Stationary battery storage:

5 preferred technologies to reduce dependence on critical materials and contribute to the energy transition

Summary of the Sia Partners study on stationary battery storage

Current market and trends

Stationary battery storage capacities increased 11-fold between 2018 and 2023 worldwide, reaching **a total installed capacity of 86 GW** . These capacities will continue to multiply in the coming years, making it possible to significantly diversify electricity storage technologies, currently mainly supported by PETS. To contribute to achieving the carbon neutrality objectives in 2050, it is necessary to **maintain the current rate of capacity increase until 2030**.

The **establishment of regulations** and the **diversification of methods for valorizing stationary batteries** will be the main vectors for the development of stationary batteries and will ultimately enable an improvement in the profitability of installations.

Material constraints

The stationary storage deployment objectives planned with the current policies will cause a **14-fold increase in demand for materials** (Cobalt, Nickel, Lithium, Vanadium and Manganese) **by 2040**. However, the mining capacities of lithium, cobalt and nickel, the main and critical components of the majority of batteries currently available on the market, are already under pressure and will no longer be able to meet the demand forecast for 2030. Furthermore, these Supply tensions caused a **x2 to x5 increase in the prices of these metals between 2021 and 2023,** impacting the price of batteries during the period. Possible instabilities in battery prices linked to supply tensions could, ultimately, threaten the contribution of stationary batteries to the energy transition.

New battery technologies

Faced with these material supply challenges and to guarantee market development, investments **must be shifted towards the diversification of** battery technologies with **more sustainable materials** . The **analysis proposed by Sia Partners** highlights that **new technologies (sodium and potassium batteries, vanadium-based Redox batteries) are emerging** and present similar or even better performances than mature technologies today, while guaranteeing a better durability, to **complement already mature and efficient batteries** .

Contents

Preamble

This study provides reading keys on stationary batteries*, in particular on the different battery technologies and associated materials. Sia Partners draws on its sectoral expertise to provide a global overview of the stationary battery storage market.

Achieving carbon neutrality by 2050 requires developing electrical flexibility solutions to respond to the intermittency caused by the integration of renewable energy sources on the network. Among these solutions, stationary battery storage should ultimately constitute the largest source of energy storage ahead of pumped-storage hydroelectric power plants, which today dominate global storage capacities.

Our study, which is based on numerous sources of information and our analysis, highlights a lack of supply of critical materials (lithium, cobalt, nickel) by 2030 given the growing demand for stationary storage by batteries necessary for carbon neutrality.

Faced with this observation, Sia Partners offers a comparative analysis of the performance of the battery technologies identified, in particular comparing mature technologies to available emerging technologies. Two major axes stand out in this analysis: the durability of the main materials making up the battery studied and the potential use of the technology for an industrial player wishing to install a park of stationary batteries on its site.

**The mention of the term “stationary batteries” in this study refers to technologies available for stationary battery storage*

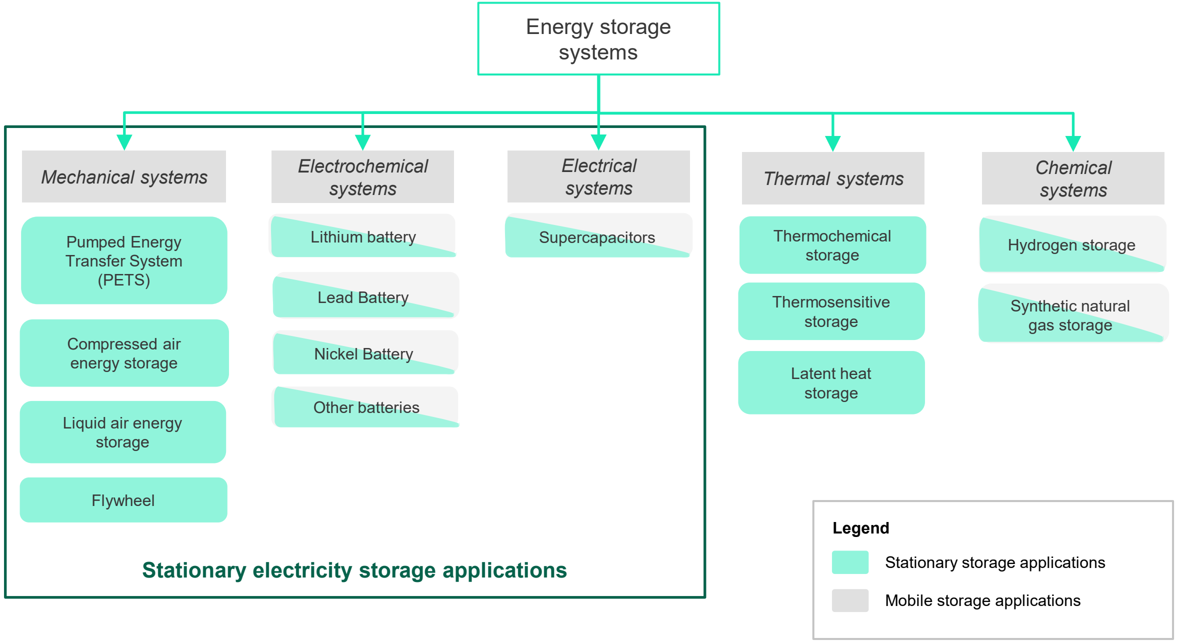
Energy storage is an essential way to adjust supply and demand while limiting losses

Energy storage allows adaptation over time between supply and demand by reserving a quantity of energy for later use. This concerns not only electricity demands, but also heat and cold demands. It also makes it possible to limit losses in the event of overproduction.

The demand for energy, particularly the demand for electricity, varies throughout the year and during the day.
The strong peaks in consumption have, to date, been mainly cushioned by the start-up of thermal power plants (gas/oil) and by the use of storage systems such as the PETS (Pumping Energy Transfer System).

The development of storage thus makes it possible to reduce CO2 production, promote renewable energy, and therefore limit electricity imports.

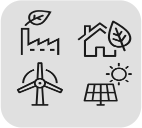
Main energy storage technologies



Source : CGE based on World Energy Council, 2017

Among stationary electricity storage technologies, PETS remains the most widely deployed today, but batteries are emerging

In opposition to on-board or portable storage, dedicated to mobile applications such as electric vehicles (EV), telephones and computers, stationary storage brings together technologies capable of storing energy in fixed installations and shifting its use to return it at a more advantageous time.

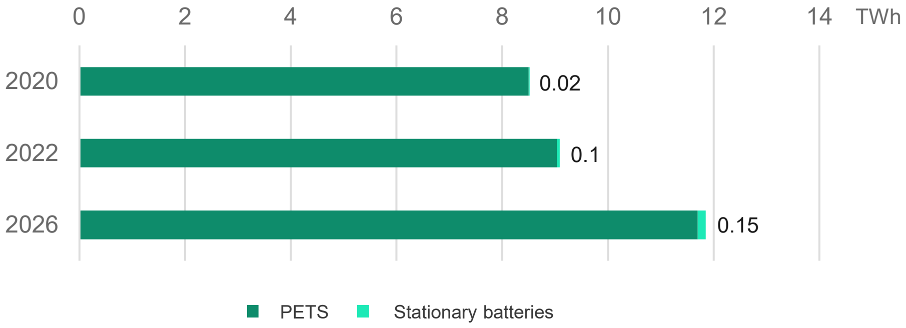


Stationary storage **makes it possible to store large quantities of electricity** (up to several MW) over **variable durations** (from 1 hour to several tens of hours) depending on the applications and technologies.

PETS is the most widespread technology to date.
However, batteries are playing an increasingly important role, particularly because they can be **installed anywhere** , and have a **varied range in terms of capacities.**

The fields of application for stationary storage are very wide and batteries can be installed in **private homes** , **industries** or even directly on the installations of **network operators** .

Stationary storage capacities* worldwide in 2020, 2022 and 2026



**Other stationary storage technologies are absent from this graph because they are currently marginal*

<u>Sources</u> : *IEA 2021, Sia Partners Analysis*

Stationary battery storage installations have been using lithium batteries for several years.

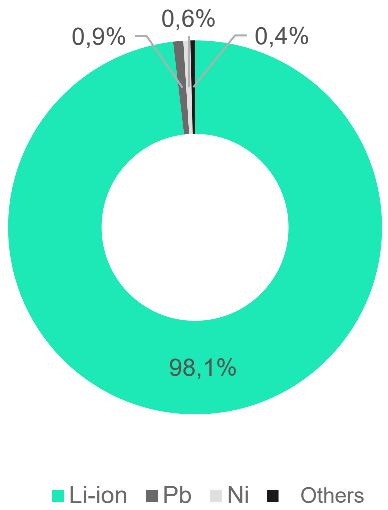
The **share of batteries in stationary storage is increasing** thanks to the diversity of battery technologies, their lower costs and their ease of installation compared to PETSs.

Among the different stationary battery technologies, **Li-ion batteries dominate, constituting 98% of the stationary battery market in 2023.**
They already dominated this market in 2020, with 97% market share.

This study will initially focus on the **9 most mature battery technologies, divided into 3 families, presented in the table against.**

The market shares of the 7 other emerging technologies chosen for this study remain negligible to date.

Global market shares for battery technologies in stationary storage facilities (2023)



Family	Mature battery technologies	
Lithium (Li-ion)	NMC	*Lithium Nickel Manganese Cobalt*
	LFP	*Lithium Iron Phosphate*
	LMO	*Lithium Manganese Oxide*
	LCO	*Lithium Cobalt Oxide*
	NCA	*Lithium Nickel Cobalt Aluminum*
	LTO	*Lithium Titanium Oxide*
Lead	Pb	*Lead*
Nickel	Ni-Cd	*Nickel Cadmium*
	Ni-Mh	*Nickel Metal Hydride*

Source : Grid-Scale Battery Market Size & Growth Analysis Report, 2024-2032 (fortunebusinessinsights.com)

Stationary battery storage, a rapidly accelerating market, driven by China

The stationary battery storage market is consolidating, with players integrating into the different stages of the value chain

Extraction and refining	Manufacturing and Assembly	Engineering, procurement and construction	Operation, maintenance and repair	Dismantling, reuse and recycling
•Miners •Refiners & Distributors	•Original Equipment Manufacturer (OEM)	•Battery Management System Suppliers •Study, design and project management offices	•Operators, maintainers and repairers of stationary battery systems	•Dismantling •Reconditioning and second-hand market •Recycling and end of life

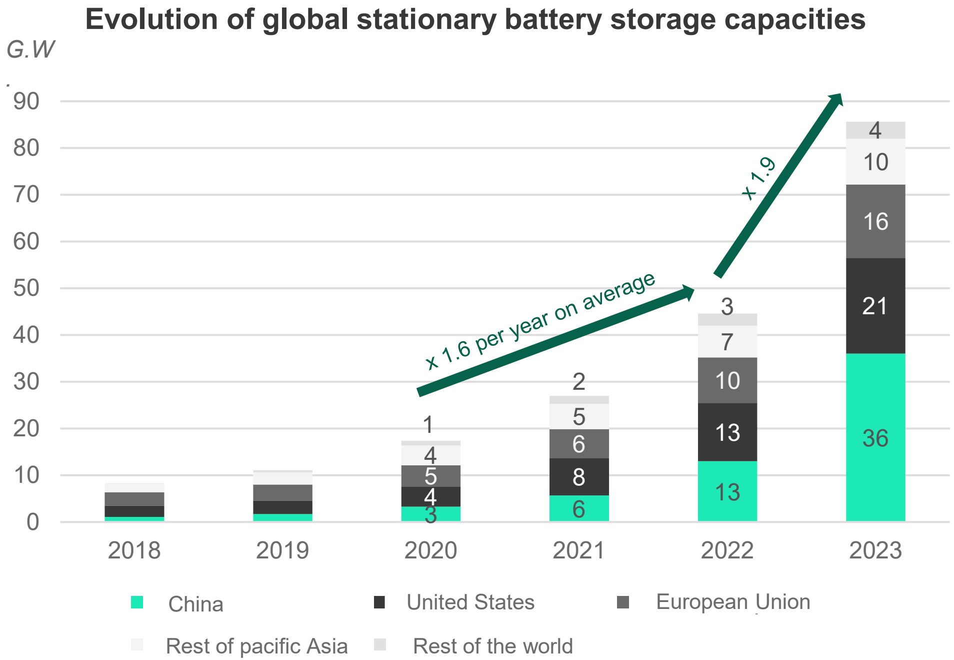
NB: The companies represented have been chosen as examples of major players in the sector, but these lists are by no means exhaustive

Since 2018, global capacity has increased 11-fold, driven mainly by China

The **number of stationary battery storage system (BESS*) installations is expected to increase significantly** during this decade, with an acceleration in 2023, where additional installations have almost doubled compared to the previous year.

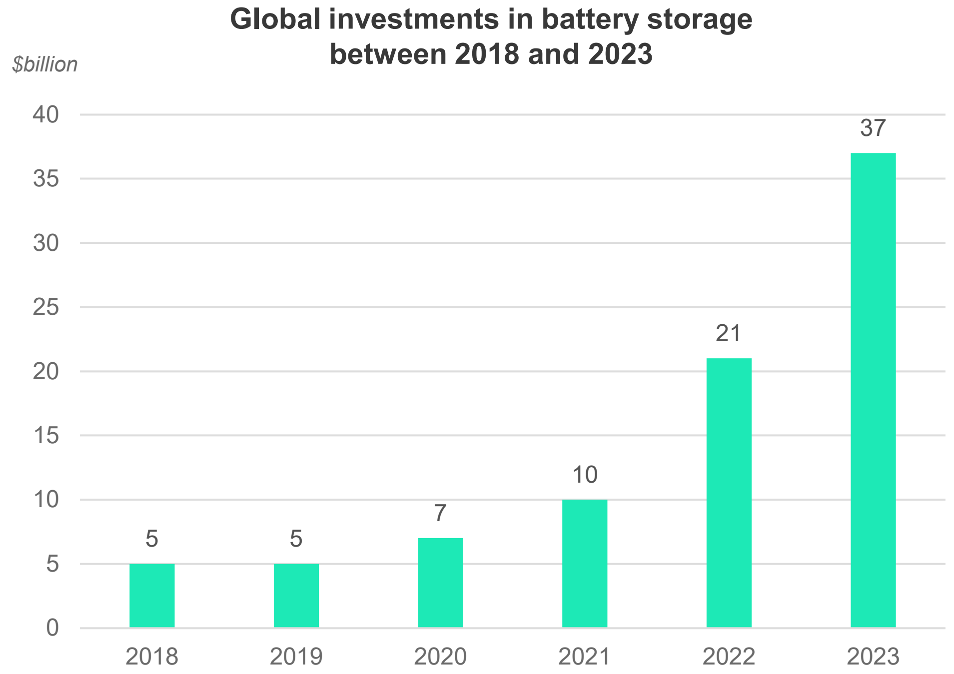
Lower costs, favorable public policies and the gradual emergence of regulation are the main drivers of the acceleration of BESS, which increasingly have access to new sources of income on the electricity market and auxiliary services.

**BESS = Battery Energy Storage System*



Sources : IEA Battery and Secure Energy Transitions 2024, Bloomber g NEF 2022, Sia Partners Analysis

Investments in battery storage have almost quadrupled in 2 years and will continue to increase to meet demand



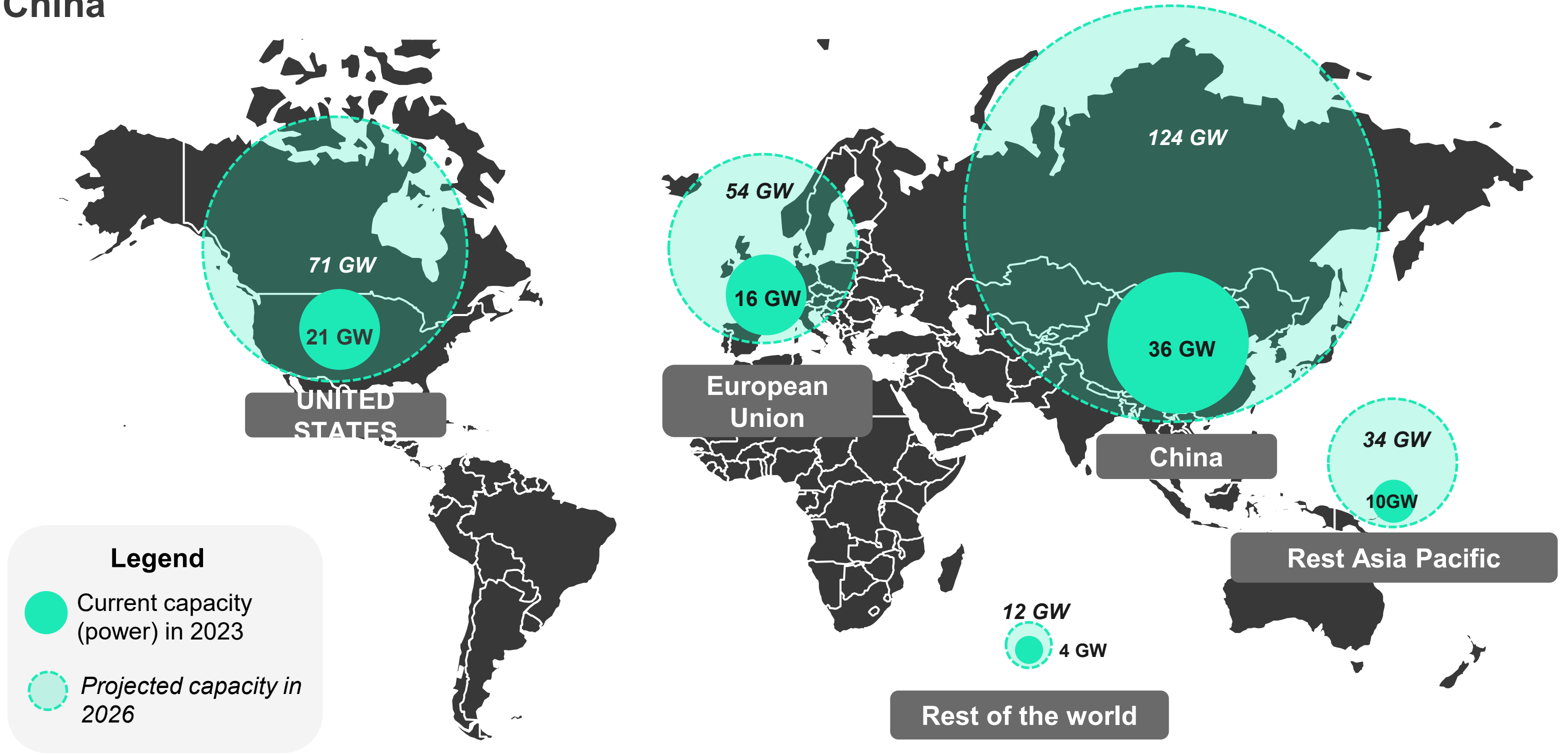
Many players in the energy sector (technology companies, battery manufacturers, renewable energy project developers, utility companies) are investing heavily in the development and deployment of large-scale battery energy storage solutions. ladder.

Investments in stationary batteries have **increased significantly** over the last two years, reaching **$37 billion in 2023** .

This upward trend is expected to continue: according to Aurora Energy Research, **cumulative investment opportunities in Europe are expected to amount to €50 billion between 2023 and 2050,** of which 40% will be deployed before the end of 2030.

Sources : *Global grids and batteries storage investments 2023, Statista , Aurora Research Energy 2023*

By 2026, the installed capacity of stationary batteries will increase threefold, mainly due to China



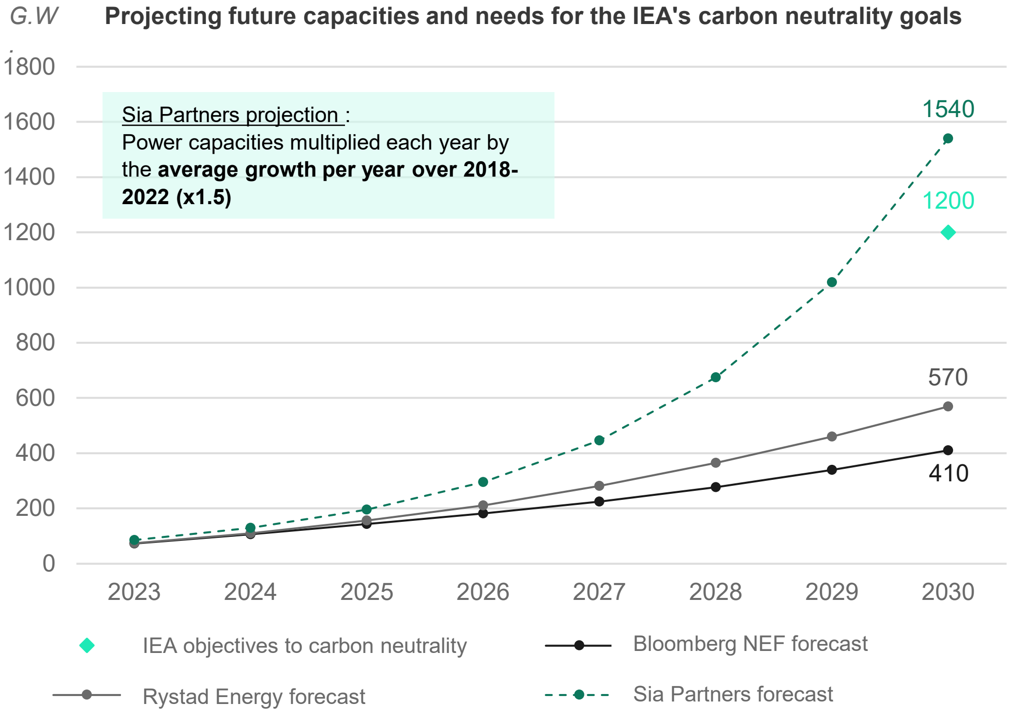
Power capacities for 2026 are calculated by projecting average growth 2018-2022.
Growth in 2023 was excluded because this year was exceptional in terms of new installations, which is due to the drop in battery prices in 2023 preceded by a price increase for the first time in 2022, and the postponement of many projects from 2022 to 2023

Source : IEA Battery and Secure Energy Transitions 2024, Bloomberg NEF, Sia Partners analysis

The objectives for carbon neutrality in 2050 will be achieved if storage capacities continue to increase according to the current trend

- According to the IEA, **nearly 1,200 GW** of **stationary battery storage will be needed by 2030** in order to achieve carbon neutrality in 2050.
- Despite the objectives, Bloomberg NEF and Rystad Energy forecast insufficient storage capacities for 2030, around 400-550 GW.
- Sia Partners is considering a more optimistic projection with more recent data, calculated from average growth over the last 6 years, choosing to exclude the year 2023 because it is exceptional in terms of new installations.

This projection **will only take place if Battery development continues to be encouraged by regulations and financial valuation mechanisms, and by the development of emerging battery technologies** addressing material supply issues.



Source : IEA 2024, Bloomberg NEF 2022, Rystad Energy 2023, EASE 2024, Sia Partners analysis

The implementation of public policies favorable to energy storage, the main driver of development, is accelerating across the globe

Countries/ regions	Text name	Date	Provisions relating to stationary storage	Voted	Proposed
	Action plan for an industrial battery policy	2018	Aims to promote a European industrial policy for batteries by supporting the battery value chain, with the aim of deploying 44 GWh in 2020 and 1200 GWh in 2030.		
	Decree Law 345	2019	Extension of credits by the Central Bank of Cuba to buyers of solar assets and authorization of self-consumption and resale of surplus electricity to the network		
	Inflation Reduction Act	2022	Extension of production tax credits (ITC) to producers in support of energy storage, battery and ENR production projects		
	New Energy Storage Development Plan	2022	Government guidelines aimed at reducing the cost of BESS installations by 30% by 2025, and deploying 30GW of BESS by 2025, taken up and supplemented at the regional level to reach 10 to 20% allocation rate renewable energy storage		
	Energy Storage Obligation	2022	Sets a mandatory storage rate for total electricity generated at 1% by 2024 and 4% by 2030 for electricity distributors		
	RED III Directive	2023	Aims to increase the share of renewable energies in final electricity consumption to 42.5% by 2030, encourages the use of renewable energy purchase agreements and facilitates processing times and permit applications for renewable energies projects		
	EU Regulation 2023/1542 relating to waste batteries	2023	Requires the declaration of the carbon footprint for industrial, rechargeable batteries and those for electric vehicles for their placing on the market, and sets collection and recyclability objectives for lithium, nickel and lead batteries		
	Energy Bill	2023	Defines energy storage as a subset of production to encourage its large-scale development in the territory.		
	Electricity market reform	2024 *(future)*	Aims to increase the predictability, security and flexibility of electricity in Europe, and obliges Member States to define national objectives for demand response and storage in their National Energy and Climate Plan.		

binding Non- binding

Source: Sia Partners

If the regulations favor the development of the sector, the profitability of stationary storage projects must still be improved to attract more private investment.

Eurelectric, representing many European players in the electricity industry, including RTE, EDF and TotalEnergies in France, proposes in its report published in 2023 incentive measures to increase the profitability of stationary storage projects.

1 Remuneration for each service rendered (*revenue stacking*)

Currently, some services provided by storage are not valued in profitability calculations, and in many countries only certain combinations of services may be permitted due to value stacking restrictions.
Remuneration **adapted to the multi-service capacity of storage would make it possible to improve the profitability of stationary storage** by diversifying sources of income.

Undersized connection for maximum requirement
Control of consumption for production with high electrical variation
Reactive power management
Management of self-consumption
Management of voltage dips and supply cuts
Contribution to the balance of the electricity network (Adjustment mechanisms)
Network frequency maintenance (System services)

Legend

- Security of supply
- Reduction energy bill
- Valorization through contribution to the network

2 Elimination of double taxation, at the level of levy at the discharge

Eurelectric + Other industrial group 03.25.2024

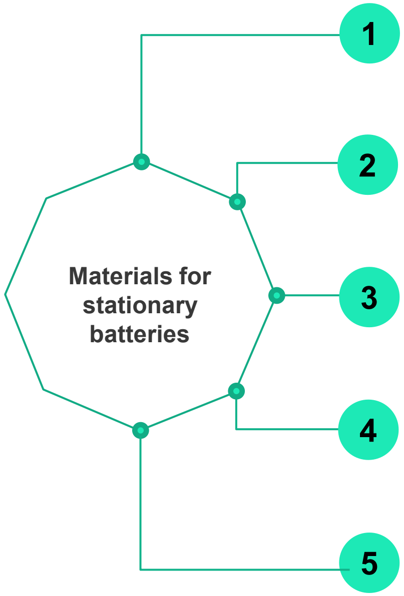
- These two entities call for **removing the existing double taxation on injection and withdrawal** , as storage facilities do not "consume energy", and should therefore not be subject to a tax on reinjection, in accordance with the Article 18 of Directive EU/2019/943 .
  Eurelectric calls for the implementation of Regulation EU/2019/943 and Directive EU/2019/944 on market design, **adopting a clear definition of energy storage,** removing price caps, reducing the minimum size of offers and limiting unpaid and non-frequency related ancillary services.

- In March 2024, in a letter addressed to representatives of the Economic and Monetary Affairs Committee (ECON), a group of industrialists (of which Eurelectric is a member) proposed an amendment so that consumers with energy storage installations (EV, stationary batteries), and electricity transformers **are considered as redistributors when they supply electricity and are therefore not subject to double taxation.**
  This would encourage the development of consumer participation in the stability of the network, including in particular the installation of local stationary battery systems.

Sources : *Eurelectric " Enabling higher integration and utilization of variable renewables ", 2023*

The supply of materials, an essential issue for the sustainability of the market

storage is currently based on 4 materials used for cathode equipment , but a 5th, vanadium, will experience the strongest growth in the years to come



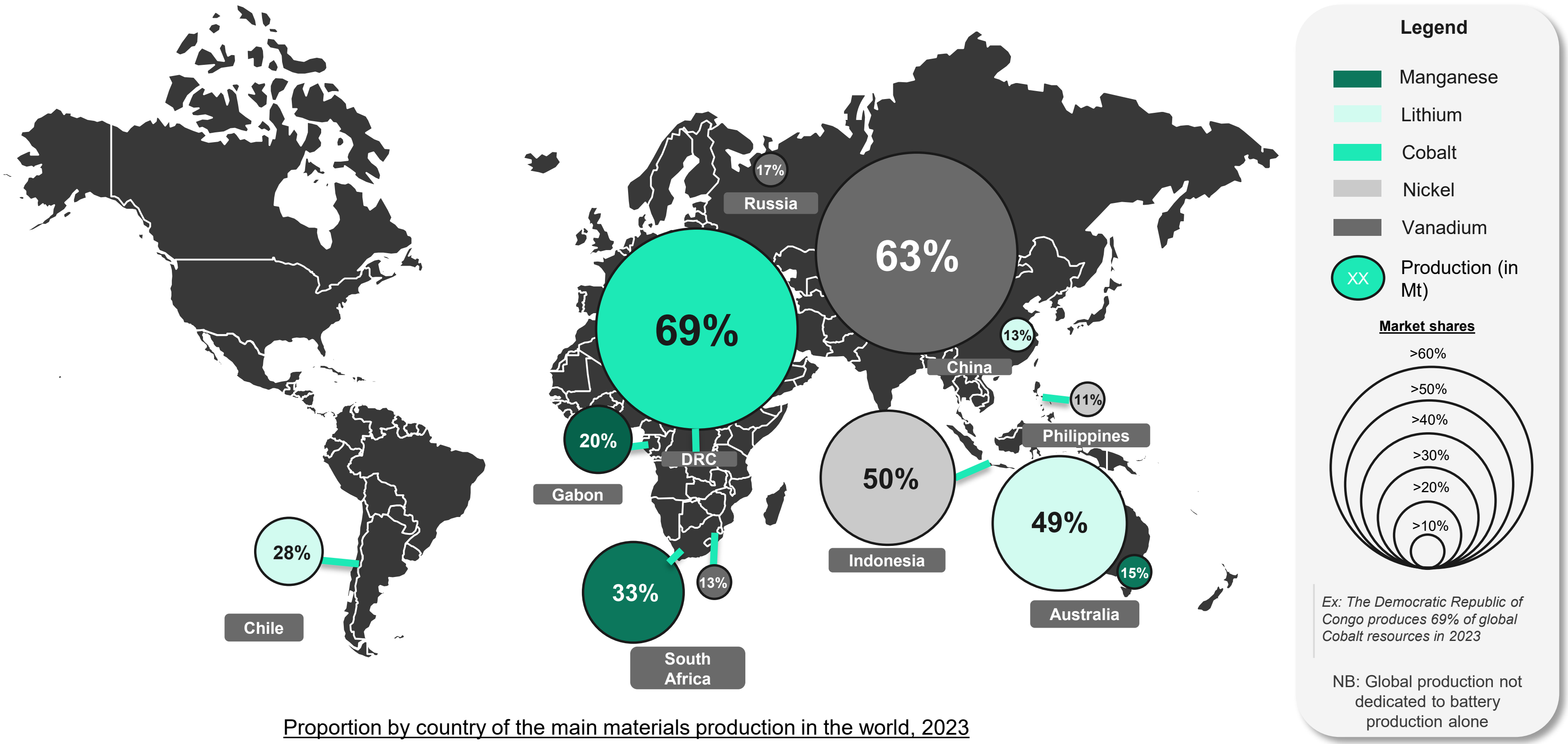
Material	Batteries developed	Quantity used 2023 (kt)
Nickel*	Li-ion, Ni-Mh	8.9
Cobalt*	Li-ion	3.6
Lithium*	Li-ion	3.4
Manganese	Li-ion	3.2
Vanadium	Redox	0

- Nickel is the **most used material** and should **replace cobalt** , more expensive and less available.
- Lithium is the **main component of market-dominating Li-ion** batteries . Lithium is gradually **being replaced by nickel** , which is more efficient, or by **more durable** and available materials.
- Manganese **,** the 12th most abundant chemical element, is increasingly present because it limits **the impact on mining resources.**
- The demand for **vanadium**, to date non-existent for stationary batteries, **has been growing** since the beginnings of the marketing of Redox flow batteries (VRFB), so that the evolution of its demand must be considered.

*Materials considered critical, given supply tensions

Source : Critical Minerals Data Explorer IEA, 2022

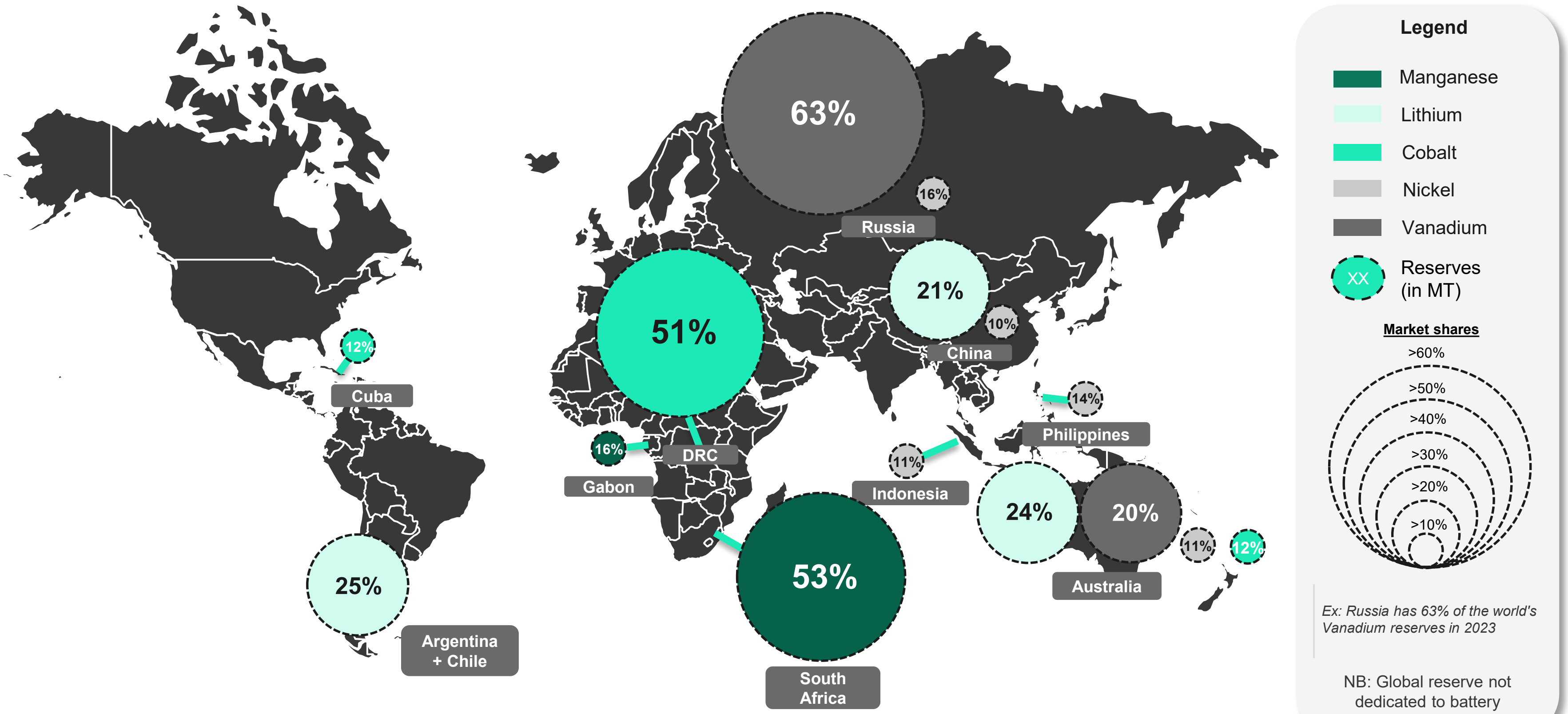
The production of the materials most used for stationary batteries is fragmented in different countries, each dominating one material.



Proportion by country of the main materials production in the world, 2023

Source : Sia Partners analysis ; European Commission: Raw Materials Information System, Statista 2023

The distribution of identified reserves is not correlated to that of production, and will need to be monitored with the advent of future needs.



Proportion by country of the main global reserves of material in the world, 2023

Source : Sia Partners analysis ; European Commission: Raw Materials Information System, 2023

The need for stationary battery storage will multiply the demand for materials by at least 14 by 2040, and in particular for vanadium.

3 scenarios allow to evaluate the forcast of demand for materials

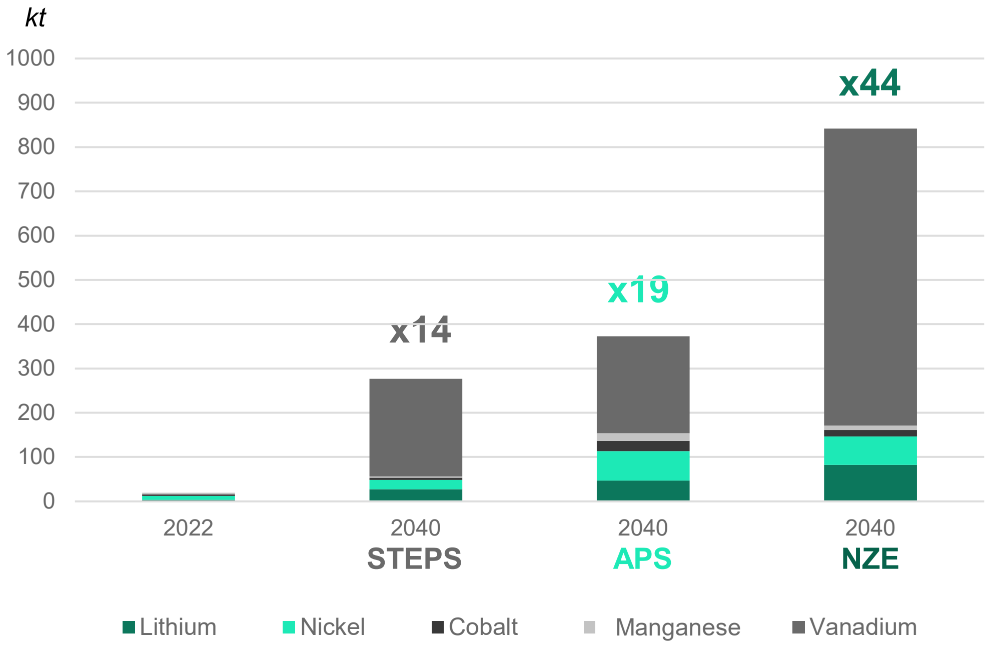
NZE **"Net Zero Emissions"**
International carbon neutrality targets in 2050 set by the IPCC

APS **" Announced Pledge Scenario»**
Achieving the objectives announced by governments

STEPS **" Stated Policies Scenario »**
Current progress according to public policies put in place

- If stationary battery storage currently **accounts for less than 1% of total material demand** across scenarios, the increase in future demand will be ≈ **6 x higher** than the trend observed for other technologies (EV, RE , etc.)

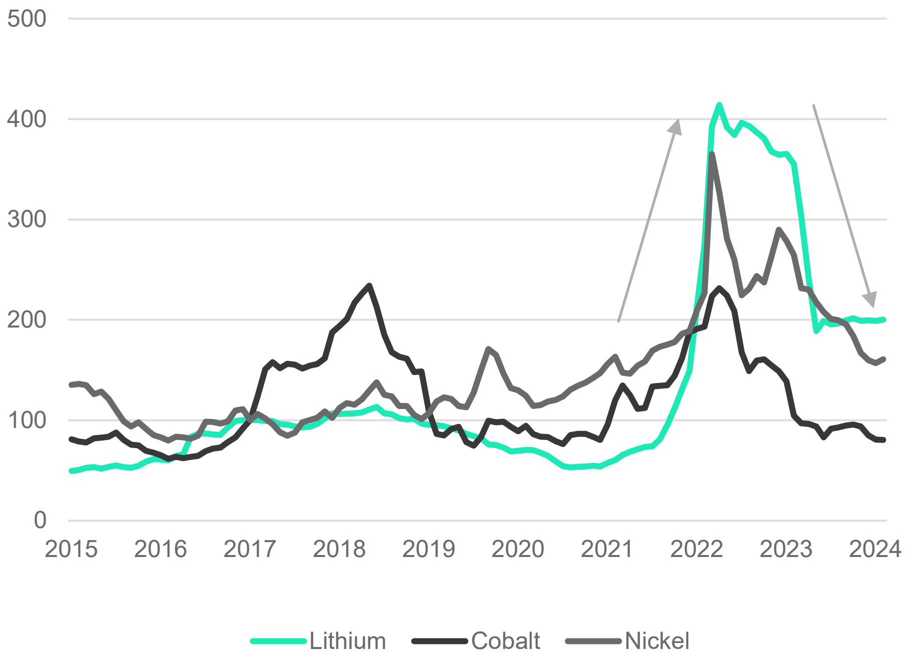
Evolution of demand for materials according to IEA scenarios



Source: *Critical Minerals Data Explorer; IEA, 2023*

The demand for critical materials is fluctuating and leads to significant volatility in market prices in recent years.

Evolution of the price of critical materials (index 100 = Jan. 2017)



Demand far exceeding the available supply of these critical materials has caused **their prices to soar in 2022** .

Since the end of 2023, the price of critical materials has **fallen drastically** .

- 70%
Lithium

- 40%
Cobalt and Nickel

Evolution of the price of a tonne of lithium carbonate, cobalt and nickel sold in China since January 1, 2023 .

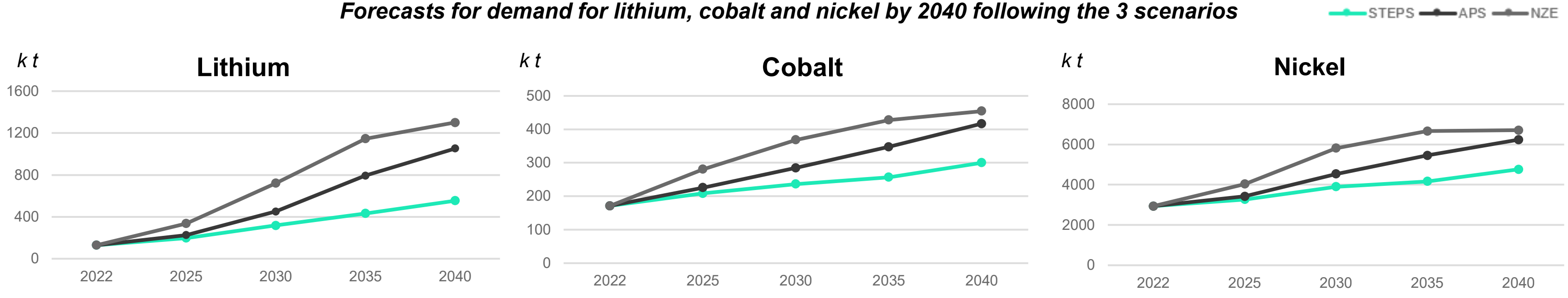
This price drop is explained by:

- the **increase production** to meet demand
- **technological advances** leading to less use of critical materials
- a **Chinese subsidy policy for electric vehicles** leading to an artificially high supply, higher than demand

Source : LME (London Metal Exchange), March 2023

However, the supply of these critical materials will continue to grow and must meet future needs, whatever the scenario considered.

Forecasts for demand for lithium, cobalt and nickel by 2040 following the 3 scenarios



- demand whatever the scenario considered will exceed supply capacities for these three main metals used, from 2030 according to the IEA. Significant **additional investments** will be necessary to address demand.
- In this context of tension, **too rapid a deployment of Li-ion batteries,** which depend on these metals, could complicate **the energy transition at the global level.**
- Whatever the scenario, it is necessary to find **solutions** to overcome these **supply tensions.** Material substitution appears to be the most effective approach .

So

volatility in market prices of materials & **Strong dependence on these materials for battery technologies**

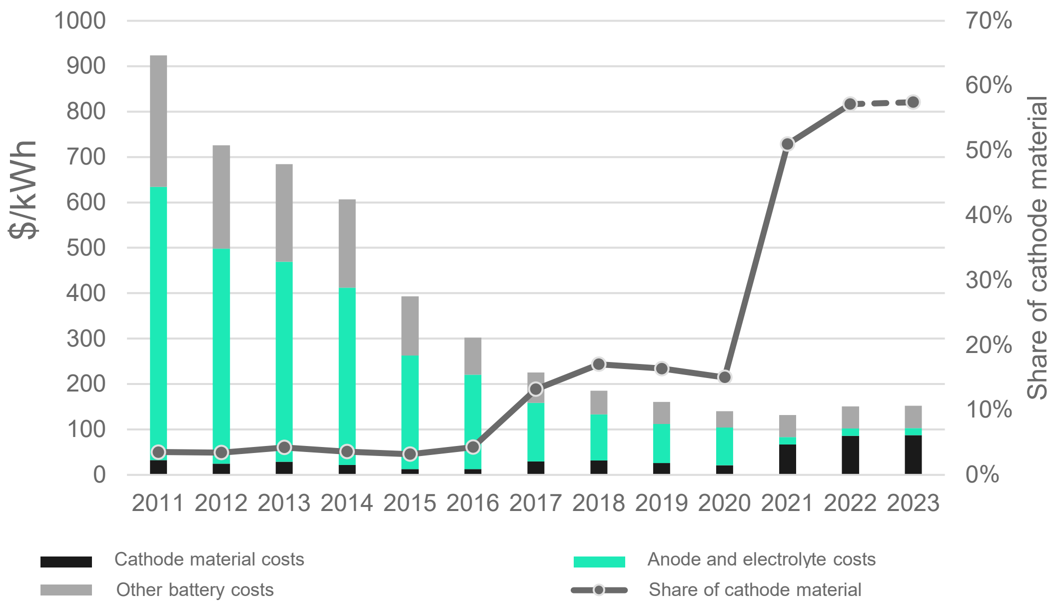
Risks and instabilities in the supply and development of battery technologies for the ecological transition

Source : IEA, 2023

Focus Lithium – Ion: The price of batteries has increased again due to the instability of the price of cathode material

The total cost of the battery *product* can be roughly broken down into the cost of the battery (anode and electrolyte), the cost of the cathode material (notably lithium, cobalt, nickel) and other costs related to the battery.

Evolution of the cost of Li-ion batteries and the share of cathode material



- Soaring **material prices threaten** to **reverse the downward trend in** battery technology costs.
- *2021* : The **share of cathode equipment** in the total cost **has been multiplied by 3.**
- *2022* : The **rise in the cost of cathode material caused a rise in battery prices** for the first time
- *2023* : Battery costs have started to decline again according to the European association EASE, despite pessimistic projections for 2022. **Volatile trends are expected** for the coming years, creating a certain **degree of risk and instability for battery costs** dependent on these materials.

Sources : IEA 202 1, BloombergNEF Report 2021 and 2022, EASE 2024

Material criticality risks impact battery technologies

	Request	Price	Dependencies	Others
Lithium	Growing demand	High price volatility	The main resources are distributed across 3 continents. On the other hand, **China dominates** refining (65%) and Chinese companies are present in many mining projects around the world.	**The lithium market is not very flexible** : putting a lithium deposit into operation can take 10 years.
Cobalt			**65% of cobalt comes from the DRC**, where mining activities pose ethical problems, and China secures its supplies by being the main refiner of cobalt (65%).	Since cobalt is mainly produced as a **by-product of copper or nickel, its production is linked to that of the main metals,** which limits the capacity for adaptation.
Nickel			**Indonesia is the largest producer** with 55% of global nickel production Refining **takes place mainly in Asia,** with 76% of capacity.	High nickel concentration **in batteries implies greater power density but has a negative impact on** battery price and reliability. Between the discovery of a deposit and production, a period of 13-20 years can pass.
Manganese			**Resources are concentrated in South Africa, which produces 33% and has 53% of the world's reserves.** 58% of refining is done in Chinese factories.	**Steel is the leading consumer of manganese** : fluctuations in demand for steel can therefore impact the supply chain. The long duration before exploitation of the deposits limits the flexibility of the market.

	Risks		
	Price	Availability	Addiction
Li-ion batteries also containing Co, Ni, Mn: *NMC, LMO, LCO, NCA*	+ + +	+ + +	+ + +
Li-ion batteries without other critical materials: *LFP, LTO*	+	+	+
Ni Batteries: *Ni-Cd, Ni-Mh*	+	+	++

Legend:

- \+ Low risk
- \+ + Moderate risk
- \+ + + Significant risk

There is therefore a real need to diversify the materials necessary for the energy transition with technologies less dependent on critical materials

	Diversification observed	How this balance between technologies can guarantee the achievement of a sustainable transition
Diversification of existing technologies	Lithium Iron Phosphate (LFP) batteries	▪ The market is expected to be **dominated by LFP batteries**, which are inexpensive and safe. They make it possible to **circumvent the inflation of critical material costs** by substituting nickel and/or cobalt.
	Transition to Nickel variants less rich in Cobalt	▪ The rest of the demand will be covered by **NMC nickel batteries, which are more expensive but more efficient**. ▪ A transition to **variants less rich in cobalt is expected** to limit the cost.
New battery technologies	Marketing of Redox batteries based on Vanadium	▪ Redox batteries are expected to be widely **commercialized by 2030** *(Energy Storage News)* and subsequently capture **an increasing share of the** storage application market for large renewable projects due to their **limited impact on mining resources**.
	Sodium batteries and new generations of Li-ion batteries	▪ Sodium (Na-ion) batteries would **greatly reduce battery costs** due to **the natural abundance of sodium**. ▪ Li-S and Li-Air batteries offer promising prospects **in terms of energy density** (connection to the electricity grid) while offering **a cost advantage.**

New battery technologies are being developed to decrease reliance on critical materials

New battery technologies making it possible to reduce or even eliminate dependence on voltage materials are being developed

	Families	Main advantages	Main disadvantages
	Lithium	• Dominant technologies on the market • High energy density and lifespan	• High impact on limited resources • Cost instability since 2020
	Nickel	• Energy density > Li-ion • Captures growing market share	• Impact on limited resources • Deterioration by repeated overload
	Lead	• Old technology, widely used • Low battery purchase cost	• Polluting and toxic • High cost per kWh
NEW TECHNOLOGIES	***Redox (VRFB)***	• Decouple power and energy capacity • High safety thanks to liquid electrolyte	• Marketing planned for 2030 • Very high cost of vanadium
NEW TECHNOLOGIES	***Sodium-Sulfur (Na-ion)***	• No impact on critical resources • Safer alternative than Li-ion	• Energy density generally ≤ Li-ion
NEW TECHNOLOGIES	***Solids***	• Energy density > Li-ion • No risk of explosion	• Discharge performance deterioration • High impact on limited resources
NEW TECHNOLOGIES	***Metal-Air (Li-Air)***	• Reduced impact on critical resources • Expected energy density > Li-ion	• Prototype phase: feasibility to demonstrate • Long charging times (current status)
NEW TECHNOLOGIES	***Potassium (K-Ion)***	• No impact on critical resources • Safer alternative than Li-ion	• Low reversible capacity • Prototype phase: feasibility to demonstrate

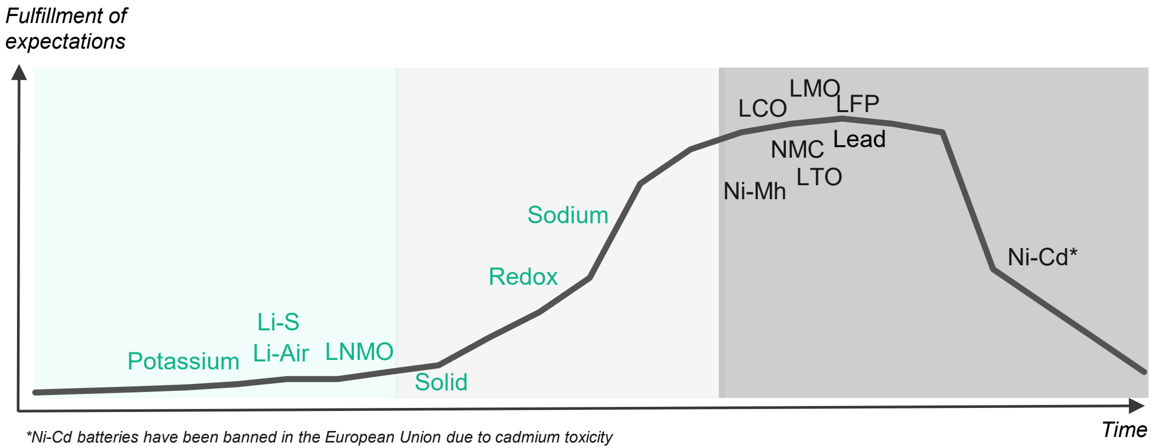
\+ ***Two new lithium technologies (Li-S and LNMO) less rich in lithium and cobalt are in development***

- A bouquet of new technologies is emerging, all sharing a low reliance on critical materials (lithium, cobalt and nickel)
- Some, like Redox and Na-ion batteries, initiate a marketing cycle, with verified characteristics and performances.
- The others will have to continue the R&D stages, but the expected performances are encouraging, and aim to match those of the dominant Li-ion batteries.

Legend

- Advantages (new technologies)
- Advantages (mature technologies)
- Disadvantages (new technologies)
- Disadvantages (mature technologies)

As Lithium and Nickel batteries reach a high level of market maturity, a new bouquet of technologies, made of more available materials, is emerging.



*Ni-Cd batteries have been banned in the European Union due to cadmium toxicity

Idea and development

- Maximum future performance
- Modeling based on the rate of improvement observed for mature batteries

Launch and growth

- Achievable performance given ongoing improvements
- Performance based on research and testing for improvement

Maturity and decline

- Performance observed and confirmed
- Little or no prospect of significant improvement

Battery technology

Mature technologies	**New technologies**
Lithium	**Lithium**
NMC	Li-S
LFP	LNMO
LMO	Li-Air
LCO	
NCA	**Others**
LTO	Redox
	Solid- state
Nickel	Sodium
Ni-Mh	Potassium
Ni-Cd *	
Lead	

Source : Sia Partners analysis based on the IEA “Guide Tool”

Sia Partners offers an analysis of battery attractiveness, based on expected technical capabilities for industrial use and current supply limits

Our analysis defines Sustainability and Industrial Potential as the two main axes to define the attractiveness of a battery in the current context of energy transition, which is broken down into 7 criteria.

A Sustainability

CRITERIA	*CONTENT / CALCULATION*	*IMPORTANCE**
Materials	• Analysis of the capacity of mines to meet current demand • ESG risks of the main producing countries to form the total ESG risk of the material	3/4
Relevance Net-Zero	• End of life recycling rate of materials used • Calculation of the recyclability rate of batteries according to their composition	2/4
Lifetime	• Number of battery life cycles <200 — 1000 to 2000 — > 4000	3/4

* Defined according to the Sia Partners methodology

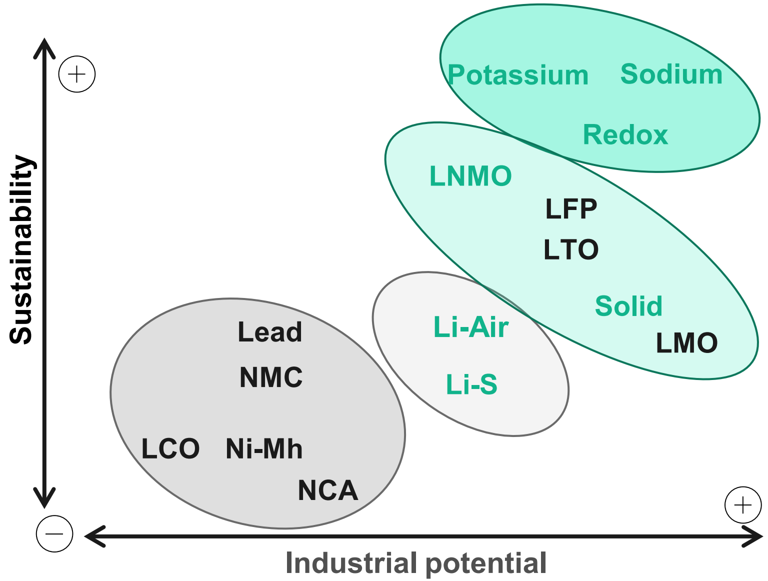
B Potential Industrial

CRITERIA	*CONTENT / CALCULATION*	*IMPORTANCE**
Security	• Battery stability analysis • Creating scores	4/4
Density energy	• Energy density in kW/h <100 — 100 to 300 — > 400	2/4
Maturity	• Technology maturity level	3/4
Cost AVERAGE	• Average observed cost (mature technologies) • Modeled average cost (in development) In USD / kWh > 2 00 — 100 to 150 — <100	2/4

Source : Sia Partners analysis

The long-term development of the market will be based both on certain mature technologies that consume few critical materials, and certain new battery technologies

Sia Partners analysis of the attractiveness of batteries



- Technologies with **very high potential** : to be prioritized in terms of initial efforts and investments because they will provide major advantages in the medium to long term.
- Technologies with **high potential** : present an additional degree of uncertainty and therefore risks to be considered requiring a more granular decision
- The technologies to **moderate potential** : investments must be carefully studied according to the priority objectives and the level of risks tolerated
- **Low potential** technologies : deprioritize efforts

Battery technology

Mature technologies	New technologies
Lithium	**Lithium**
NMC	Li-S
LFP	LNMO
LMO	Li-Air
LCO	**Others**
NCA	Redox
LTO	Solid-state
Nickel	Sodium
Ni-Mh	Potassium
Lead	

We recommend prioritizing mature LFP and LTO batteries, using only lithium as a critical material, and also new Sodium and Redox batteries, and over a longer period of time potassium batteries.

These new technologies will allow the stationary storage market to develop without suffering the risks and constraints linked to the supply of critical materials.

Source : *Sia Partners analysis*

About Sia Partners

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About Sia Partners

Our global footprint and expertise across more than 40 industries and services allows us to improve our clients' businesses around the world. We guide their projects and initiatives in strategy, business transformation, IT and digital strategy. Sia Partners supports its clients to develop the innovative ecosystems of tomorrow, reinvent business models and organizational schemes, and reimagine the art of leadership and transformation in a concrete, efficient and responsible manner.

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Since 2000, our experts have supported energy companies, network managers, R&D centers, investment funds in their growth strategy, management and implementation of transformation or even demonstrators of tomorrow's sectors as part of the energy transition .
The future energy mix will be centered on electricity. With 350 consultants dedicated to energy around the world, including 200 in France, Sia Partners supports its clients in their transformations linked to new means of production, their integration into the network but also the development of innovative offers and new uses such as electric vehicles and stationary batteries

Glossary

BESS: Battery Energy Storage System
Family: categorization of batteries by chemical component chosen in this study, encompassing several battery technologies
Material: In this study, the term material refers to lithium, nickel, cobalt, manganese and vanadium
Critical materials: materials in tension necessary for the manufacture of batteries (Lithium, Nickel, Cobalt)
Battery storage: stationary battery storage
Technology: battery technology chosen in this study
K-Ion: Potassium (Other family)
LCO: Lithium-Cobalt (Li-Ion family)
LFP: Lithium-Iron-Phosphate (Li-Ion family)
Li-Air: Lithium and Air (Metal-Air family)
Li-S : Lithium-Sulfur (Li-Ion family)
LMO: Lithium Manganese Oxide (Li-Ion family)
LNMO: Lithium-Nickel-Manganese-Oxide (Li-Ion family)
LTO: Lithium-Titanium-Oxide (Li-Ion family)
Na-Ion: Sodium sulfide (Sodium family)
NCA: Lithium-Nickel-Cobalt-Aluminium (Li-Ion family)
Ni-Cd: Nickel-Cadmium (Ni-Ion family)
Ni- Mh : Nickel-Metal-Hydride (Ni-Ion family)
NMC: Lithium-Nickel-Manganese-Cobalt (Li-Ion family)
Lead: lead acid battery (Lead family)
Solid-state: components similar to Li-ion, solid polymer or ceramic separator, solid electrolyte (Solid-state family)
VRFB: Vanadium Redox Flow Battery (Redox family)