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Prospects for lead-carbon batteries in Chinese BESS installations

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- Grid-scale energy storage will play critical role in achieving Net Zero targets
- Huge expansion in energy storage required to accommodate rapid growth in renewable power generation, especially wind and solar
- Batteries will be required to manage impact on grid of hourly and seasonal variations in renewable energy generation and overall increase in electricity demand
- While pumped-hydro is currently the world's most widely used technology for energy storage its application is dependent on suitable locations being available
- Batteries can be installed almost anywhere and are scalable across a range of capacities

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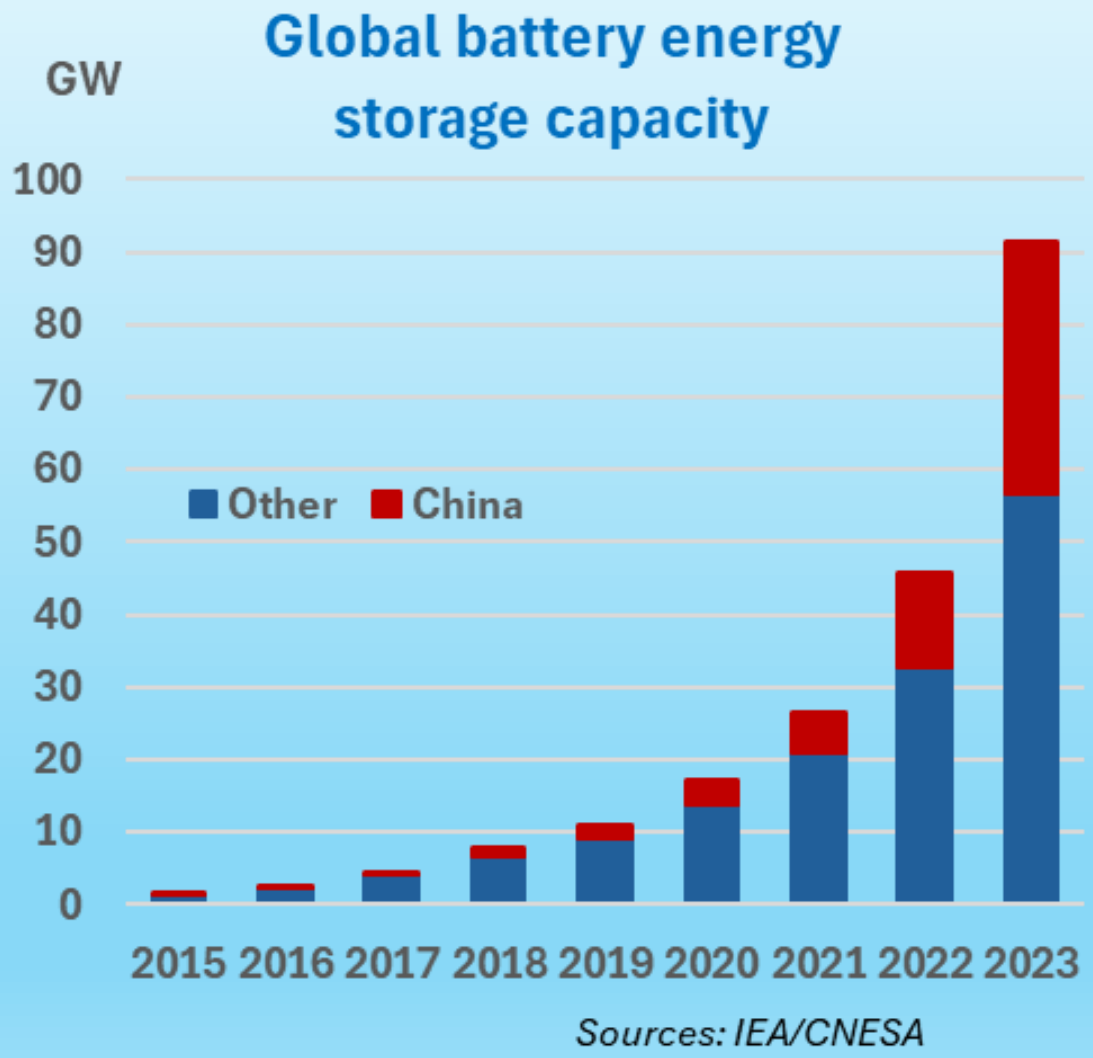

- Battery energy storage capacity has grown very rapidly over the past few years
- Capacity estimated to be over 90 GW at end of 2023 with more than one-third installed in China
- As recently as 2020 pumped hydro storage accounted for more than 90% of global energy storage overall with lithium batteries having a 92% share of *battery* storage
- In 2023 pumped hydro's share of global energy storage had fallen to 67%, with lithium batteries accounting for 96% of other storage technologies – mainly batteries

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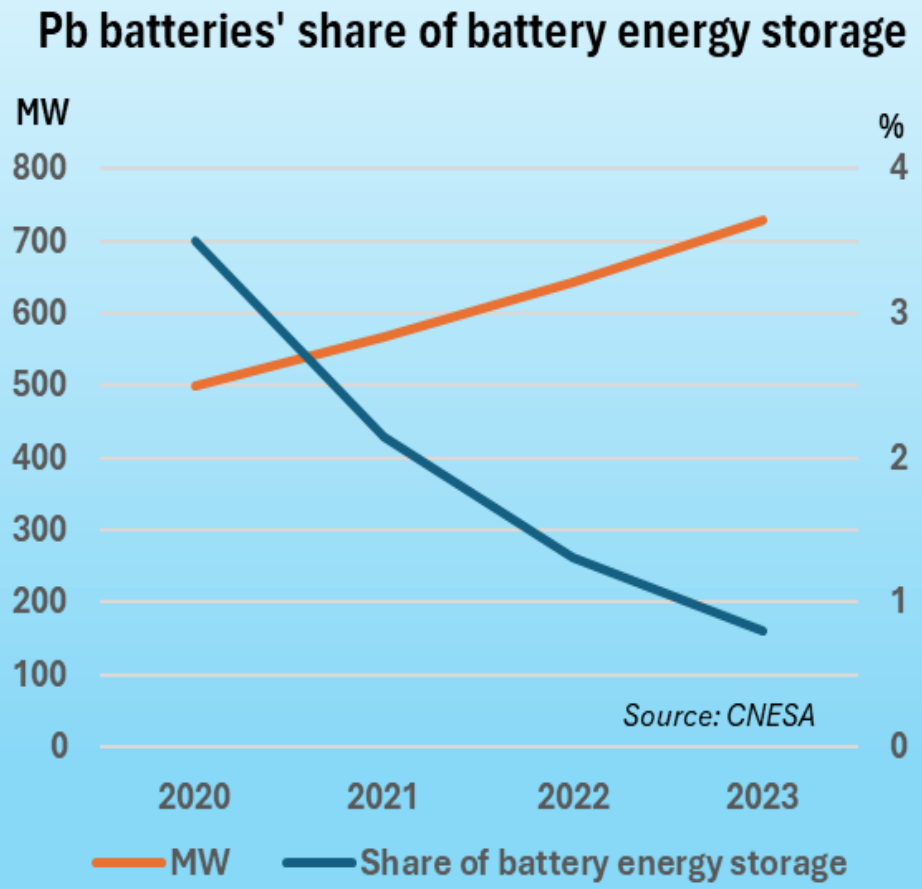

- Other energy storage technologies currently installed include molten salt thermal storage, compressed air energy storage and fly wheels, as well as sodium, lead and flow batteries
- As recently as 2020 lead batteries are estimated to have had a 3.5% share of the global battery energy storage market – in 2023 this was down to 0.8%
- With increase in battery energy storage overall this implies an increase in the capacity of lead batteries from 500MW in 2020 to 730MW in 2023

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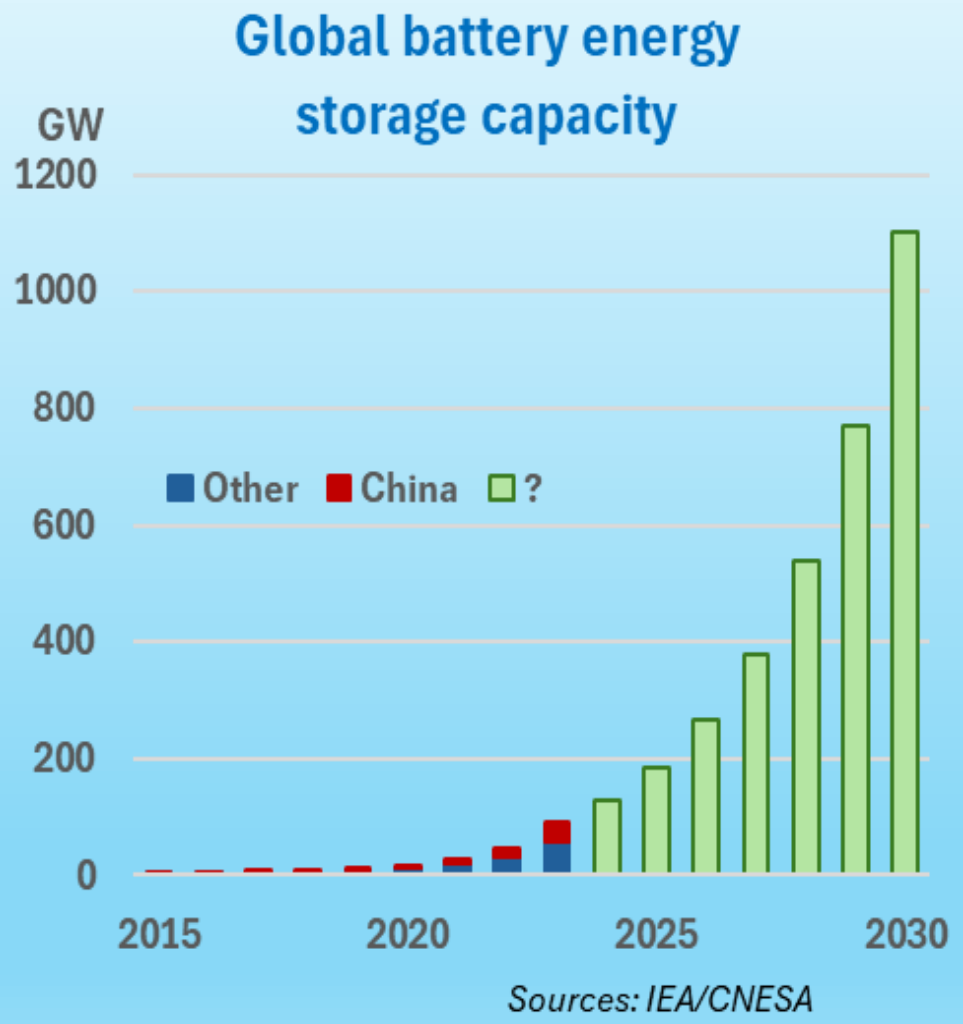

- Scale of energy storage required in the future is enormous
- Global renewable energy capacity needs to triple by 2030 to keep on track to achieve Net Zero by 2050 (IEA)…
- …requiring a six-fold increase in energy storage to maintain security of power supply
- The IEA envisages total global energy storage capacity of 1500GW by 2030, with batteries satisfying 90% of the growth
- This implies an increase of 1100GW from a little over 90GW capacity at the end of 2023
- Some context – battery capacity in electric vehicles at the end of 2023 was already ten times that deployed in energy storage

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- Projections of global electric vehicles sales (including PHEVs) show a rise from a little over 14 million in 2023, to around 40 million in 2030 and 60 million by 2035
- Requirements for battery materials and finished batteries must rise with EV sales
- Supplies of battery materials and capacity to manufacture batteries are currently surplus to requirements
- Expectations are that supplies of battery materials will tighten in due course
- Decline in lithium battery prices has been steep and consistent over past 10 years

- Cheaper LFP battery packs have contributed to lithium batteries dominating energy storage at the expense of all other technologies
- There are questions about sustainability of battery material supplies at current low prices especially as demand for batteries continues to grow
- Few make money manufacturing lithium batteries

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轻工业稳增长工作方案

- In July 2023 three Chinese ministries published a “Work Plan for Stabilizing Growth of Light Industry (2023-2024)” which, among many other subjects, gave encouragement to several battery chemistries to be developed for energy storage
- In particular, the work plan included a call to “*vigorously develop high-safety lithium-ion batteries, **lead-carbon batteries**, sodium-ion batteries and other products, and expand their applications in new energy vehicles, energy storage, communications and other fields*”
- In mid-2023, apparent official encouragement meant optimism increased about a role for lead-carbon batteries in the roll out of energy storage in China
- Work plan did not include active financial support for R &D or investment

- Progress in implementing lead-carbon battery installations has been slow
- Few new lead battery energy storage projects have been announced since a spate of activity in July 2023
- Excepting lithium, alternative battery technologies suitable for energy storage are, today, eking out an existence on the periphery of the BESS market
- Current outlook not positive for lead batteries in BESS applications but as demand for batteries grows developments in future supplies of lithium battery materials and prices for lithium battery packs may change perceptions
- There will be no shortage of lead to meet likely future demand for lead batteries

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What are lead-carbon batteries?

- A lead-carbon battery is, in essence, a lead-acid battery that has carbon additives in its negative plate
- Carbon in various forms, including activated carbon, carbon nanotubes, graphite, etc may be added to the negative active material
- Advantages are improvements in cycle life at greater depth of discharge (>2,000 @ 50% DOD) compared with conventional lead-acid batteries, faster charging rates, operation over a very wide range of temperatures (-40°C to +65°C)
- Many companies are now manufacturing lead-carbon batteries for a variety of applications

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- **In mid-2023 we identified 12 lead-carbon battery projects in China that were already commissioned and mostly located in Zhejiang province**

City	Province	Constructor	Installed capacity	Commissioned
Huzhou	Zhejiang	State grid	12MW/24MWh	2020 Nov
Quzhou	Zhejiang		100KW/500KWh	2021
Huzhou	Zhejiang	Taihu Electric	460MWh	2018 Feb
Huzhou	Zhejiang	Taihu Electric	2MWh	2021 Apr
Lhasa	Tibet	Jinlin Electric Power	6MW/30MWh	2022 Feb
Dingbian	Shaanxi	Taihu Electric	5MW/12MWh	2022 Jun
Jieshou	Anhui	Huabo & Narada	18MW/144MWh	2022 Jun
Huzhou	Zhejiang	Jinlin Electric Power	10MW/97MWh	2022 Dec
Huzhou	Zhejiang	Taihu Electric	7.5MW/75MWh	2022 Dec
Huzhou	Zhejiang	Taihu Electric	100MW/1.06GWh	2023 Mar*
Jiangyin	Jiangsu	Taihu Electric	25.3MW/243MWh	2023 Aug
Huzhou	Zhejiang	Taihu Electric	42MW/285MWh	2024 Apr

**1st phase of 478MWh completed, 2nd phase under construction*

- Authorities in China aim to encourage and give opportunities to competing battery technologies
- Some new battery facilities will be built at full scale as demonstration plants and to provide accurate performance and cost data
- Two new investments specifically for the manufacture of lead-carbon batteries were approved last year
- In November 2023 Guangdong province approved the construction of a 27GWh lead-carbon battery plant in Lechang city (Shaoguan prefecture) with a planned total investment of RMB 5.175 billion (~US$ 725 million)
- Originally announced in July 2023, construction is reported to have started in May 2024 on Kungong Technology's 20GWh lead-carbon battery plant in the Yinchuan High Tech zone in Ningxia Hui Autonomous region with investment of RMB 2.4 bn (~US$330 million) with 1st phase commissioning now not expected until June 2025

• Selection of lead-carbon BESS planned

City	Province	Constructor/Developer	Planned capacity	Announced
Huzhou	Zhejiang	Huaneng Energy Development	100MW/200MWh	2022 Dec
Huzhou	Zhejiang	Taihu Electric	600MW/3000MWh	2023 May
Huangguang	Hubei	Guohua New Energy	100MW/200MWh	2023 May
Yinchuan	Ningxia	Taihu Electric	200MW/400MWh	2023 Jun
Zhongwei	Ningxia	China National Chemical	200MW/400MWh	2023 Jun
		Engineering Construction		
Foshan	Guangdong	Guangzhou Energy Valley	100MW/400MWh	2023 Jul
Jiangmen	Guangdong	Guangzhou Energy Valley	470MW/1880MWh	2023 Jul
Guangzhou	Guangdong	Guangzhou Energy Valley	100MW/400MWh	2023 Jul
Guangzhou	Guangdong	Guangzhou Nenggu Technology	200MW/800MWh	2023 Jul
Guangzhou	Guangdong	Guangzhou Qingchuang Trade	200MW/800MWh	2023 Jul
Guangzhou	Guangdong	Taizhou Linhu Nenggu Technology	150MW/600MWh	2023 Jul
Shanwei	Guangdong	Guangdong Southern Smart Energy	200MW/800MWh	2023 Aug

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The case for lead-carbon batteries

- Well proven, established and safe technology with no risk of thermal runaway or spontaneous combustion and using a relatively non-toxic electrolyte
- Cost effective with potential to deliver 2,000+ cycle life
- Significant improvement in terms of depth of discharge compared with conventional lead batteries
- Operation possible over a wide range of temperatures
- Proven in micro-grid applications
- Fully recyclable with a well-established recycling infrastructure already in place
- Spent batteries have a significant value as battery scrap which improves the overall life cycle cost of installations

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Perceived disadvantages of lead batteries

- Lead-carbon batteries are not considered suitable for longer duration energy storage
- Life-cycle costing negatively affected by two issues – number of cycles before battery replacement and limits on depth of discharge which necessitates larger installed capacity relative to, for example, lithium systems
- Falling cost of competing battery technologies, especially lithium

- At this early stage in the battery energy storage business there are almost no actual case studies where installations have gone through a full life cycle which can be used for purposes of comparing operating performance and actual lifecycle cost of different technologies
- Much performance data are currently still laboratory based
- Huge investment in improving lithium battery technology in recent years and assurances of significant lifecycle advantages provide lithium batteries with an almost unbeatable advantage
- LFP cell prices forecast to halve by end of 2024 compared with December 2023!

- After reviewing developments over the past year, we conclude that few new lead-carbon battery storage installations of any meaningful scale have been commissioned
- Several projects are in the pipeline, but it is difficult to determine whether much progress has been made in bringing them to fruition
- There has been news of one lead-carbon battery plant, which was to have been built near Zibo in Shandong province, being terminated even after some initial spending on land acquisition and with planning and engineering studies already underway

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What needs to be done?

- Lead BESS demonstration projects need to be funded and widely promoted
- More investment required to enhance the performance of lead batteries in all applications
- Huge potential for use in battery energy storage systems, but other opportunities should not be downplayed
- Risk that the major role of lead batteries in two and three-wheel electric mobility is being air-brushed from history
- This end use currently accounts for 20% of global lead demand in batteries, mainly in China
- More effort needed to counter assumption that only lithium batteries are suitable in roll out of electric two and three-wheelers in countries other than China

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- Providing independent, detailed analysis and forecasts of global lead and zinc industries
- Covering all aspects of mine and smelter supply and end-use consumption
- Data from original sources wherever possible
- A particular focus on Chinese market
- Offices in the UK and Xi'an
- Clients include producers, consumers, traders and hedge funds

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