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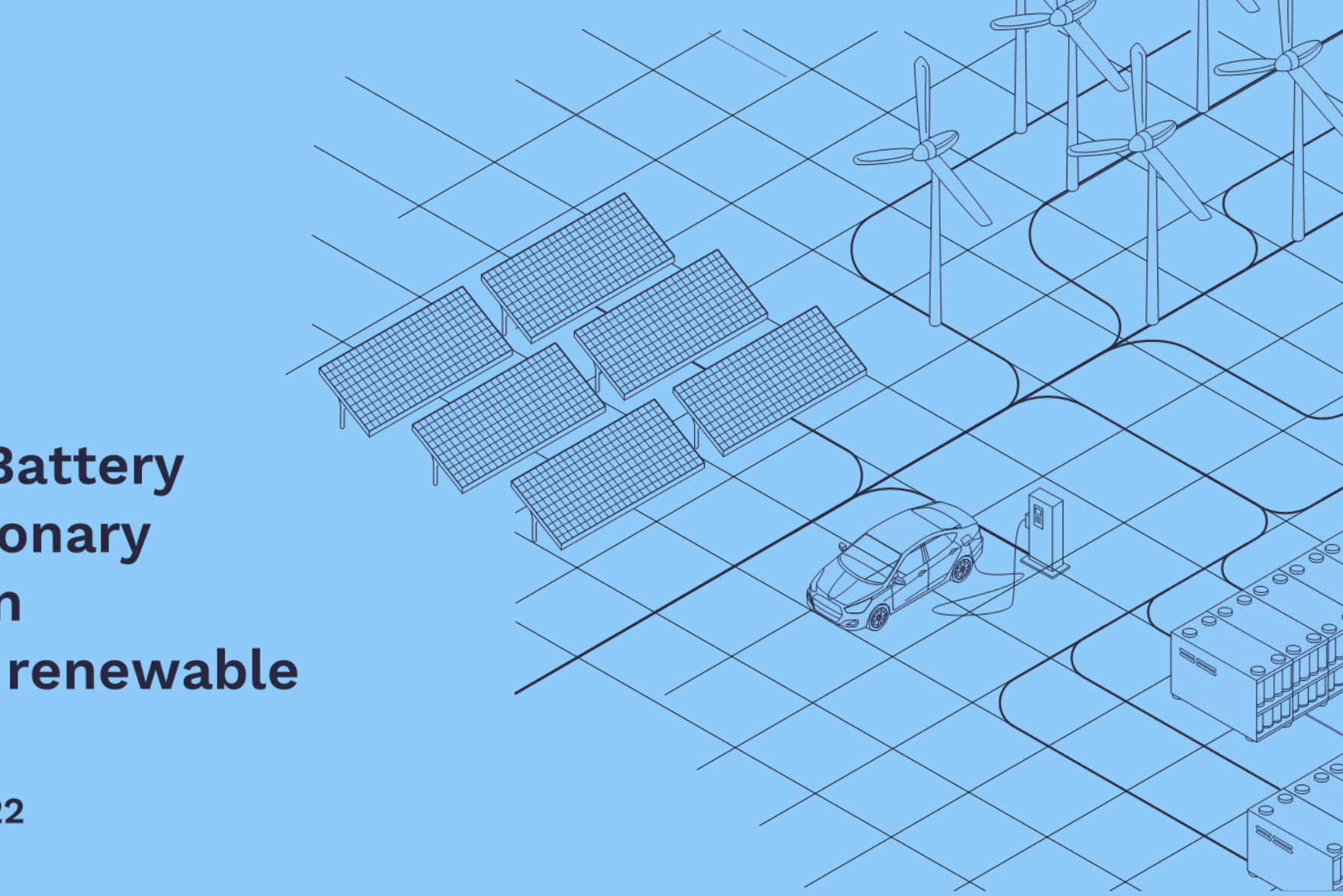
The role of Battery Energy Stationary Storage in an increasingly renewable grid



15th September 2022

Iola Hughes

Battery Show North America

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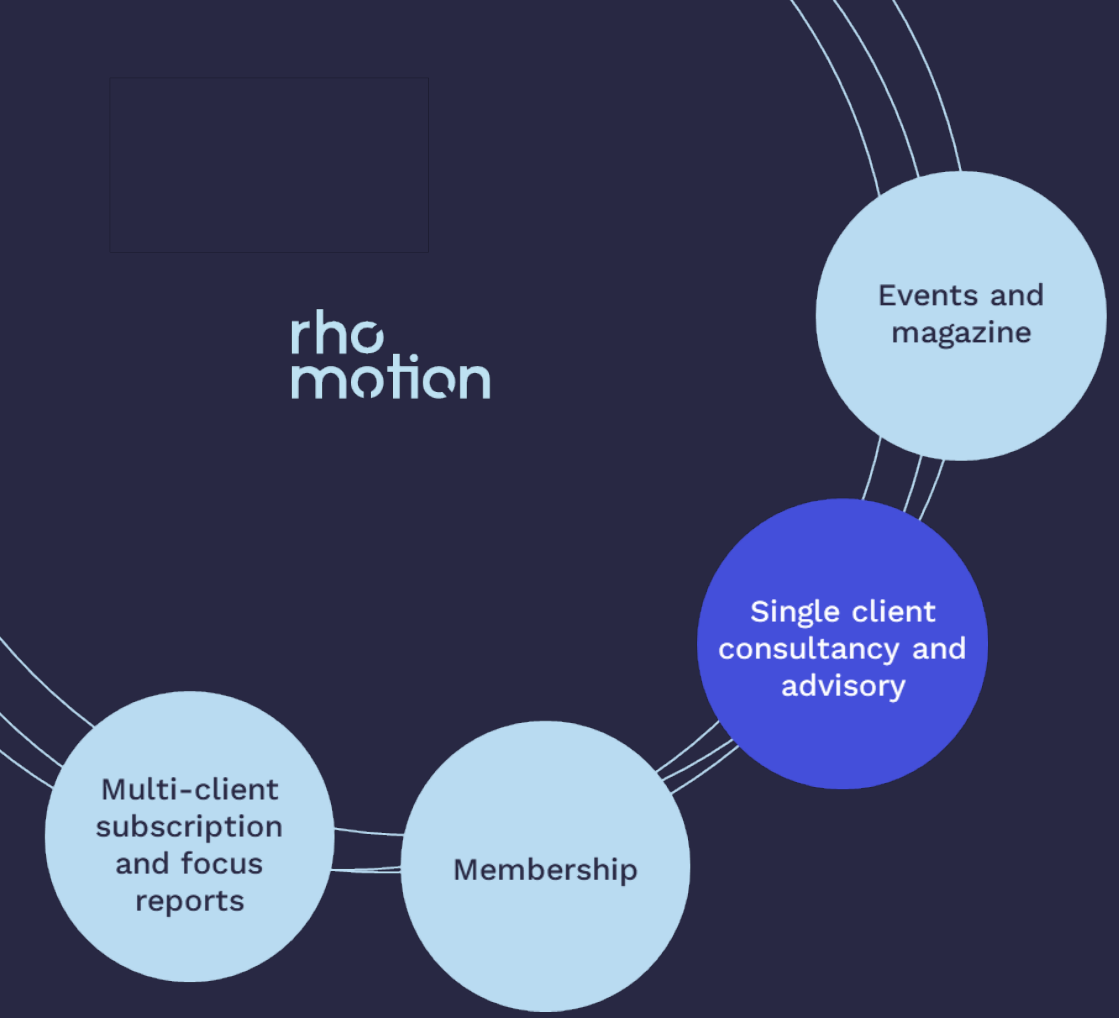

ABOUT RHO MOTION

Rho Motion offers the most comprehensive and well-informed forecasts and analysis for the energy transition

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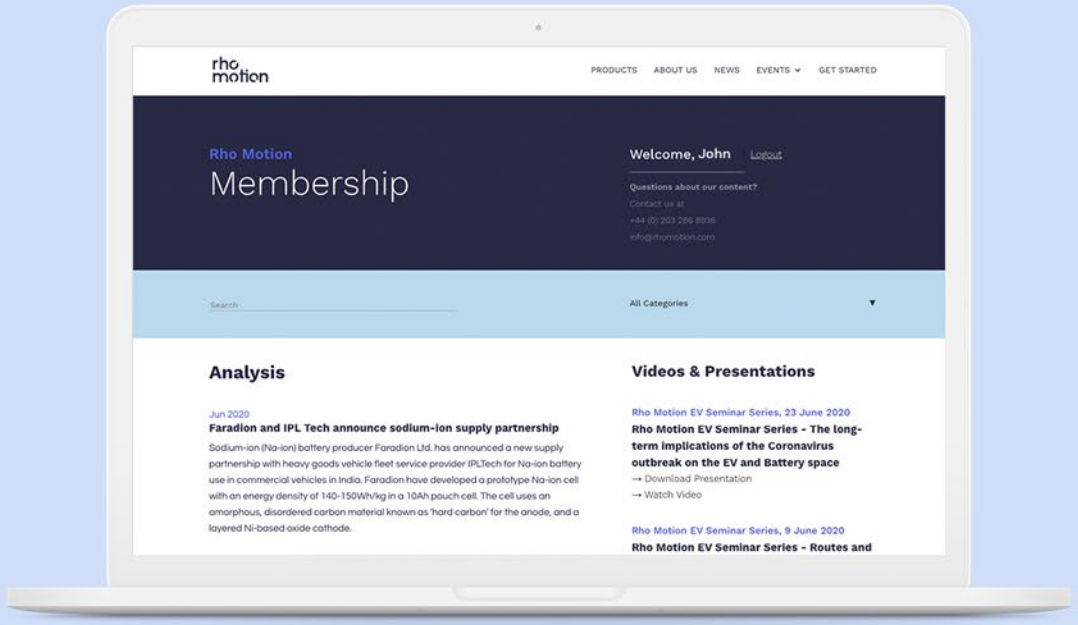
Our Membership Platform provides up-to-date analysis, news and data

Exclusive access to our EV, Battery and Charging commentary and analysis, as well as our presentation and video archive.



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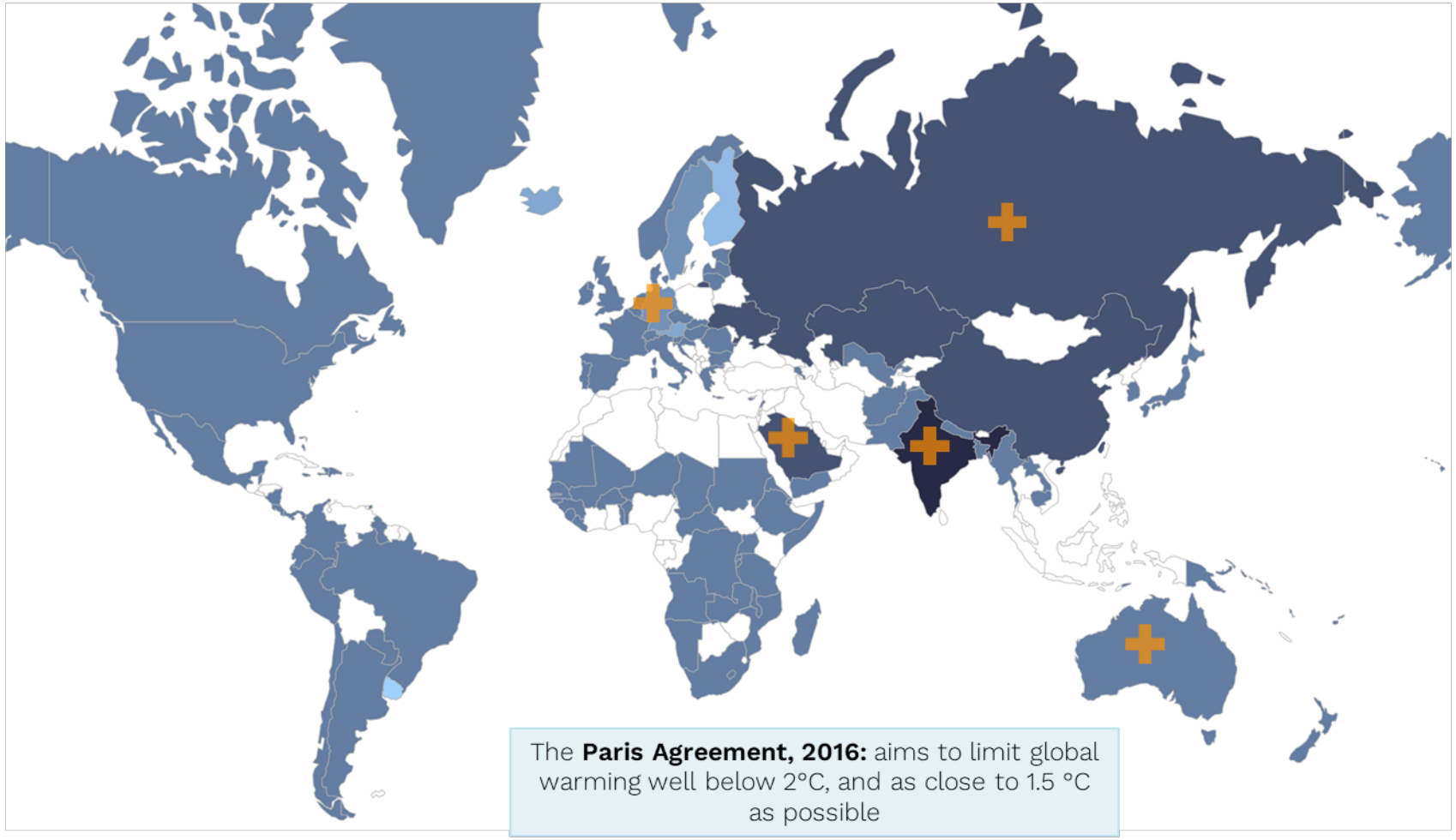
138 countries have announced national net zero carbon emission targets



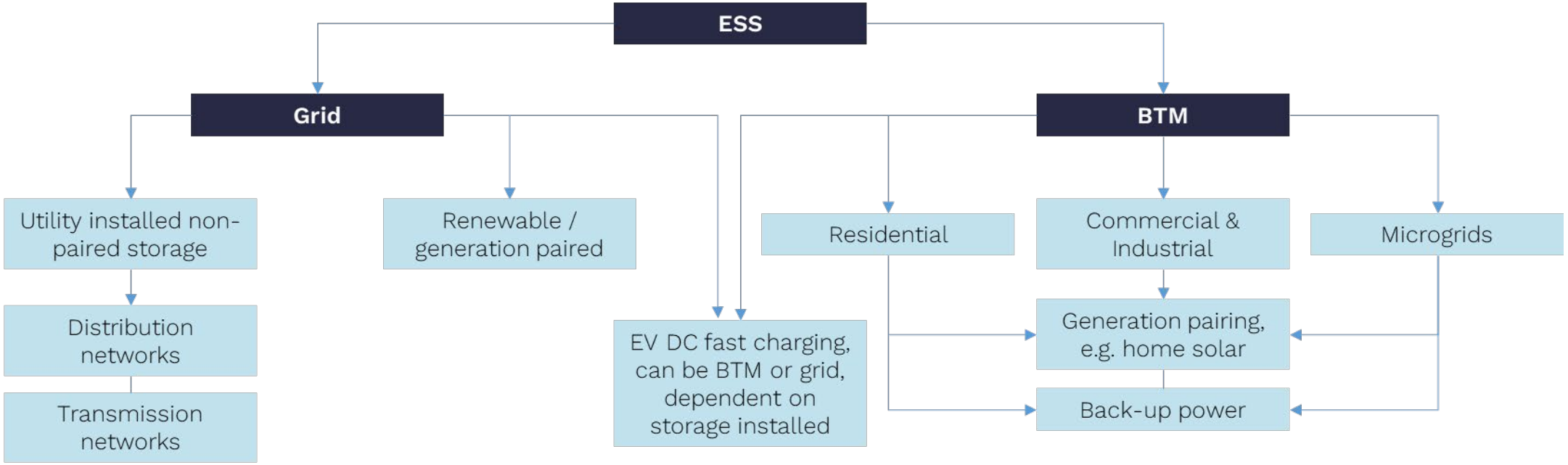
Targets driving the energy transition: Renewables

Renewables Share of the Electricity Grid Timeline

		2019 Renewables % of electricity
	China saw a 5.8% YoY rise in electricity demand from May to October 2020, renewable investment struggling to keep pace with demand growth	26% (18% hydro)
	Varies hugely on a state level, California has set targets of 44% by **2024**, 52% by **2027**, 60% by **2030**, 100% by **2045**.	17% (2% hydro)
	Japan has set a 2030 target of 24% of power mix	19% (7% hydro)
	Germany 50% by **2030,** 65% by **2040,** 80% by **2050**	46% (4% hydro)
	Canada 90% by **2030**	64% (61% hydro)
	UK 50% by **2030,** under review for 65%	40% (2% hydro)
	Norway is set to overshoot renewable electricity generation, with a **2020** target of 114%	98% (95% hydro)
175GW of renewable energy by **2022**	India 50% by **2030,** 450GW of renewable energy	35% (12% hydro)
France's electricity mix was 72% nuclear **2019**	France 40% by **2030**, of which wind power could supply half	23% (11% hydro)

The EU targets 60GW of offshore wind by 2030, 300GW by 2050. Current capacity = 12GW

ESS applications can be split into two broad categories: grid and behind-the-meter





North America and China represent 70% of the BESS market, and over 85% of the grid BESS market

BESS Regional Update

US & Canada

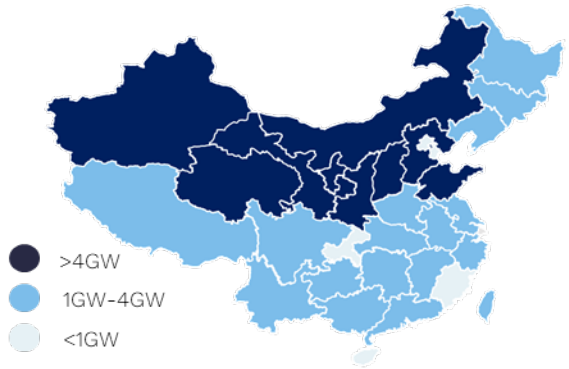
- In H1 2022 over 4GWh of grid BESS entered operation across more than 20 projects, a further 7GWh of capacity is planned for completion in the second half of the year.

US States with direct Energy Storage Legislation

China

- In H1 2022 over 7GWh of grid BESS entered operation across more than 200 projects, reflective of the relatively smaller size of projects compared to the US. A further 15GWh of capacity is planned for completion in the second half of the year.
- The map below covers the updated regional ESS targets, more detail can be found in section 6.

Regional ESS target by 2025



EU, EFTA & UK

- In the EU, EFTA & UK 0.3GWh of grid BESS entered operation across more than 10 projects. The second half of the year should be much stronger with a further 2.3GWh of BESS capacity planned.
- Support remains relatively limited in the region with many players hopeful REPower EU would include stronger support for stationary storage than what was announced,

European Energy Storage Targets for 2030 (GW) announced in H1 2022

The Inflation Reduction Act

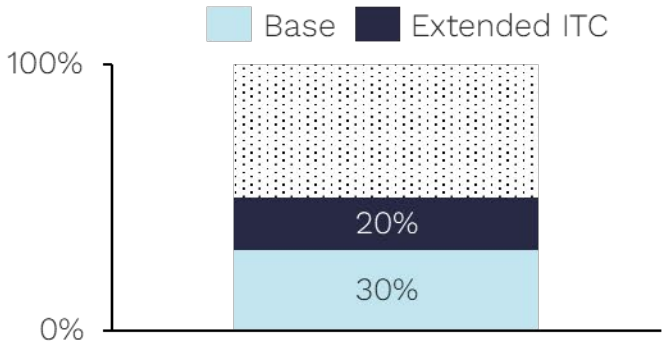
In the US, a reduced and reworked budget reconciliation bill named the Inflation Reduction Act of 2022 was proposed in late July 2022, following months of failed negotiations for the Build Back Better Bill. The new bill is sponsored by Senators Chuck Schumer and Joe Manchin, the latter being the biggest opponent of the Build Back Better Bill, making this bill more likely to pass than its predecessor. The Act needs to now pass through the Senate and the House before making it into law.

- If enacted the bill would represent the largest investment into addressing climate change in US history, authorising $369 billion in spending on energy security and climate change. $30 billion in loans and grant programs available for states and utilities to "accelerate the transition to clean electricity", earmarked for production tax credits to accelerate US manufacturing of solar panels, batteries and critical mineral processing.
- The Act would extend the solar investment tax credit (ITC) of 30% and the production tax credit (PTC) of 1.5 cent per kWh for 10 years.
- The act also includes the **ITC for standalone storage**, a long sought after measure, with the current ITC only covering paired solar and storage. The ITC would provide an immediate reduction to the upfront CAPEX of energy storage projects by an estimated 30%.
- The ITC will cover storage facilities of which construction begins before 2025, and would extend the ITC for certain costs associated with the construction of interconnection equipment installed in connection with other ITC-eligible facilities.

Extended ITC and PTC

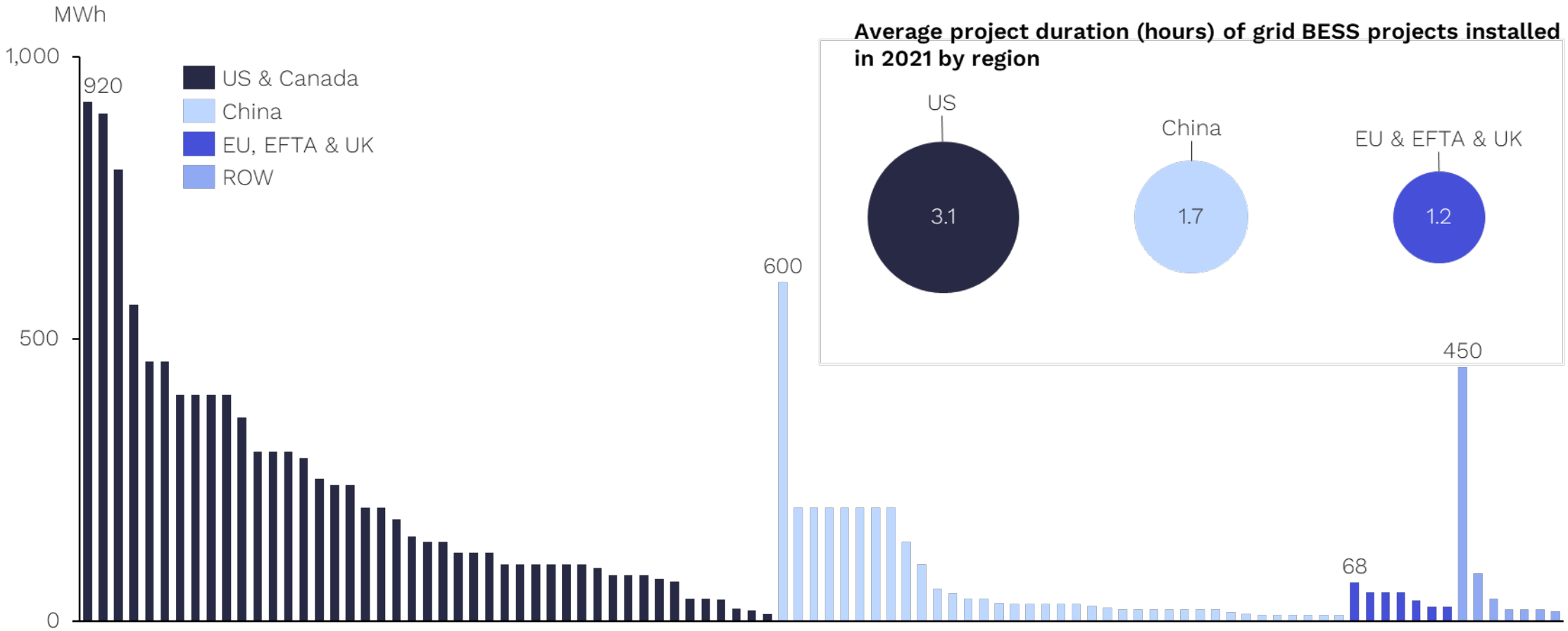
- The Act also adopts credit adders for eligible ITC and PTC facilities that satisfy certain domestic content requirements or are located in specific "energy communities", including
  - Brownfield sites
  - Communities with significant employment related to extraction, processing, transport, or storage of coal, oil or natural gas
  - Communities located in census tracts with closed coal mine or retired coal-fired generating facilities.
- Combined these adders have the potential to increase the ITC to 50% and PTC to 20%

Standalone storage ITC Credit proposal 2022



Regional trends in grid project size and duration

Grid scale projects over 10MWh installed in 2021 by project capacity and region

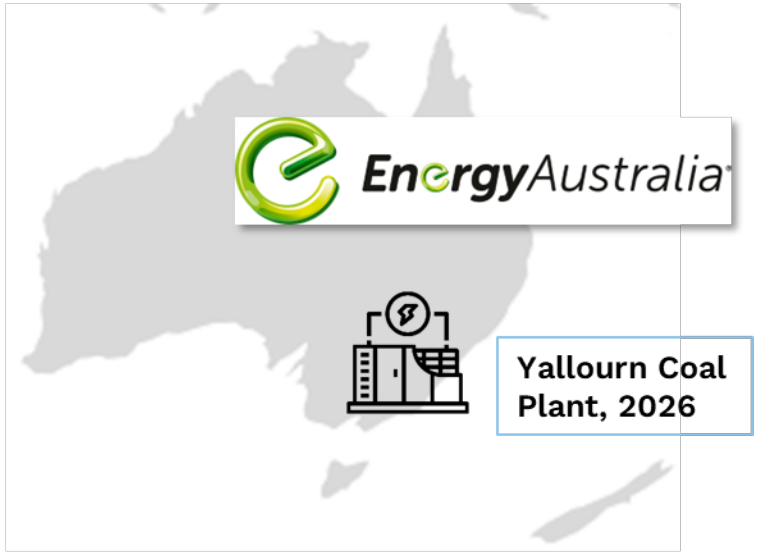


Average project duration (hours) of grid BESS projects installed in 2021 by region

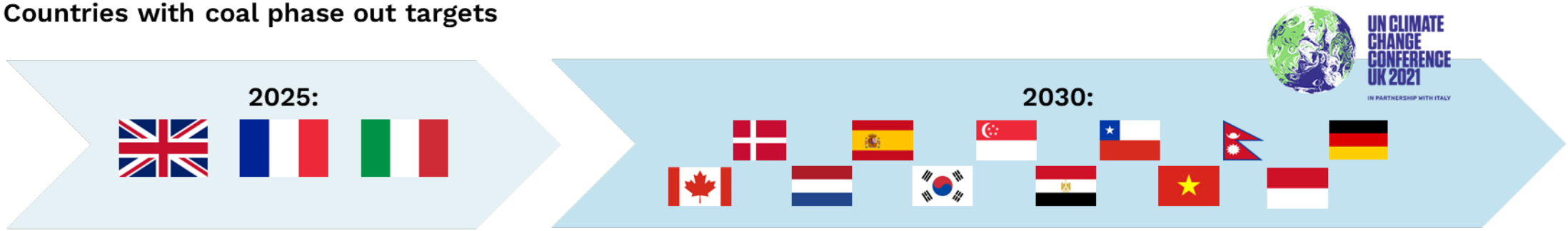
Stationary storage assets to replace coal and gas plant

Decommissioning of coal and gas plants

- With the increasing share of renewables, energy storage assets can play an increasingly important role in meeting peak demand.
- Similarly, as wholesale energy prices become more volatile – due to the variable nature of renewable generation – the opportunity for storage to participate in wholesale arbitrage and balancing will also grow.



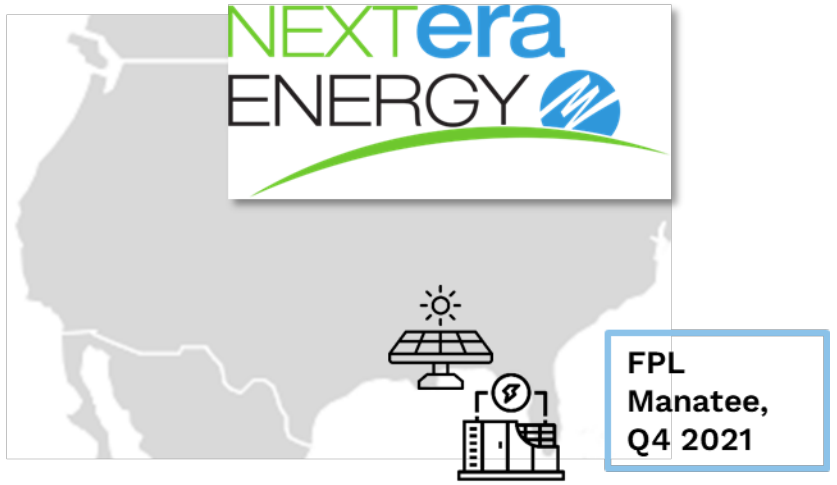
Countries with coal phase out targets



The growth of the hybrid solar and storage project

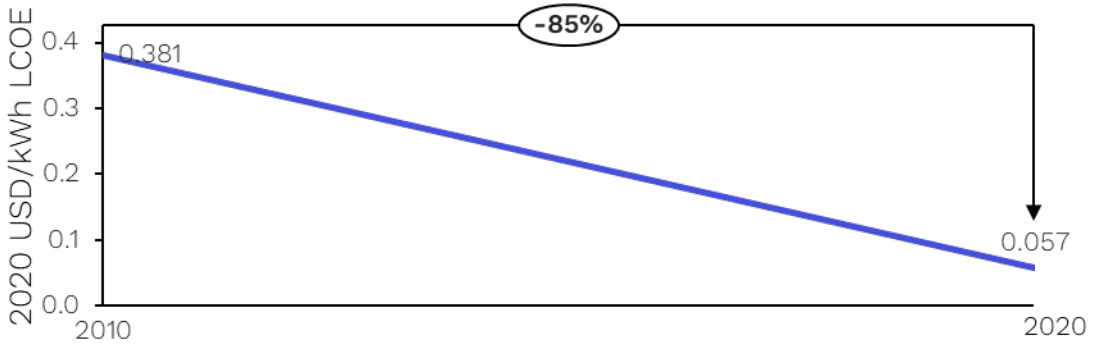
Three key drivers

- Legislation directly supporting hybrid installations:



Declining Cost of Solar & Storage

Solar PV

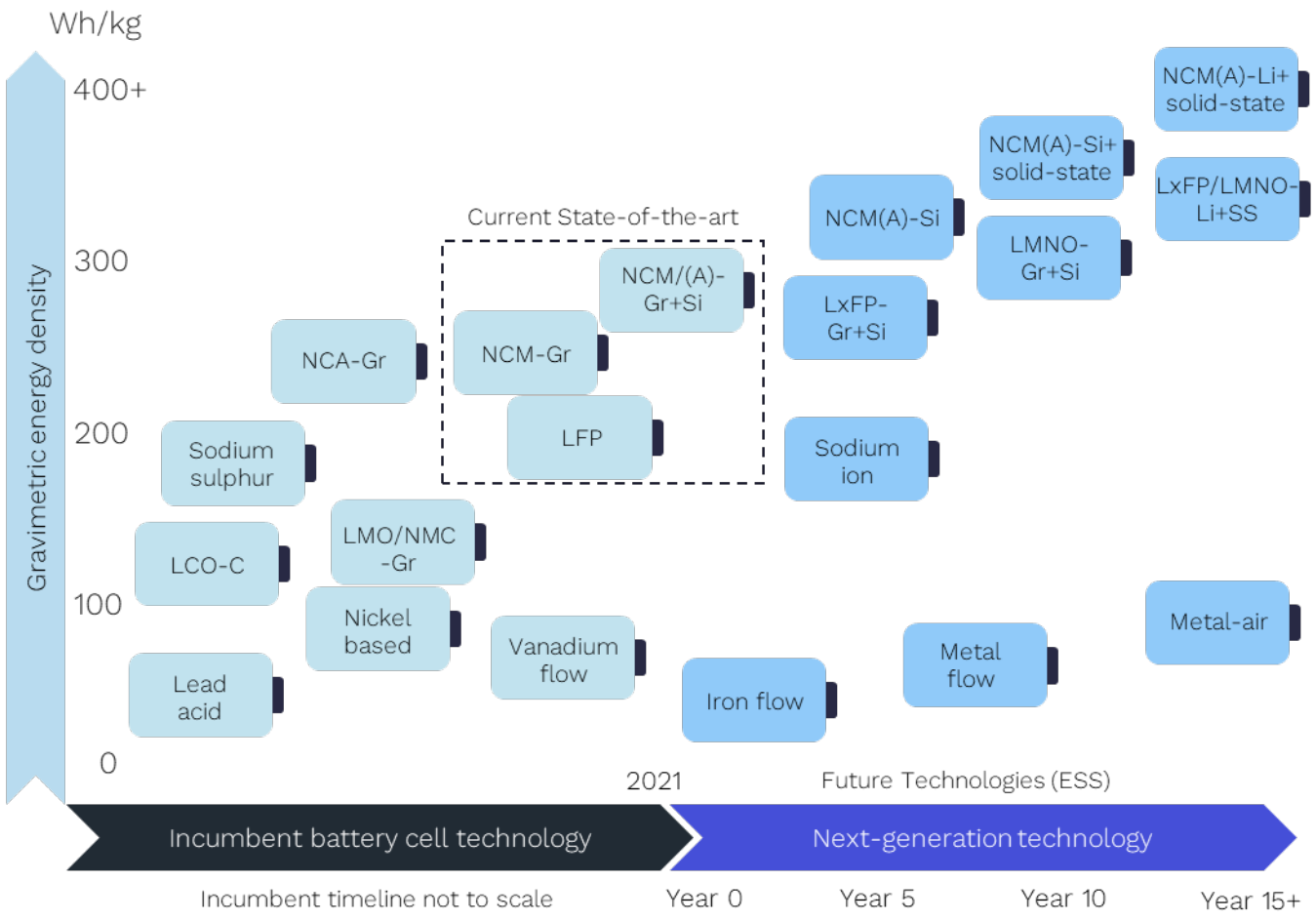


Li-ion (NCM) battery cell prices: automotive, large contract

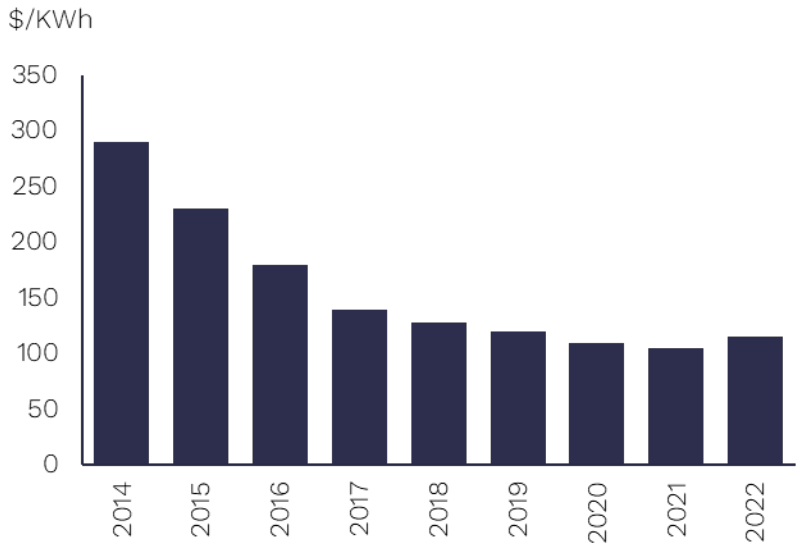
Battery technologies for ESS overview

Key Performance Indicator (KPI)	Relevant Unit	Priority (BESS)	Notes
Gravimetric Energy	Wh/kg		Generally not relevant (besides cost, $/kWh)
Volumetric Energy	Wh/L		High energy reduces cost, and volumetric is more relevant than gravimetric (e.g., facility footprint)
Power / C-rate	W, C-rate		Highly dependant on application, e.g., Uninterruptible Power Sources (UPS) might require high power vs. ESS for peak shaving
Cost	$/kWh, /cycle		Give long life and that ESS can generate revenue, $/cycle can be more important than $/kWh (e.g., consider OpEx vs. CapEx)
Cycle life and lifetime	Cycle n., years		Generally, applications require long life (e.g. >> 3000 cycles, 10-15y of operation).
Safety	Std. testing		As for most applications, safety cannot be compromised, also considering size of some installations (e.g., >1MWh)
Roundtrip efficiency	%		Parameter indicating how much energy is lost per cycle. Key in determining $/cycle.

Battery progress timeline



Li-ion (NCM) battery cell prices: automotive, large contract



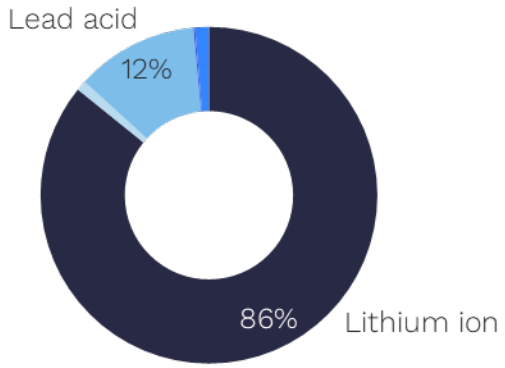
Source: Benchmark Mineral Intelligence

In 2022, lithium-ion cell price (in $/kWh) is set to increase for the first time in the last decade due to increasing lithium prices. LFP is still likely to be the preferred option for up to 4-6h storage. Depending on the application, incumbent technology might be an interesting option but mostly still far from scaled and reliably deployed.

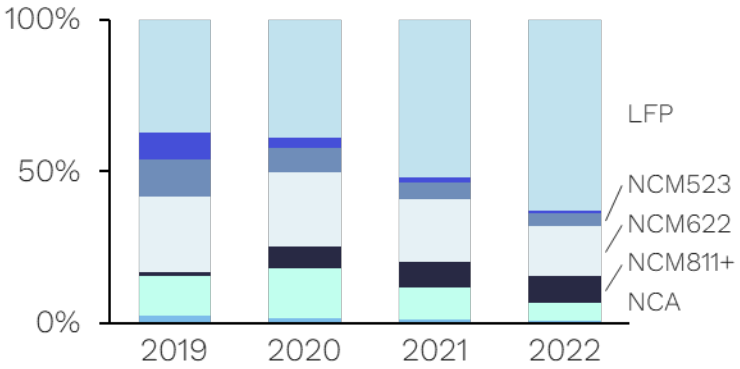
LFP is expected to be the chemistry of choice, but we'll be talking more about diversification

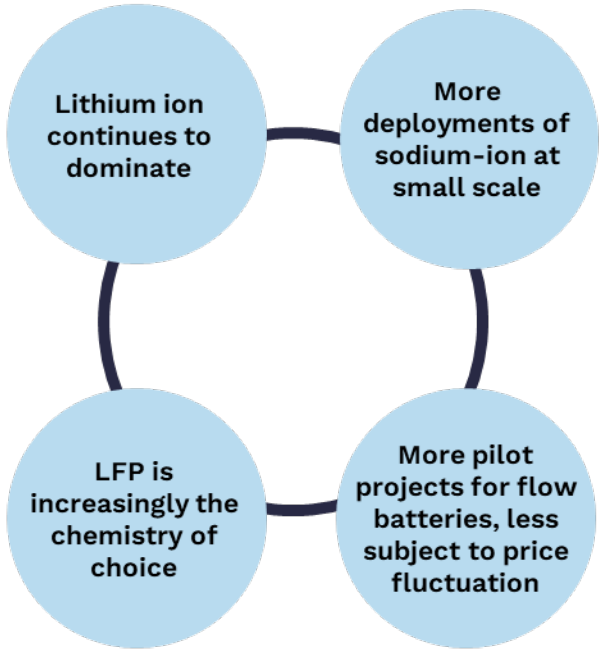
The incumbent chemistries

2021 installed BESS by battery type

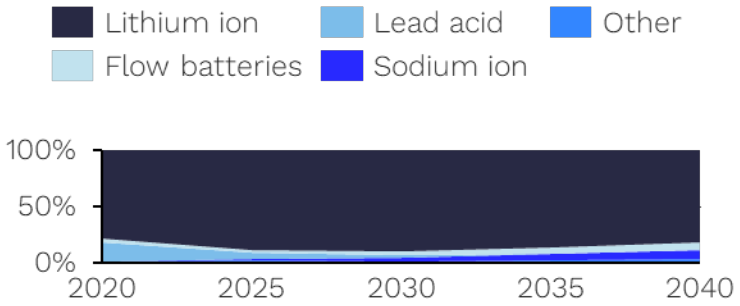


Annual installed BESS by lithium ion chemistry

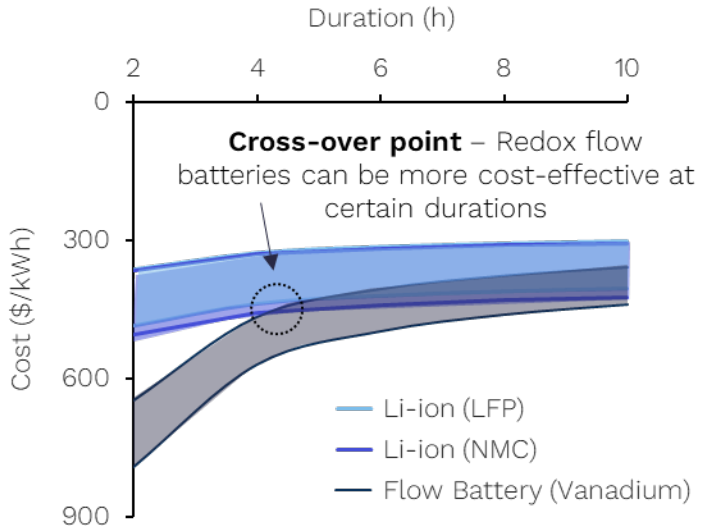




The emerging chemistries



Cost of Storage Duration Curve, PNNL (2020)



Bespoke battery technologies for BESS project

As demand for lithium-ion batteries in stationary storage increases, suppliers are starting to provide products which are better tailored towards this application, the focus being on lithium iron phosphate (LFP). Cells and systems based on this chemistry are generally safer and cheaper, and benefit from longer cycle life. Moreover, a recent switch from the automotive industry towards LFP, is motivating further technological development. Industry is now looking at innovating this chemistry to further improve energy and reduce system cost. China dominates the technology landscape for LFP, with a very mature and well-developed value chain. As of H2 2022, there is no major scaled up cell manufacturing in the west, with the exception of players such as SAFT, that serve a niche market.

CALB · BYD · CATL · SVOLT · Gotion · saft a company of TOTAL · EVE · SUNWODA

Next Generation LFP cells – Short term, roadmaps

Envision AESC — 160-200Wh/kg LFP + Gr

Gotion — 210-260Wh/kg LFP + Gr/Si

SVOLT — 210-230Wh/kg LFP + Gr/Si

CATL — 210-230Wh/kg. LxFP, or M3P. CATL confirmed that the new LxFP is a ternary L(M)P, with M including Mn, Fe and other dopants. Vanadium, Niobium, Zinc are some of the typical metals.

saft a company of TOTAL — Looking at LMFP by 2023, 60-80% Mn. Targeting ca. 400-500 Wh/L

SK · LG ESS Battery Division — Both LG ES and SK On have confirmed plans to manufacture LFP battery cells. LG is planning to set-up a manufacturing plant in the US to manufacture LFP cells for stationary storage.

SAMSUNG SDI — Other companies, such as Samsung SDI, are instead targeting Mn-rich chemistries to compete on cost.

Second life batteries for BESS

- Battery end-of-life use is increasingly become a central topic to battery supply chain. The decision on whether to recycle or reuse a battery is driven by a number of key variables.

Battery residual value

Battery design specifications

Economics of recycled materials

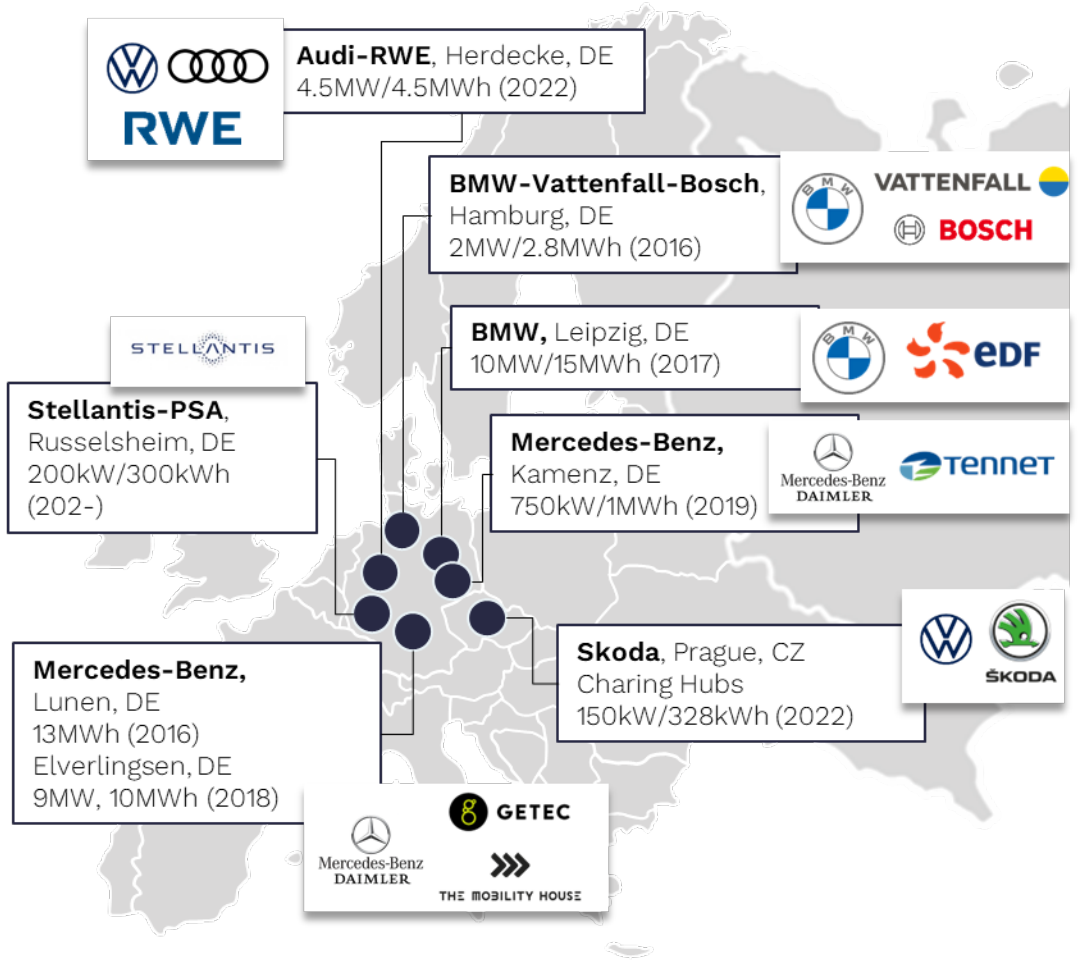
Warranty & insurance

Regulatory pressures

Case study

- The largest trial for second-life batteries is happening in China, commissioned by China Tower, for telecommunication towers. Eight providers of second-life batteries have been selected to provide a total of 2GWh of storage.

Second Life projects in Europe



ESS Battery demand relative to the EV market ~10%, rising to 20% by 2040

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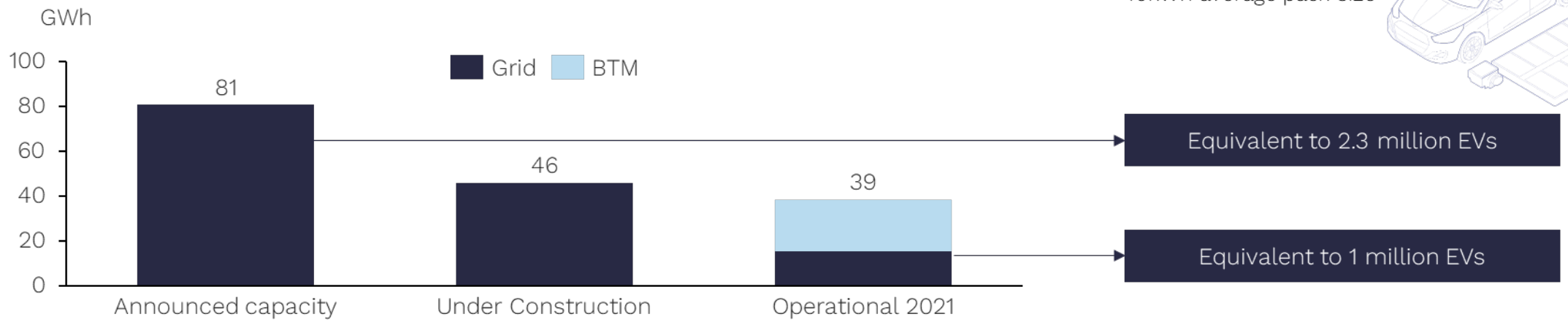
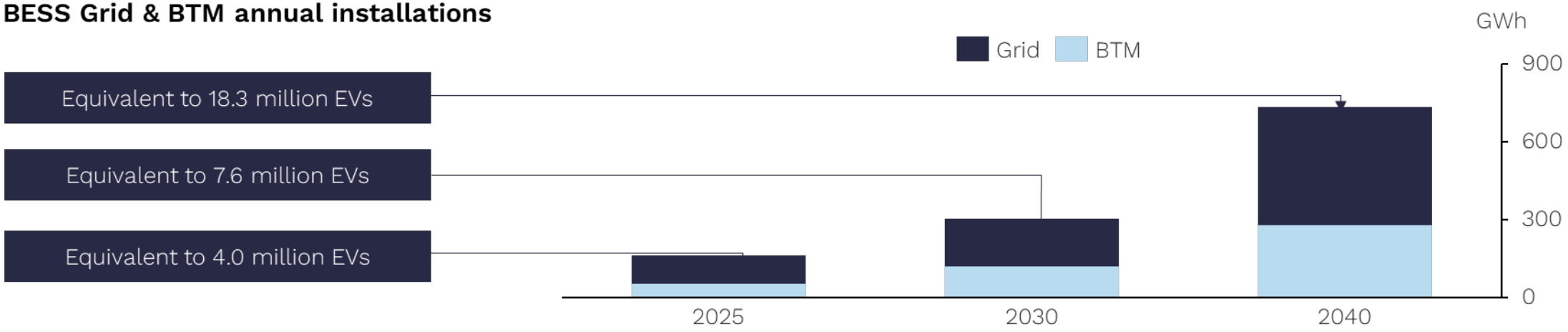
2021 BESS



*Calculations based on 40kWh average pack size

BESS Grid & BTM annual installations



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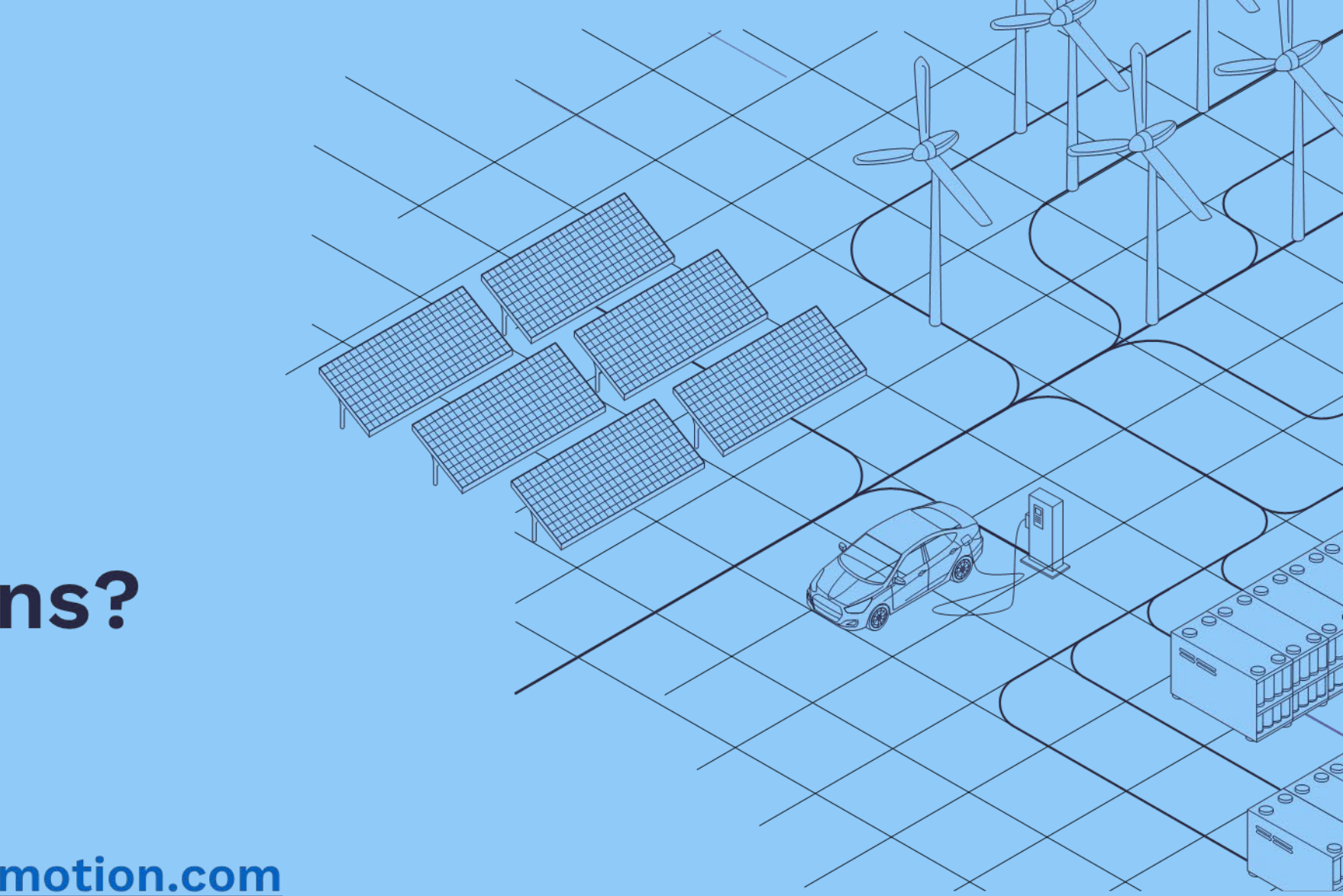

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