BATTERY STORAGE

Market Analysis
October 2020

BDO

Content

Did you know that?

Top producers of battery metals in 2019 were…


DRC[1]

70%[2]
Cobalt


Australia

54%
Lithium


Indonesia

30%
Nickel

Top producers of Lithium-Ion batteries in 2019 were…

LG Chem

South Korea

CATL[3]

China

BYD

China

~5% of the total production capacity

In order to meet 2025 demand for Lithium current supply has to be increased by

3 times

requiring an investment of at least 8 Bn USD in the next 10 years.

Total investments in battery storage production are projected to exceed…

150 Bn USD

by 2023, which is close to 20 USD for every person in the world.

Raw materials make up…

79%

of the Lithium-ion battery cost (25% of the manufacturing cost of Tesla Model 3 is the raw materials of the battery).

Over the last decade battery prices fell by…

87%

reaching 156 USD/kWh[4] in 2019, which made EVs and energy storage commercially viable for the first time in the history.

Number of people employed in a battery value chain accounts for[6]…

2 Mn

more than 3/4 of which work in developing countries.

Number of people still living without access to reliable electricity amounts for[7]…

600 Mn

which could be decreased by the deployment of battery storage technologies.

You might be surprised to know that…

28,000 years

is an estimated useful life of Nano-diamond battery, which is likely to be commercialised in 2020.

>50%

of New Caledonia citizens, use electricity produced by island's solar panels combined with battery storage.

2019 Nobel Prize in Chemistry

was awarded to 3 scientists[5] for the development of the Lithium-ion battery.

1,050 kg

is the battery weight you may need to store enough electricity to run everything in your house for a week[8].

Source: World Bank; International Energy Agency; S&P Global; BloombergNEF; World economic Forum; Benchmark Mineral Intelligence
Notes: (1) Democratic Republic of Congo; (2) Share in the global production in 2019; (3) Contemporary Amperex Technology; (4) Kilowatt-hours; (5) John Goodenough, Stanley Whittingham, Akira Yoshino; (6) As of 2018; (7) As of May 2019; (8) Based on average US household consumption, 0.3 USD/kWh electricity price, 150 USD/kWh battery cost;

Batteries background

Evolving role of battery storage

History of battery energy storage development

The 20th century was highly impacted by the invention of batteries and the devices they powered. From a purely scientific experiment in the beginning, to becoming an essential part of people's lives. Today, batteries are helping the global energy transition and the move to a low-carbon world.

⚡ - technology differentiator

First steps towards battery future

The first batteries were large constructions with a short lifespan and often caused short-circuits, but later developments made batteries useful rechargeable storage for energy.

1800

The first electric battery discovered was built of Zinc, Copper, and Cardboard. ⚡ It could provide a continuous electrical current.

1859

The first Lead-acid battery was constructed, a primary type of storage in automobile starters today. ⚡ Rechargeable, low cost, supply high surge currents.

Spread of battery usage

Continuous improvement in safety, mobility and power capacity transformed the massive battery to a portable energy source, which has become an integral part of people's modern life.

1950s

Development of Alkaline battery, widely used in household devices from remote control to flashlights. ⚡ Inexpensive and typically non-rechargeable.

1989

First sales of Nickel-metal hydride batteries, used in power tools, electronic devices, applied in early EV. ⚡ More environmentally safe, higher density.

Lithium-ion revolution

Li-ion technology allowed portable computers and phones to become lighter and smaller, fundamentally altering the way people work, communicate and access information.

1991

Sony released the first commercial Lithium-Ion battery. ⚡ Increased lifespan, lighter and smaller.

2008

Tesla released the first serial-production battery-powered car. ⚡ 320 Km of travel per charge, full-battery charging time — 4 hours.

Rising environmental concern

With the ever-growing battery production and increasing ecological impact awareness, companies start to make power storages for renewable energy and reuse old batteries.

2015-2017

Automotive giants (Daimler, Nissan, BMW, Renault) engage in recycling and reuse of their EV energy storage. ⚡ Increased useful life of EV batteries.

2020

LS Power built the largest battery in the world (230 MWh[1]) to provide a surplus of solar-generated energy after sunset. ⚡ Increased grid stability, min energy loss.

Battery storage transformational potential

Nowadays, batteries are key to hybridisation and electrification, which brings considerable opportunities in terms of job creation, economic growth, energy security, health, and environmental protection.

30%

of required emission reductions in the power and transport sectors can be obtained using batteries.

150 Bn USD

of economic value and 10 Mn jobs can be created due to a sustainable battery value chain.

600 M

people could receive access to electricity, reducing the lack of electrification by 70%.

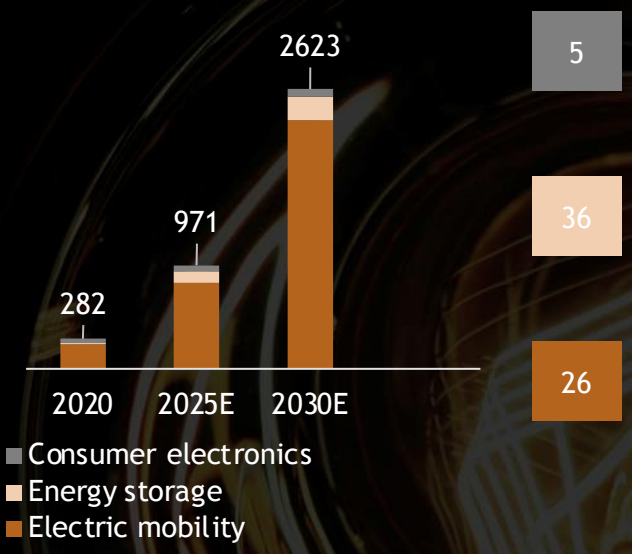
Source: World Economic Forum; Global Battery Alliance
Notes: (1) Megawatt-hours

Battery solutions for various needs

Battery energy storage applications

Battery technologies are an essential catalyst to unlock growth in sectors such as electronic vehicles, electronic devices, and battery energy storage for renewable energy. The market is projected to reach 546 Bn USD in 2030, growing with a CAGR of 21% in 2020-2030.

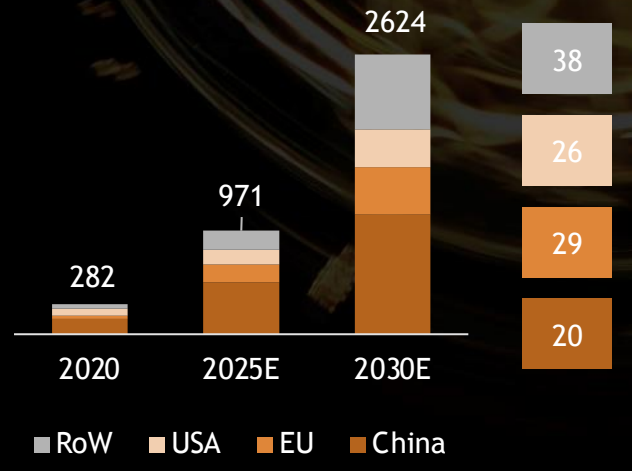
Global battery demand by application, GWh[1]



CAGR, % 2020-2030

The main drivers of growing battery demand are the electrification of transportation and the deployment of batteries in electricity grids.

Global battery demand by region, GWh[1]



CAGR, % 2020-2030

Global battery demand is expected to grow by 25% annually. Currently, China is the biggest market, taking a 50% share in the global demand in 2020.

Large-scale industrial batteries applications

Energy

1. **Hornsdale Power Reserve, Australia**
   One of the world's largest Lithium-ion batteries, developed by Tesla, can power 30 K homes when dispatching at peak output.
2. **Tesla Powerwall, the USA**
   Powerwall is a home energy storage solution. Tesla's solution optimises energy costs and reduces dependency on the power grid.

Transportation

3. **Battery storage, the Netherlands**
   Grid operators and Renault have built 1 K public solar-powered smart charging stations with battery storage, decreasing peak load by 27-67%.
4. **Yara Birkeland, Romania**
   The world's first electric and zero-emission container vessel was launched to the sea in Romania in February 2020.
5. **Hybrid-electric regional airliner, the UK**
   EAG[2] started the development of 70-seat hybrid-electric airliner, which is planned to be ready to enter service in 2028.

Aerospace

6. **Mars Curiosity Rover, the USA**
   Li-ion is the battery of choice for satellites. The Mars Curiosity Rover, developed by NASA, uses a specially designed Lithium-nickel battery.

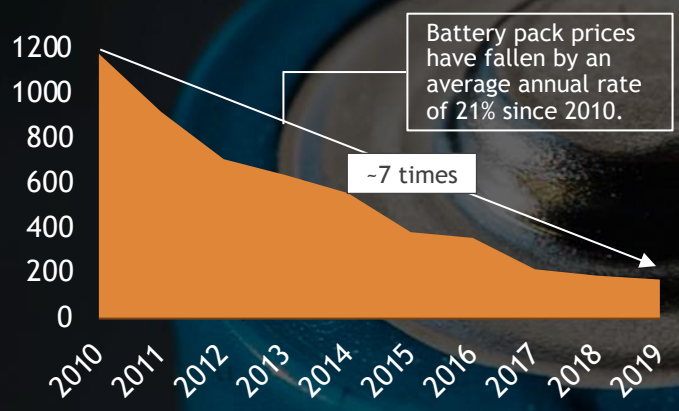
Source: US Department of Energy; Queensland Government website; Battery university; BloombergNEF; CNBC; Lux Research; Tesla website; NASA website
Notes: (1) Gigawatt hours; (2) Electric Aviation Group

Future look at battery innovations

Achieved improvements

Recent rapid improvements in batteries' costs and performance has unleashed the massive potential of the advanced battery technology ecosystem. Batteries are simultaneously becoming longer-lasting, lighter, and safer, leading to rapid increases in value for customers.

Battery pack price, USD per kWh[1,2]



Improved battery safety
Batteries become more resistant to overcharge and electrolyte leakage. It is reported that resistances of the passivated cells could be increased by ~5 times, ensuring high safety and thermal stability.

Battery innovations

Increased energy density
New battery technologies enabled batteries to achieve a higher energy density. For instance, Li-ion batteries' density increased by 50% in 2010-2019.

Decline in production costs
Batteries become cheaper due to the improvements in manufacturing equipment and reduced capital costs. For example, battery packaging costs[3] are projected to be reduced by 10-15%.

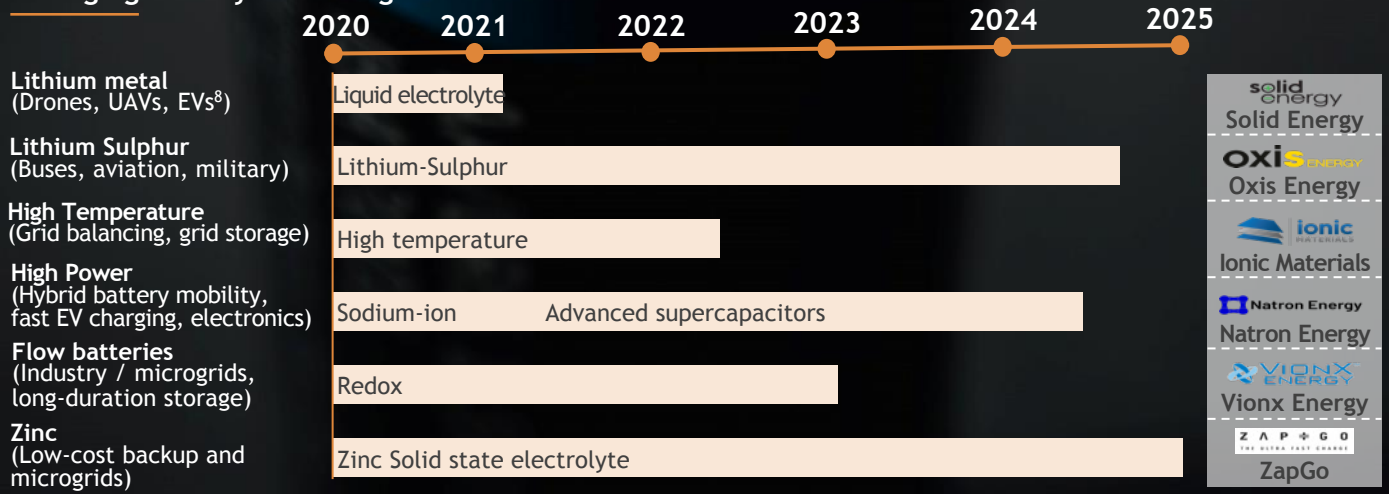
Recycling evolvement
Thanks to the new production methods, battery manufacturers can produce the batteries with up to 4% of recycled materials.

Batteries' innovations impact
As batteries become cheaper and more efficient, more markets are electrifying[4]. Furthermore, falling battery costs are changing the economics of wholesale power markets. For instance, these changes led to the decline in investments and cancellations of new natural gas-fired power generation projects.

Next-generation technologies

Scientists continuously develop more space- and weight-efficient batteries at an affordable cost (such as NMC[5] and NCA[6]). Next-generation technologies under development are likely to deliver a step-change in the performance of key battery characteristics.

Emerging battery technologies timeline[7]



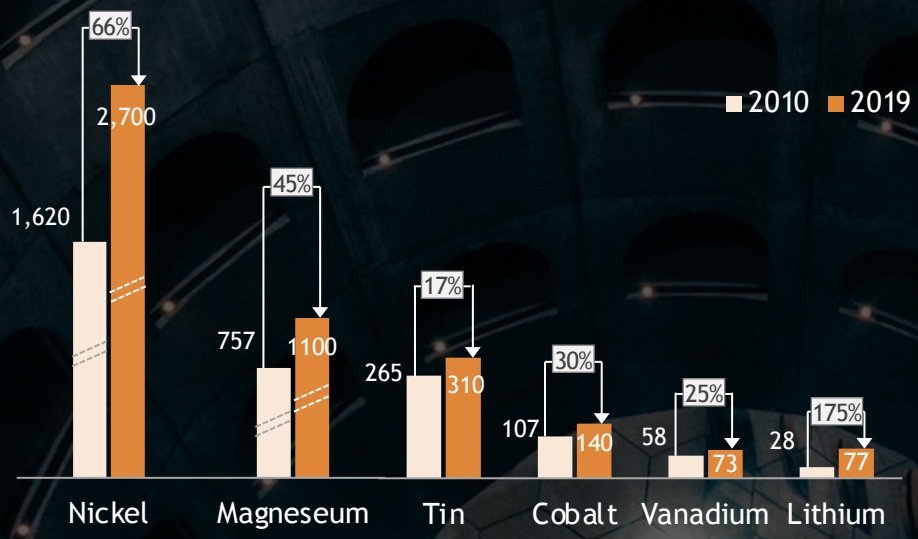
Source: Lux Research; US Department of Energy; Queensland Government; Battery university; Rocky Mountain Institute; BloombergNEF; CNBC
Notes: (1) Gigawatt hours; (2) Electric Aviation Group; (3) Usually, battery packaging costs represent around 19%-34% of the total pack price; (4) For instance, low-cost Li-ion batteries contribute to a rapid scale-up of demand for smaller EVs in fast-growing markets like India; (5) Li-nickel manganese cobalt oxide; (6) Li-nickel cobalt aluminum; (7) Timeline represents the planned duration of technology development; (8) Unmanned aerial vehicle and electric vehicle

Battery metals market overview

Battery metals market overview

The growing electrification of transport and adoption of renewable energy sources is driving rapidly increasing demand for batteries and their input commodities including Lithium, Cobalt, Nickel, Graphite, Manganese, and Aluminium.

Battery metals production, MT[1]



Production of Nickel and Tin as the main components of Li-ion batteries increased by 65% in 2010-2019. However, considerable supply challenges are expected due to the booming EV demand.

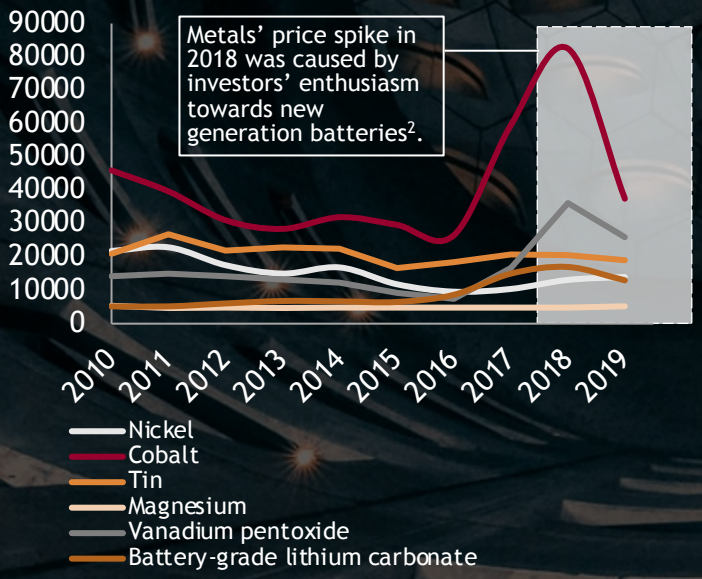
Battery metals supply is oligopolistic in structure and mainly concentrates in developing countries. Currently, China controls the global market, supplying more than 90% of global rare earth production.

It is expected that demand for Lithium, Graphite, and Nickel will skyrocket by 965%, 383%, and 108% respectively by 2050. Battery manufacturers, such as Tesla, expect global shortages of electric-vehicle battery minerals and as such is making considerable investments to ensure its own supply.

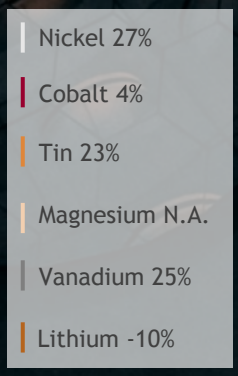
Battery metals price analysis

A sharp decline in battery metals prices in 2019-2020 has been caused by several issues that include a slowdown in all vehicle sales (including EVs), disruptions in supply chains globally caused by the pandemic and subsequent weak economic performance as the world adjusts to life after.

Battery metals price, USD per MT[1]



Price change 2020 YTD[3]



Geographical supply concentration is putting considerable downward price pressure across all battery metals, particularly Cobalt and Lithium.

The COVID-19 has created a prolonged low-price environment for the most commodities. However, Cobalt and Lithium remained relatively strong, slipping just 4% and 10% accordingly from the beginning of the year.

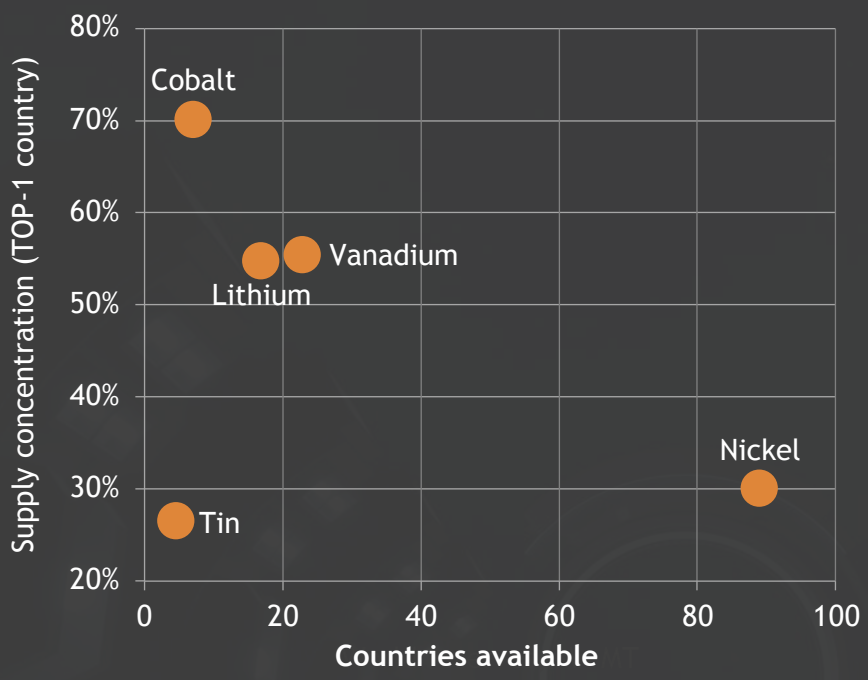
Source: USGS; Thomson Reuters; World Bank; S&P Global Platts
Notes: (1) Metric Toone; (2) Particularly, investors were interested in Lithium and Cobalt application in EVs and Vanadium usage in utility grid scale flow batteries that supercharge wind and solar farms; (3) Price change was calculated based on the metals' spot prices on 1 January 2020 vs 17 September 2020

Challenges faced by the battery storage industry

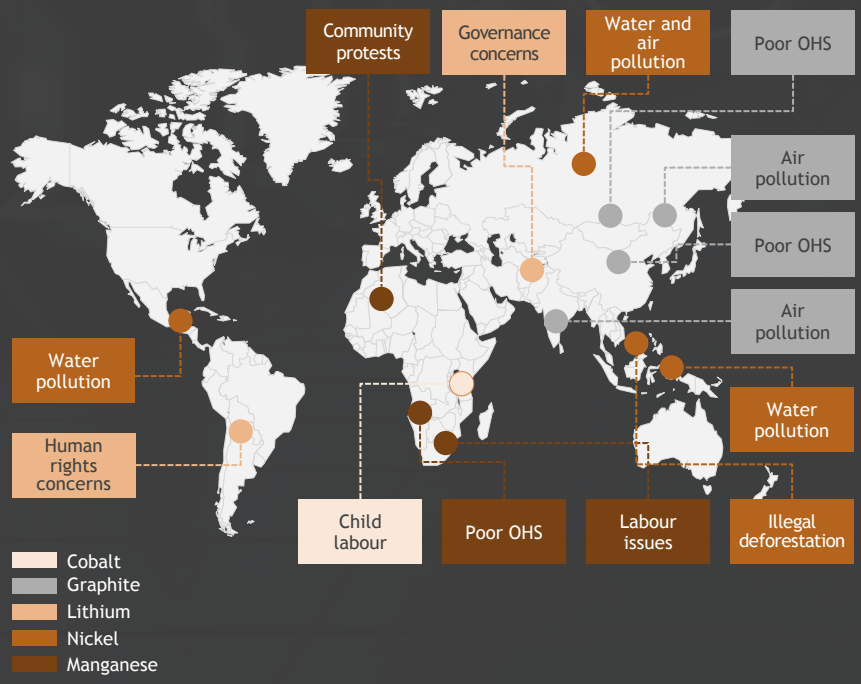
Battery market bottlenecks

The battery market faces many challenges due to the rapid scaling of battery applications. Those harnessing the battery revolution including automotive, electronics, and utility infrastructure might see competition rise from outside industries and the limited resources and new technologies coming online.

Battery metals resource analysis



Battery metals challenges snapshot



1 Battery minerals supply concentration

Metals supply concentration is a major concern for battery producers. With 70% of Cobalt production and 55% of Vanadium production coming from the DRC and China, respectively. There are significant risks of supply disruption caused by government policy or socio-political instability.

2 Battery metals supply shortages

Many battery production stakeholders are concerned whether supply could meet demand in the future. However, it is expected that supply can even outpace demand based on significant reserves.

3 Undeveloped recycling market and standards

Whilst modern recycling technologies are improving, presently only the high-value metals are being recycled, not the entire batteries. For instance, the average recovery rate of Cobalt is 30%, whereas it could go up to 95% using appropriate technology.

4 Unethical and non-environmental production

The most prevalent battery market risks are environmental, followed by poor OHS[1] conditions and human rights violations. This puts additional pressure on battery producers due to the socially-conscious consumers & investors who are increasingly questioning the provenance of raw materials in products they use[2].

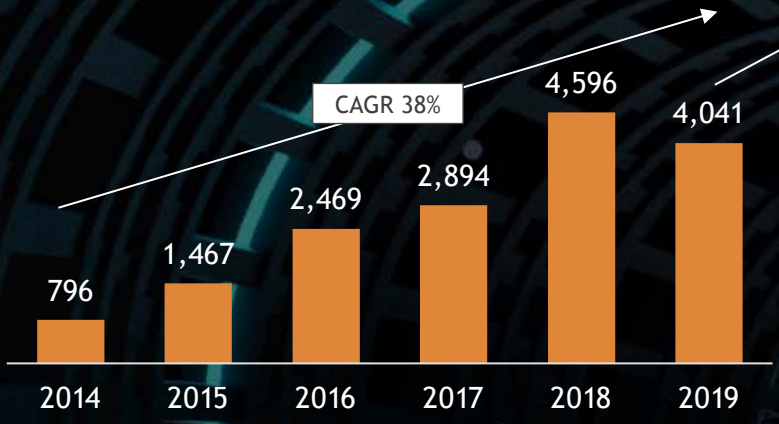
Source: USGS; S&P Global; Berkeley University of California; RCS Global
Notes: (1) Occupational Health and Safety; (2) For instance, Apple stopped buying Cobalt from artisanal mines in the DRC due to their dangerous working conditions

Battery storage market investment climate

Current investment climate

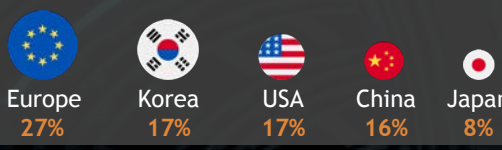
Global investments in battery storage increased by 5 times from 2014 and reached 4 Bn USD in 2019, driven by recent rapid improvements in battery costs and performance, coupled with a growing demand for electric vehicles and increased renewable energy generation.

Battery storage investments worldwide, Mn USD



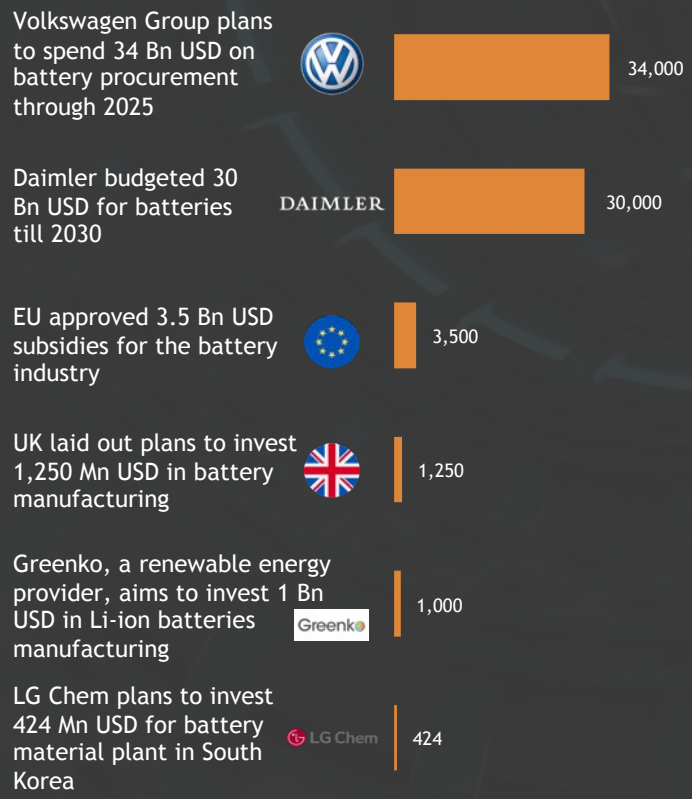
Industry experienced a 12% investment downturn in 2019 compared to 2018, mainly because of 15% decrease in spending on grid-scale batteries.

Top 5 battery storage investing countries, % of total 2019



Future battery storage investments

Battery related investments (selection), 2019-2020, Mn USD



Largest Battery industry M&A in 2019-2020[1], Mn USD

Buyer	Target	Country	Value
John Hancock Infrastructure Fund	Duke Energy	USA	1,250
Volkswagen Group	Gotion High-Tech	China	1,100
Wesfarmers	Kidman Resources	Australia	776
MIND ID	Vale Indonesia	Indonesia	391
Equis Development	Jara 1 Project	South Korea	50

Major investment trends

Government support

As countries set ambitious goals for clean energy adoption, programs to support battery manufacturing have followed[2].

Green energy shift

Renewable energy is expected to eclipse natural gas after 2040. New stations require more energy storage, which is expected to reach 942GW by 2040 with 620 Bn USD in investments.

Transition to EV

During 2010-2019 the number of battery-powered cars increased by 420 times. Therefore, 29 global automakers plan to invest another 300 Bn USD[3] in battery storage till 2030.

Source: International Energy Agency; Forbes; BloombergNEF; Rocky Mountain Institute; IJ Global
Notes: (1) Until 20 September 2020; (2) For instance, in 2020 Australia released 5.5 Bn USD renewables (mostly solar and battery) investment plan; (3) With Volkswagen Group (91 Bn USD) and Daimler (42 Bn USD) at the top of the list

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