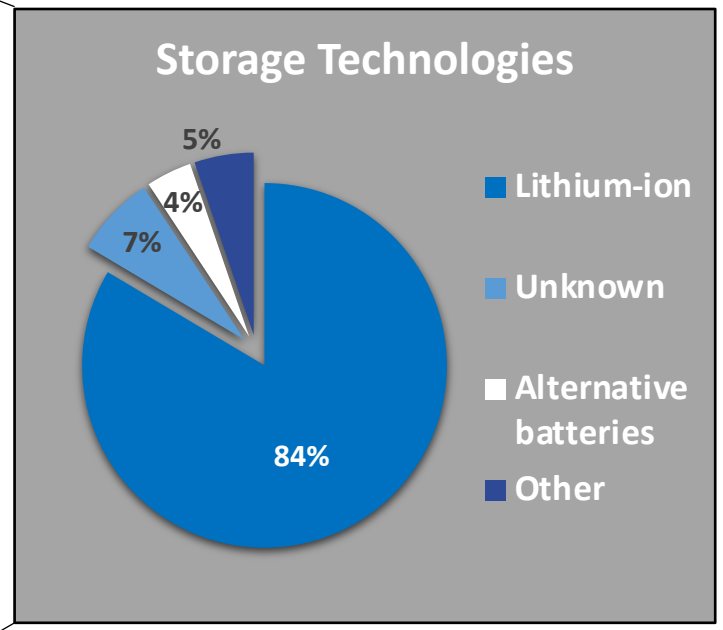
Source: Clean Horizon Energy Storage Source (CHESS) - May 2020
* These values exclude the 7.5GW/30GWh Sun Cable Tennant Creek facility (Northern Territory, Australia)

Current state of the market: Global Overview – large-scale energy storage installations

Global Large-scale Energy Storage Projects by Status (as of May 2020)



At the global level: 20 GW of battery storage projects, with roughly 79% under development and almost 84% lithium-ion batteries



Source: Clean Horizon Energy Storage Source (CHESS) - May 2020
* These values exclude the 7.5GW/30GWh Sun Cable Tennant Creek facility (Northern Territory, Australia)

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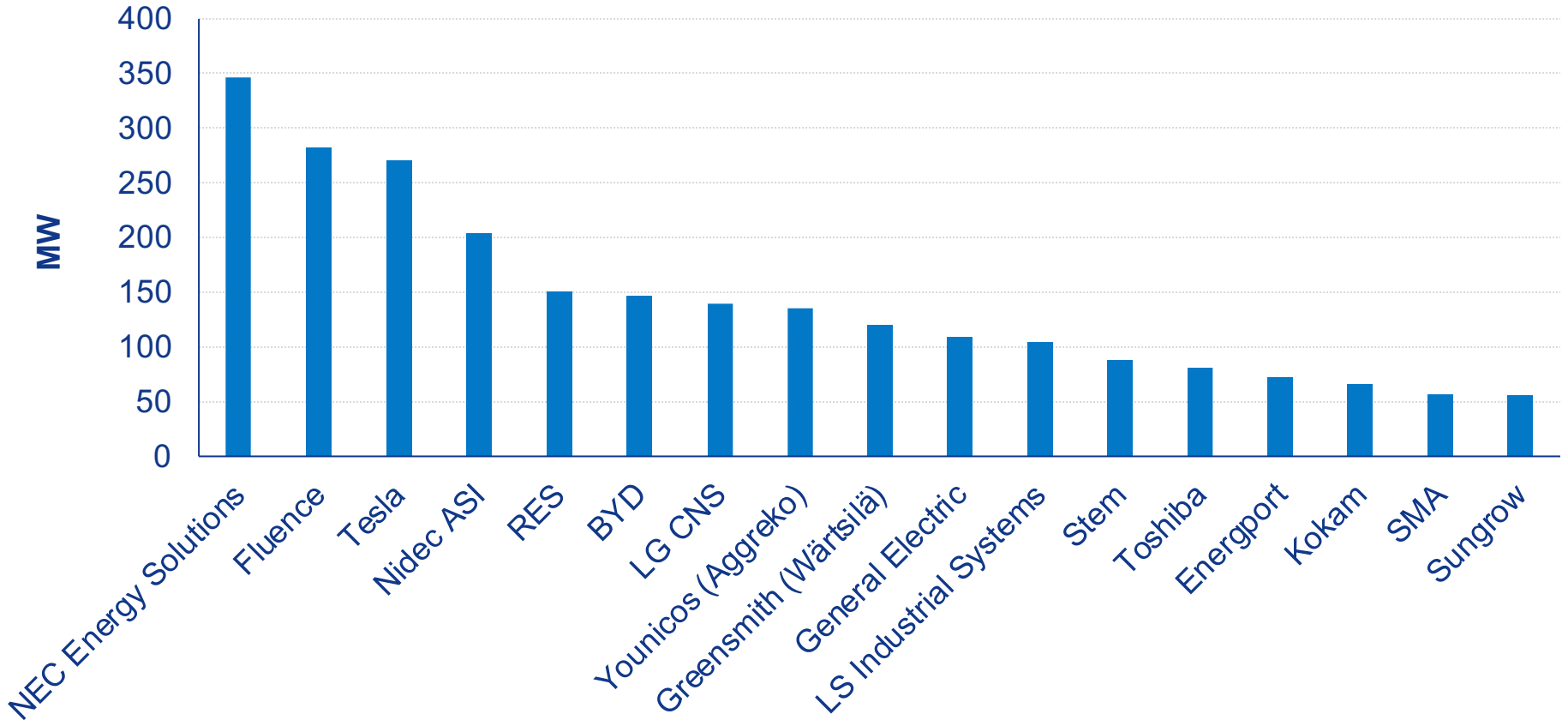
System integrator leaderboard

Top storage integrators with portfolios over 50 MW of operational projects

System integrators are crucial for the implementation of energy storage systems

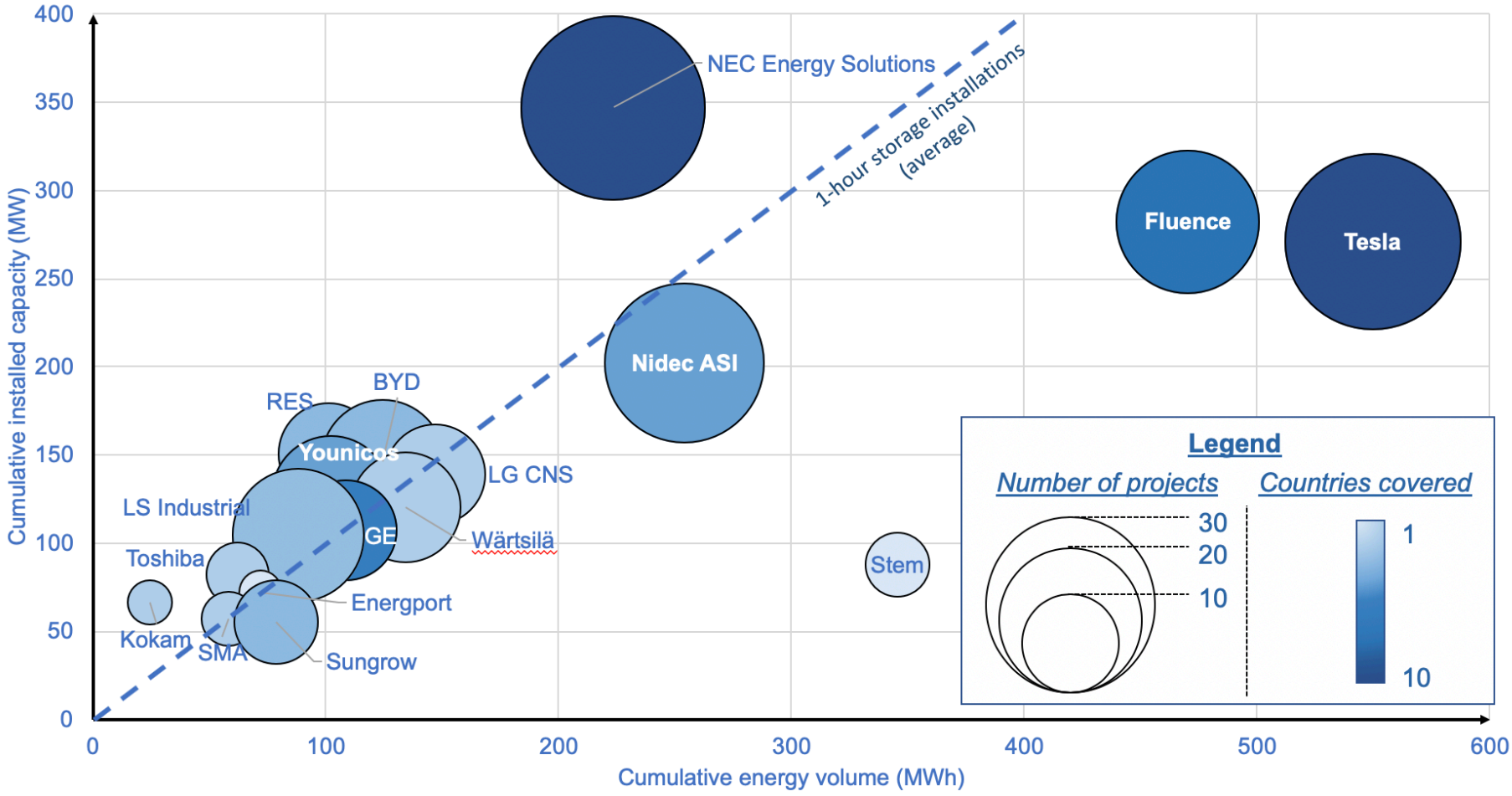
System Integrator portfolios of **operational** large-scale (> 500 kW) lithium-ion energy storage systems *(MW)*



Source: Clean Horizon Energy Storage Source (CHESS) – May 2020

Using installed projects as a basis for comparison allows to draw a complete view of the system integrator leader board as of Q2 2020

System Integrator portfolios of installed large-scale lithium-ion energy storage systems

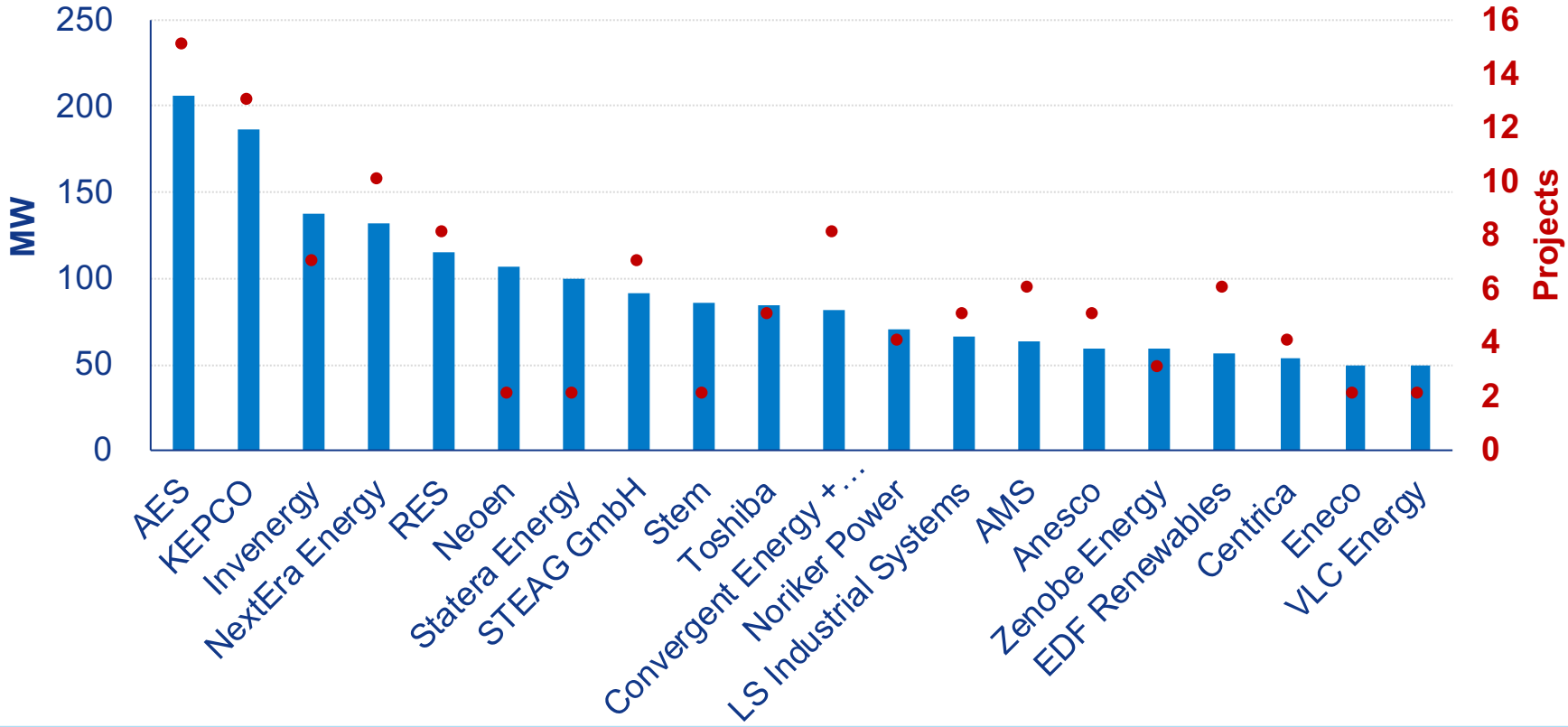


Project developer leaderboard

IPPs and utilities developing and owning storage globally are far more numerous (based on operational projects)

Most experienced project developers (top 20) pertaining to operational large scale energy storage projects

Developer portfolios of operational large-scale (> 500 kW) energy storage systems *(MW)*



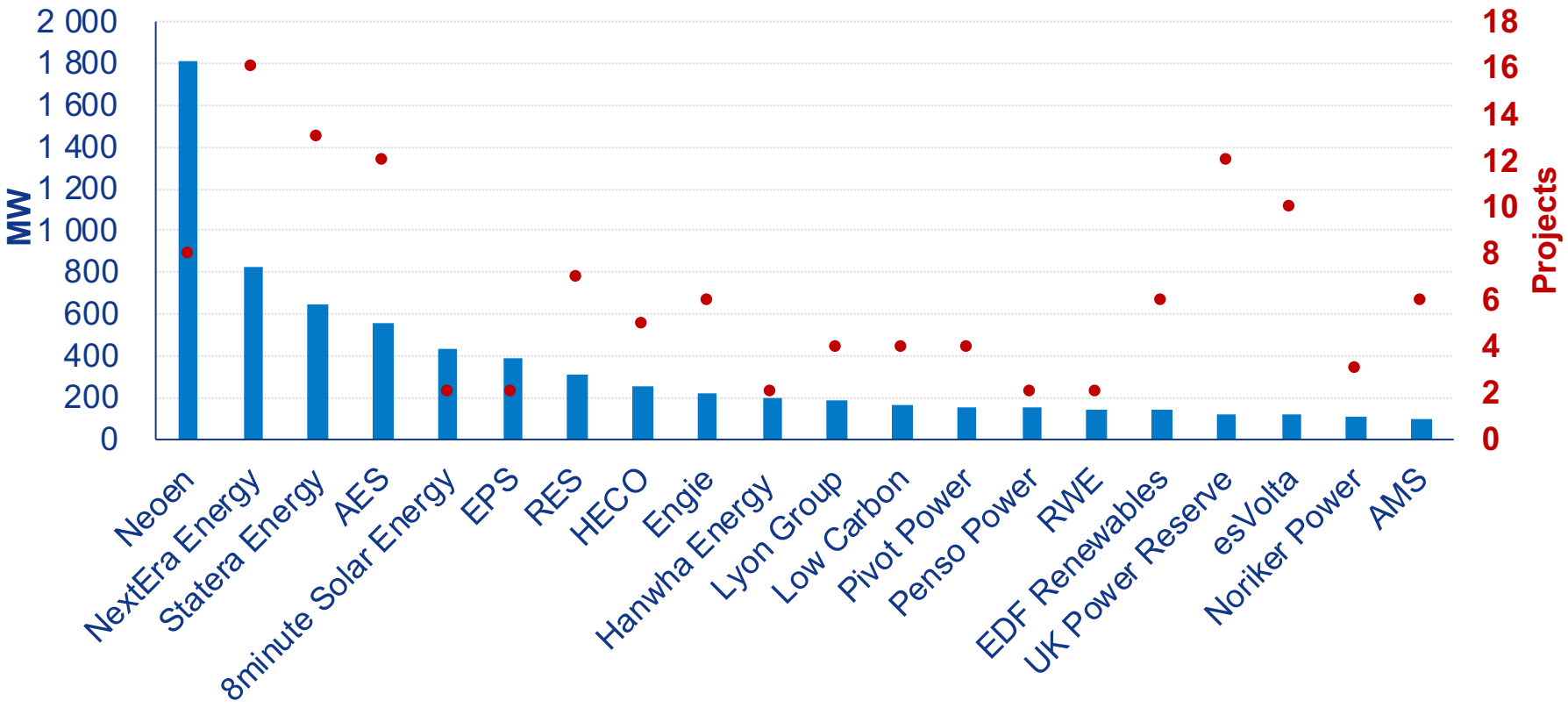
Notes: Selected actors at least have two operational energy storage projects.
KEPCO: Korea Electric Power Corporation, RES: Renewable Energy Systems, AMS: Advanced Microgrid Solutions

Source: Clean Horizon Energy Storage Source (CHESS) – May 2020

Using announced projects, thus portraying the future of the industry, orders of magnitude are drastically changing

Top 20 project developers (IPP or utilities) with largest portfolios of announced energy storage projects

Developer portfolios of announced large-scale (> 500 kW) energy storage systems *(MW)*

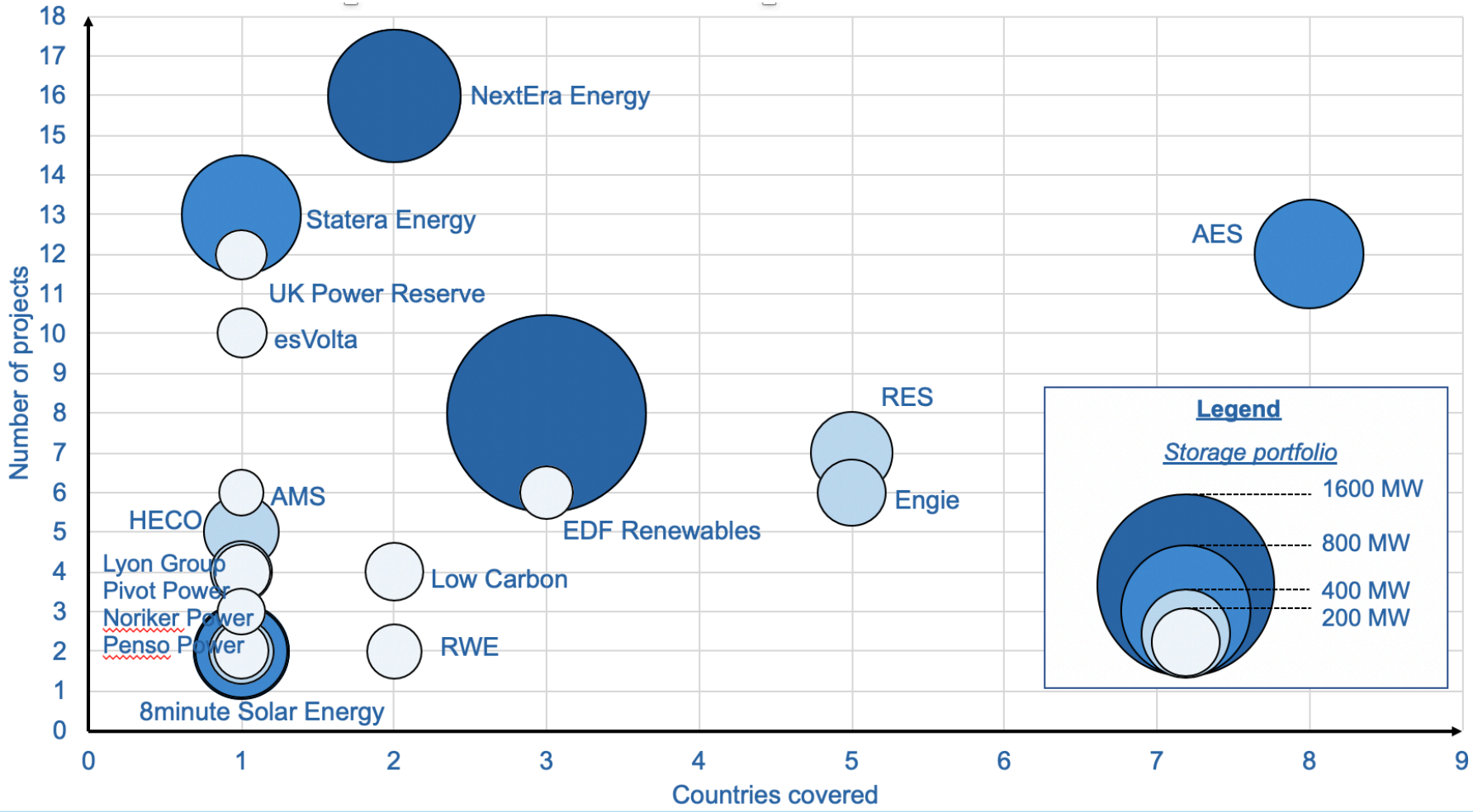


Notes: Selected actors at least have two announced energy storage projects. Neoen's values include the recent filing of the 600-MW Victoria Big Battery project
HECO: Hawaiian Electric Company, EPS: Energy Projects Solar, RES: Renewable Energy Systems, AMS: Advanced Microgrid Solutions

Source: Clean Horizon Energy Storage Source (CHESS) – May 2020

While most IPPs have their projects limited to few countries, larger ones go international

IPPs portfolios of **announced** large-scale energy storage systems



Notes: Selected actors at least have two announced energy storage projects. Neoen's values include the recent filing of the 600-MW Victoria Big Battery project
HECO: Hawaiian Electric Company, EPS: Energy Projects Solar, RES: Renewable Energy Systems, AMS: Advanced Microgrid Solutions
Source: Clean Horizon Energy Storage Source (CHESS) – May 2020

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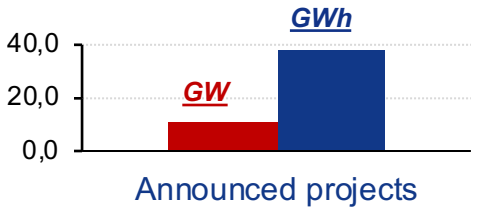
Global market size

Energy storage leader board: top players

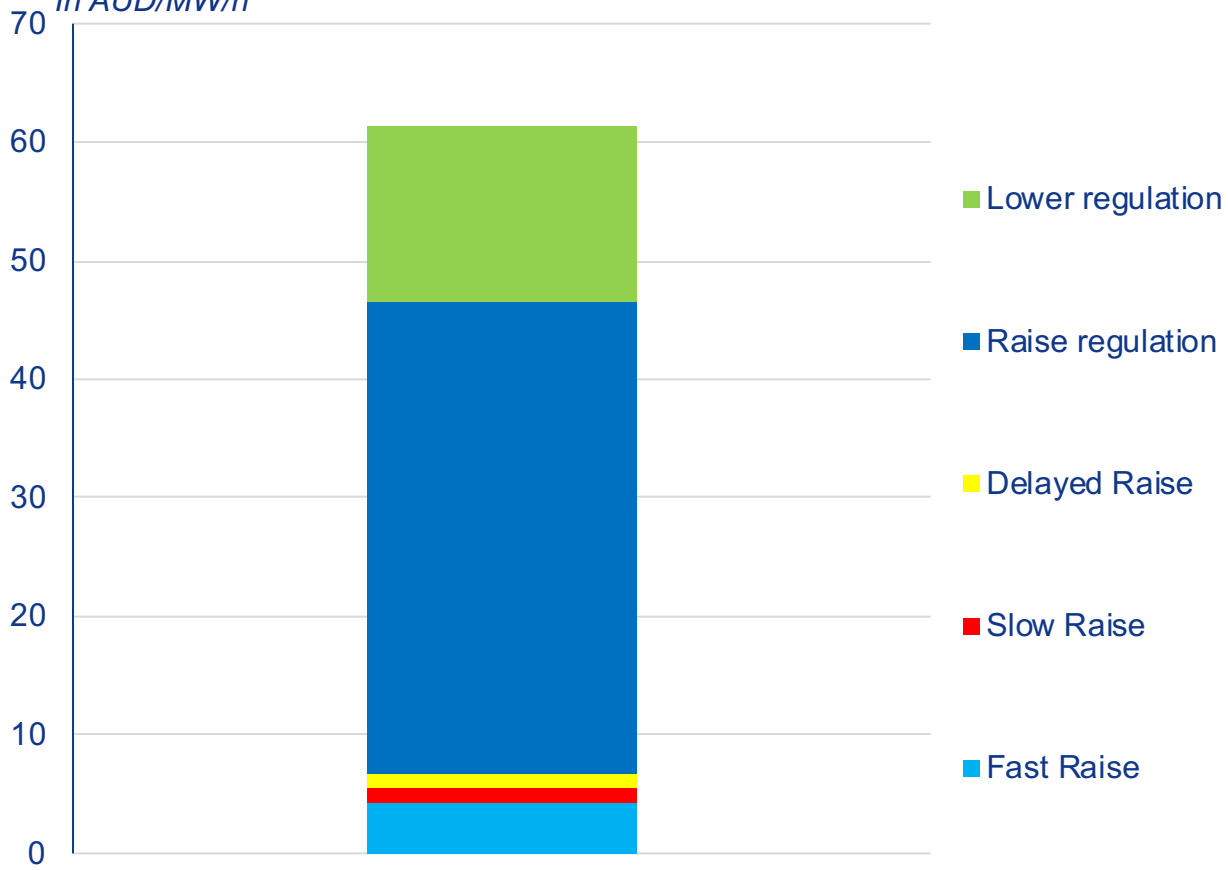
Energy storage leaderboard: top countries

Australia: Frequency Control Ancillary Service (FCAS): payments



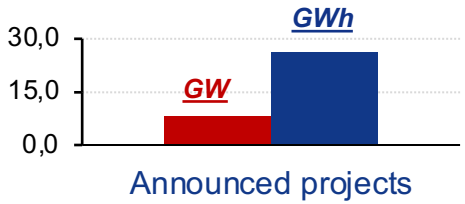
FCAS revenues are extremely high, even when factoring in the weighing coefficients

FCAS prices in 2019 (average price)
In AUD/MW/h



- At above 60 AUD/MW/h (approx. 40 USD), the revenues are more than sufficient to build a positive business case
- Prices are however expected to decrease, and grid fees are extremely high, thus hindering a long-term commercial investment

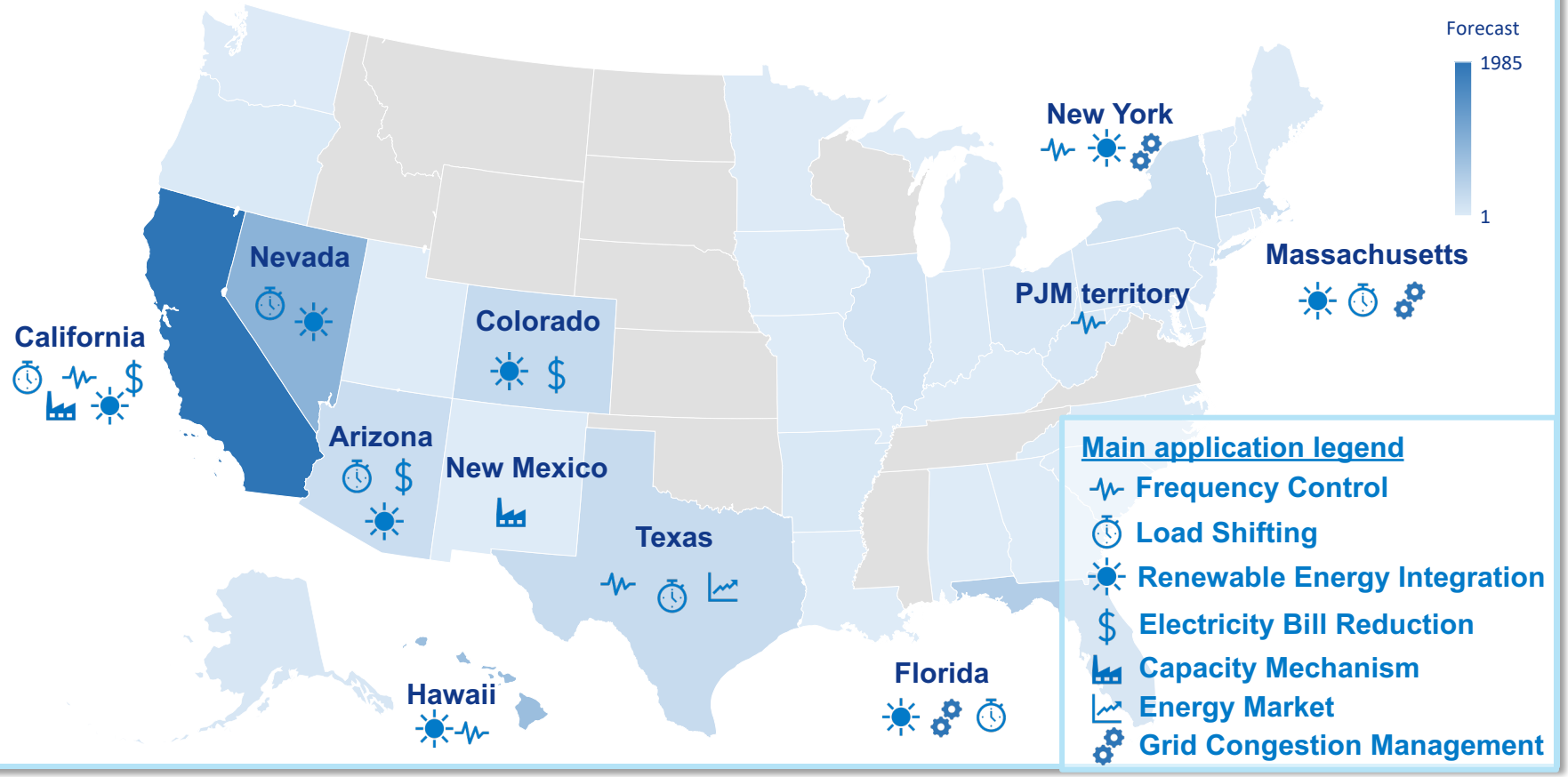
U.S.A : Most relevant applications for large-scale energy storage



Of roughly 1.2 GW of operational large-scale storage, approximately 50% are used for frequency regulation / control as main application, though California has procured storage for capacity as well as solar load shifting to avoid the effects of the duck curve

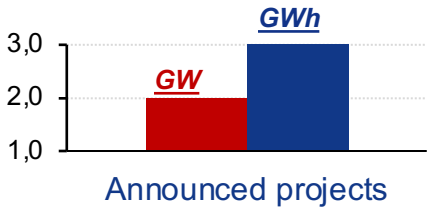
(Lower bound) Large-Scale Energy Storage Forecast in terms of Applications (U.S.A)

Based on CHC analysis of project details (end of 2023)



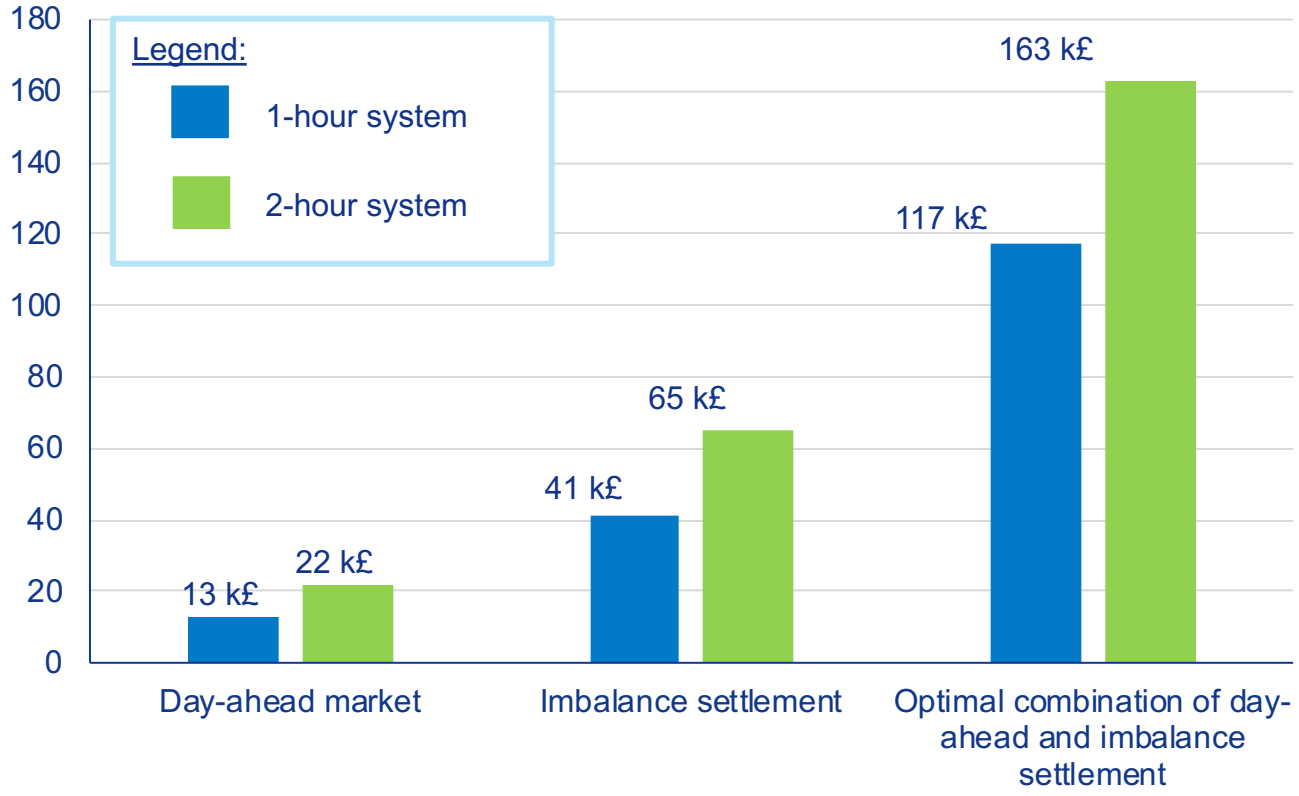
Source: Clean Horizon Energy Storage Source (CHESS) - Guam, Marshall Islands, and American Samoa not included

Great Britain : The optimisation of expected energy market revenues requires specific forecast and trading techniques



Day-ahead markets present little volatility, and the imbalance settlement on its own is not sufficient to recover an investment in a battery storage system.

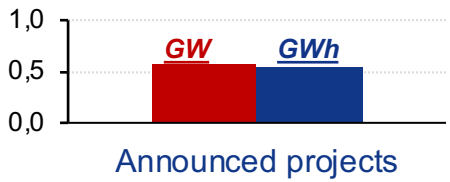
Revenues accessible[1] to a 1 MW battery system in the UK, on the various energy markets over the May 2018 – April 2019 period



- **Revenues presented on this slide are the theoretically maximal accessible revenues. Revenues actually accessible will necessarily be lower, and the ratio between actual vs theoretical revenues will depend on the quality of the forecast of the future prices.**
- **Only a combination of the various markets can allow to reach a viable level of revenues. This strategy is however risky, and its success highly depends on market forecasting capabilities.**

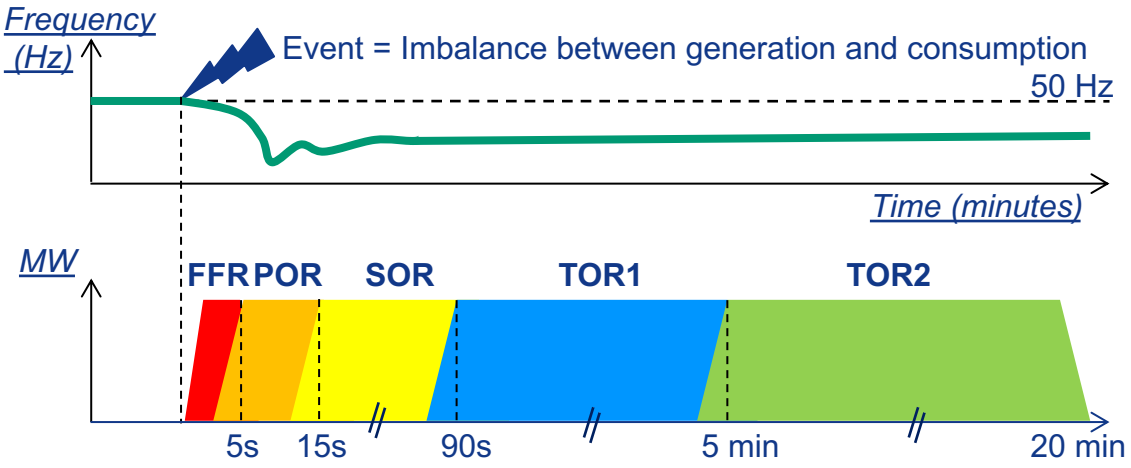
Note: 1. Simulations achieved by Clean Horizon on historical prices assuming perfect forecast of future prices. Those revenues are achieved assuming 1000 cycles per year, and a round trip efficiency of 85 %.

Ireland: Energy storage systems used for fast frequency response provide reserves and participate in the capacity mechanism



A 30 min to 45 min energy storage duration should be long enough to provide 5 system services (FFR, POR, SOR, TOR1, TOR2) under the DS3 program.

Overview of the activation time frame of FFR and operating reserve products



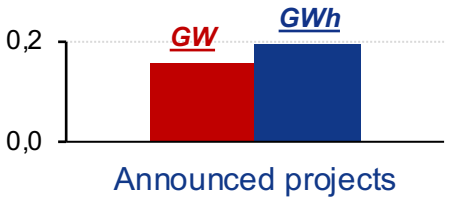
An energy storage system can deliver these five services simultaneously: **110 MW have been awarded a 6-year contract at 9€/MW/h**

On top of that, storage is also eligible for the capacity mechanism

Moreover, energy storage systems can participate in the capacity mechanism accompanying the aggressive final aim intended to reach: 75% of renewable penetration.

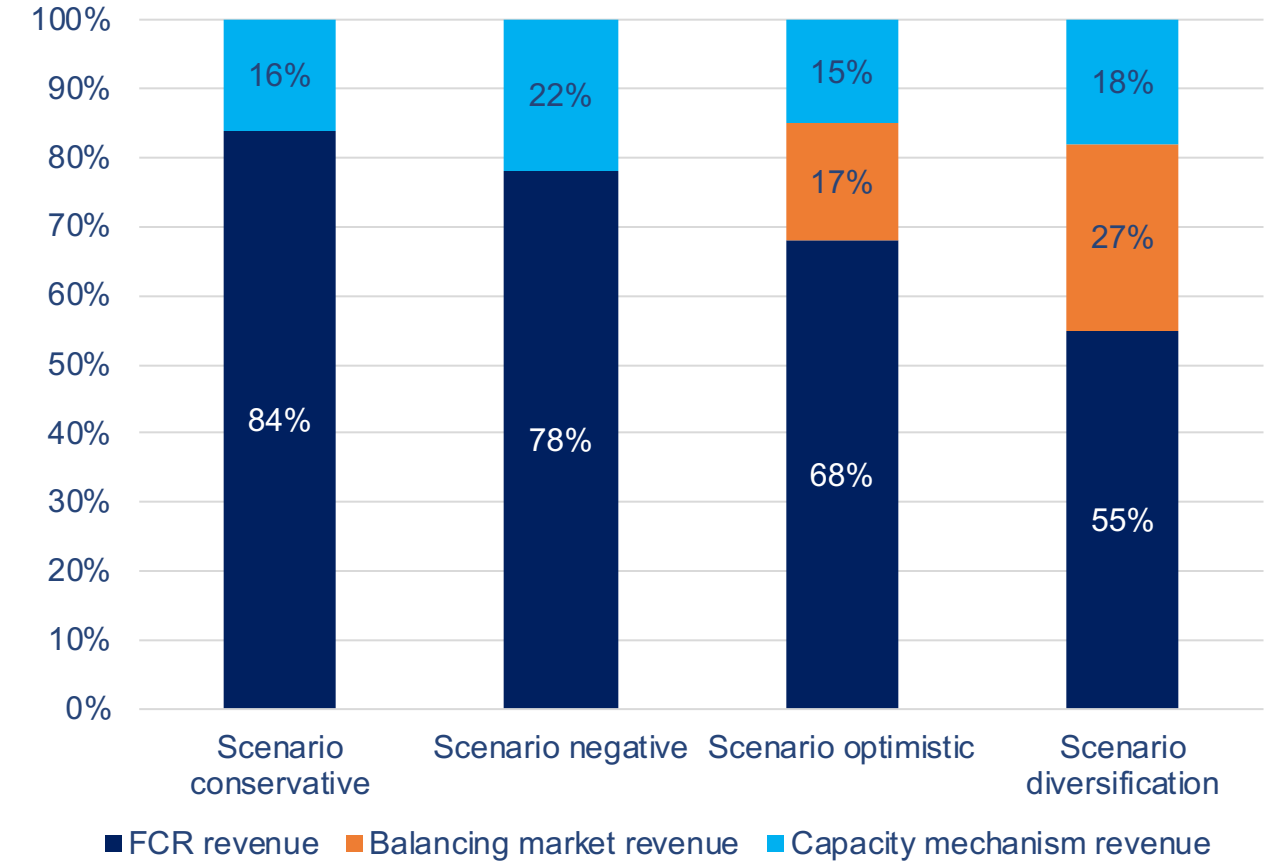
Source: Clean Horizon's Energy Storage Source (CHESS) - May 2020

France: Arbitrage on the balancing market can be a solution to mitigate the FCR market risk



In some scenarios, balancing market can make up to 27% of the project revenues

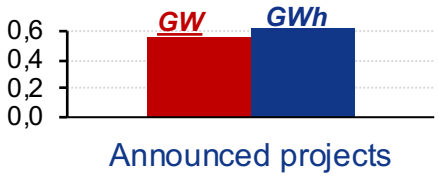
Total discounted revenue distribution for each scenario
(%)



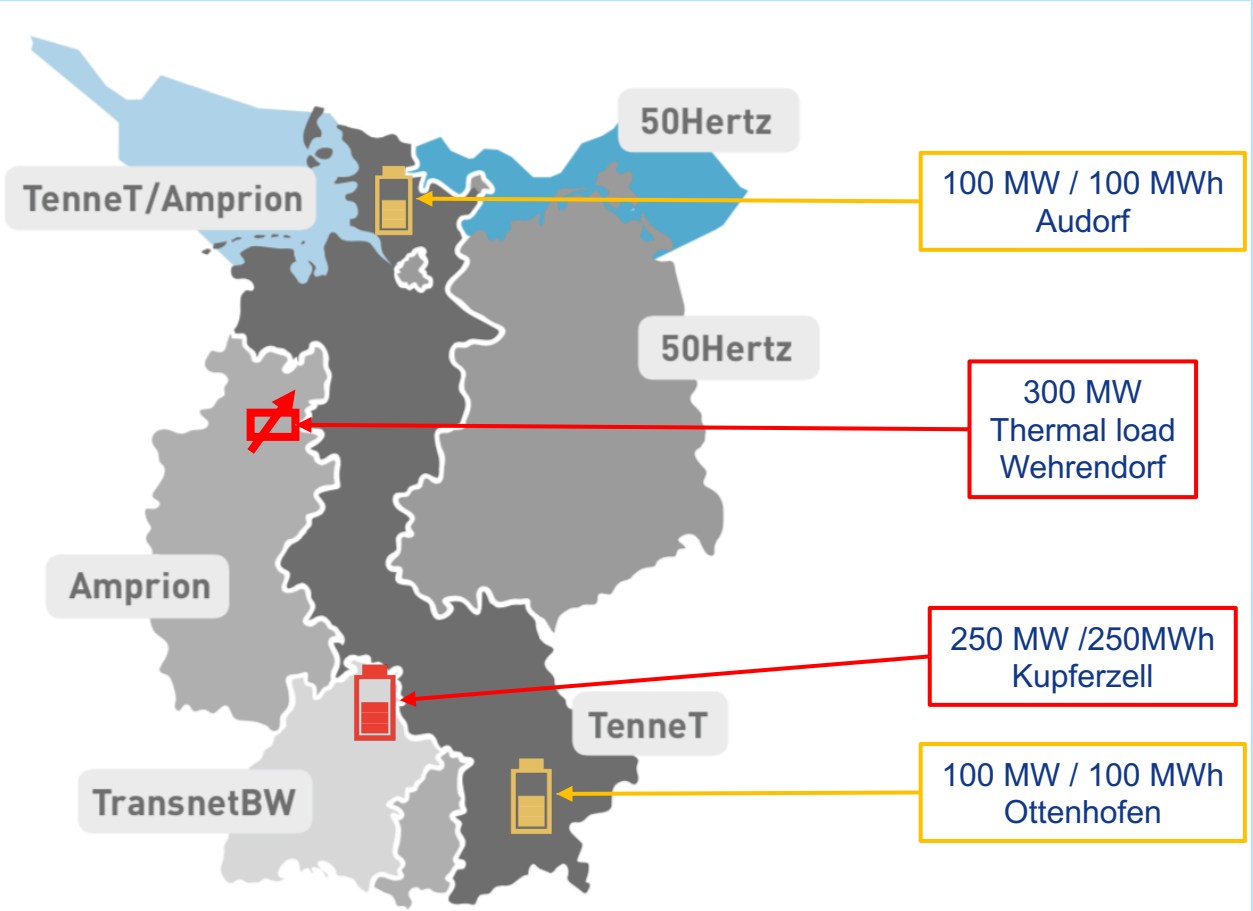
MW announced: 165
MWh announced: 205

- **Yearly capacity payments represent between 15% and 22% of the total project revenues**
- **As of today, following the conservative scenario, a project is highly dependent on FCR revenues**
- **Participation in the balancing market when FCR prices are down enables a storage system to diversify its revenue streams**

Germany: TSOs will operate 450 MW of storage (called *Netzboosters*) to reduce re-dispatching costs



Three TSOs should deploy *Netzboosters* as pilot projects to increase network utilisation rate, using batteries as N-1 redundancy



The network development plan published in December 2019 confirmed 450 MW of storage for TSOs to experiment higher network utilization

1.3 GW of energy storage was proposed by TSOs and 450 MW will be built by 2025 to limit costs due to power re-dispatch and relieve transmission congestions

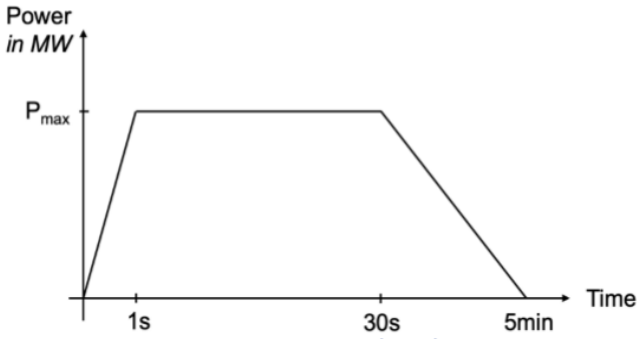
Sources:https://www.transnetbw.de/de/presse/presseinformationen/presseinformation/bundesnetzagentur-bestaetigt-netzbooster-im-raum-kupferzell, https://www.energie-chronik.de/190805.htm, https://www.netzentwicklungsplan.de/de/bestaetigung-des-nep-2030-version-2019, https://www.netzausbau.de/bedarfsermittlung/2030_2019/nep-ub/de.html;jsessionid=E37EB5E3C5A352C10DE1CCED517C6FB3

Italy: To prevent further stability issues, Terna decided to purchase 230 MWs of fast reserves in 2021

Characteristics of the fast reserve service are favorable to storage

1. This fast reserve service is very similar to the British Enhanced Frequency Response (EFR) tender as it is **symmetric** and open to units **from 5 MW to 25 MW**

2. The dynamic response is similar to that of EFR:



Dynamic response for fast reserve

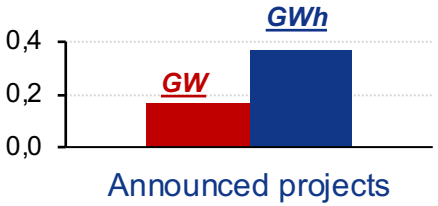
3. Volumes are relevant as Terna intends to procure for this service:
- **200 MW of in continental Italy**
- **30 MW of fast reserves in Sardinia**

4. Contractual arrangements will be an availability Will pay for availabilit **with 3 to 4-year contracts** (commissioning expected **by January 1st, 2022**)

- **Activation and response times for the fast reserve service are perfectly fit for battery storage projects**
- **Availability required is 11%, Terna will confirm activation 7 days ahead**

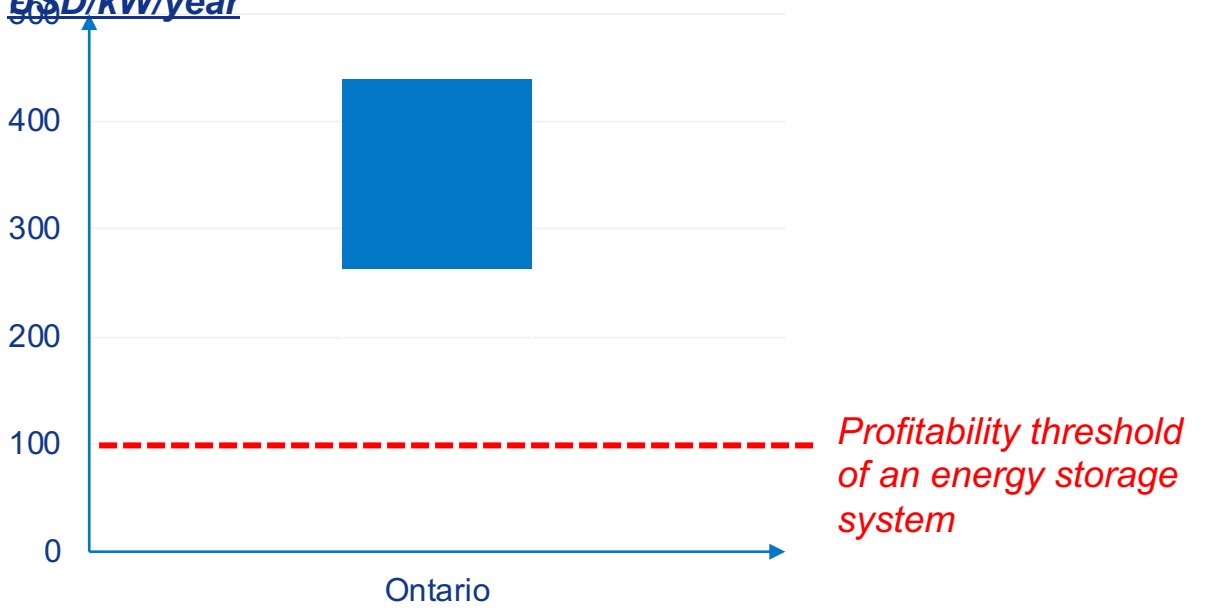
Sources: https://www.terna.it/en/electric-system/pilot-projects-pursuant-arera-resolution-300-2017-reel/fast-reserve-pilotproject
https://www.terna.it/it/sistema-elettrico/pubblicazioni/news-operatori/dettaglio/progetto-pilota-riserva-ultra-rapidafrequenza--avviso-avvio-consultazione

Canada – Ontario: The Global Adjustment Mechanism (The C&I market)



Regarding the business for energy storage, only Global Adjustment makes for now the most significant revenue stream for energy storage

Order of magnitude of the revenues accessible to an energy storage system installed behind the meter at a C&I facility
kUSD/kW/year

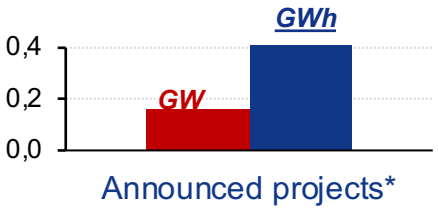


- **Storage can generate high amounts of savings in Ontario, between 260 to 435 kUSD/MW/year.**
- **The generated savings are however dependent on how well the consumption of the Ontario system is predicted by the operator of the storage system.**

Assumptions and comments: In Ontario, the electricity bill for large consumers (Class A customers: > 5 MW average load) is composed of two components :

- One energy component, indexed on the market electricity price
- One "power component", called "Global adjustment" which is calculated based on the contribution of the customer to the 5 highest hourly peak demands of the year (5 CP: 5 coincident peaks). A battery can help shave the peak during these periods, and therefore reduce the Global Adjustment fee.

South Korea: an unregulated market pushed by excessive incentives



The South Korean government has set strong incentives for storage deployment, resulting in very fast market expansion (+500% in a year)

- Electricty from solar plus storage receives strong subisidies[1]
- Public buildings are required to install storage

Large storage deployment[1]
2017: 723 MWh
2018: 3.6 GWh

Market growth = x 5

From Aug17 to Dec19:
23 battery fires reported[2]

Dec18 –Nov19
Suspension of ESS operation
1490 sites inspection

- Two rebates are accessible:
  - A rebate on the capacity charge of the facility (which can amount to 8.7 USD/kW/month)
  - A rebate on the energy used to recharge the battery during off-peak periods

1. Capacity charge discount

Peak reduced (kW) ✖ Base rate (€/kW) ✖ 300% ✖ Weighting factor

2. Discount on the energy cost for off-peak battery charging

Charging consumption (kWh) ✖ Consumption Rate (€/kWh) ✖ 50% ✖ Weighting factor

Weighing factors

[1]ESS cap. / Cont. Cap.	Weights
Higher than 10%	X 1.2
5% up to less than 10%	X 1.0
Less than 5%	X 0.8

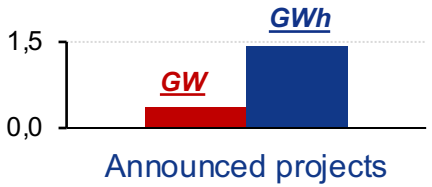
[1]ESS capacity compared to contracted capacity

The scheme is available until the end-2020. After this date, the rebates will likely not be accessible anymore.

- **With the rebates in place, a storage system can save up to 31$/kW/month.**
- **These high revenues explain the deployment of several large storage systems behind the meter in South Korea, representing over 210 MW of capacity.**

* CHESS database is **incomplete** in South Korea so these numbers are too low

South Africa: the new World Bank testbed for large-scale battery storage



The ambitious and heavily supported South African energy transition

- Ambitious renewable targets aim to alleviate the dependency on coal and cope with the 35 GW peak demand:
  - 2.4 GW of intermittent renewables installed today
  - 18 GW and 55GW respectively by 2030 and 2050
- The World Bank dedicated more than USD 5 billion in funding by 2025 for storage.
- South Africa is the first country to benefit largely from this storage fund and become the World Bank's testbed for stationary storage.

Phase	Financed	Number of sites	Storage capacity	Storage active power
Phase I	Yes by a combination of DFIs	47	800 MWh	200 MW
Phase II	Not yet	43	640 MWh	170 MW

- **South Africa's ambitious renewable energy goals are attracting remarkable investmens**
- **South Africa will benefit from DFI investments to finance more than 1440 MWh of projects**
- **ESKOM's monopoly over the energy market limits opportunities for developers**

DFI: Development Finance Institution

Sub-Saharan Africa: Burkina Faso example

Energy storage projects in most sub-Saharan countries are driven by DFIs and are owned by public utilities.

- **The French development and African development banks will finance the Yeleen project : 10MW/10MWh to assist renewable energy integration and sustain grid stability.** This system is located at the site of a **43-MW solar generation plant**
- **The *International Finance Corporation (IFC)* is supporting the roadmap for energy storage deployment in Burkina Faso**
- **The *World bank* issued an Ecowas Battery Energy Storage System Feasibility Study focusing on Ivory Cost, Mali and Niger**

IFC International Finance Corporation WORLD BANK GROUP
Creating Markets, Creating Opportunities

THE WORLD BANK IBRD • IDA

- **The main application of this announced project is to provide primary reserve to deal with frequency control.**
- **Driven by DFIs, some storage projects might emerge in other countries, especially in the ECOWAS region**

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THANK YOU!

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