



**Globe**  
Metals & Mining

# Niobium

**Solving the requirement  
for faster-charging, safer,  
lighter EV batteries**

**Poised to play key role  
in EV battery progression  
with significant growth  
in demand predicted**

# Introduction



Consumption of niobium oxides and metal powders is projected to grow rapidly over the next decade due to its growing application in electric vehicles and in a range of other technological areas.



Sales of niobium oxide, used in e-batteries, is expected to grow from 100 tons (in 2021) to ~45,000 tons (by 2030), or to US\$1.8Bn per annum.<sup>1</sup>



Ferro-Niobium (FeNb) used in the production of High Strength Low Alloy (HSLA) Steels is a US\$1.4Bn per annum Global Market expected to grow at 5.6% CAGR to 2030.



Globe Metals will look to manufacture high grade niobium oxides and powders and be only the second vertically-integrated supplier.

<sup>1</sup> Internal Globe estimate based on current value of niobium oxide, CBMM production capacity and estimated market share of CBMM at full production



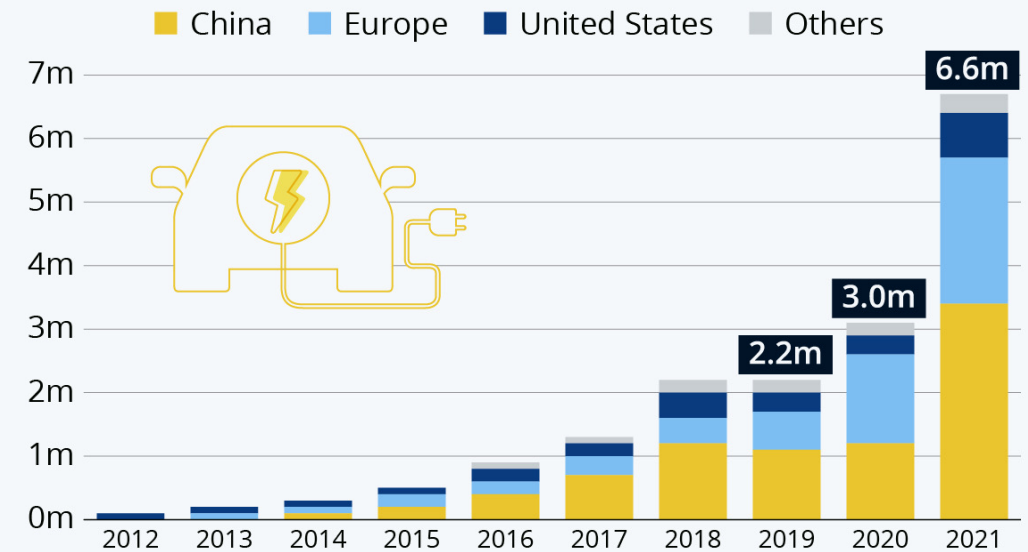


# The EV evolution: only getting started

- It may seem like electric and electrified cars are everywhere, but in the grand scheme of things we're only just getting started.
- If you look at global auto sales as one big pie, EVs right now are only a tiny sliver, making up just **2% of sales**.
- EVs simply offer a better driving and ownership experience. EVs are quieter, smoother and, with many fewer moving parts, more reliable and near maintenance-free.
- With energy prices as they are, the cost of fuel for an average sized SUV is more than three times more expensive than electricity. Some adopters of EV fleets are currently seeing a 20% reduction in cost thanks to fuel and maintenance savings.

## Global Electric Car Sales Doubled in 2021

Global registrations of electric vehicles (incl. plug-in hybrids), by region\*



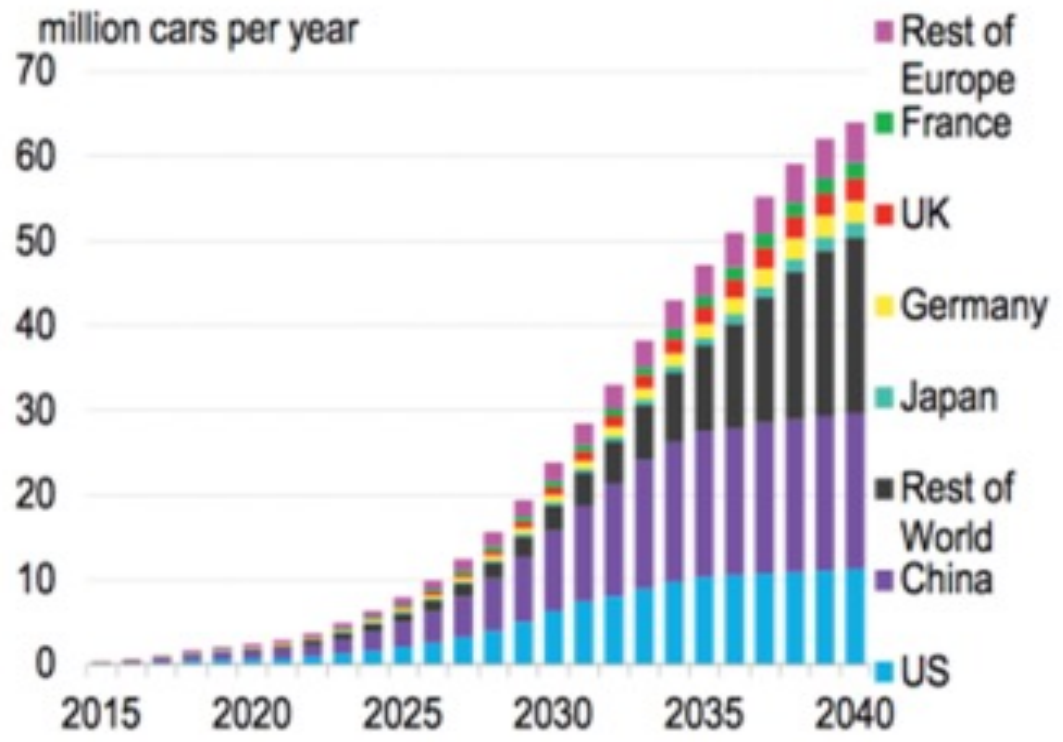
\* incl. passenger cars and light commercial vehicles (vans, light trucks)

Source: EV-volumes.com via IEA

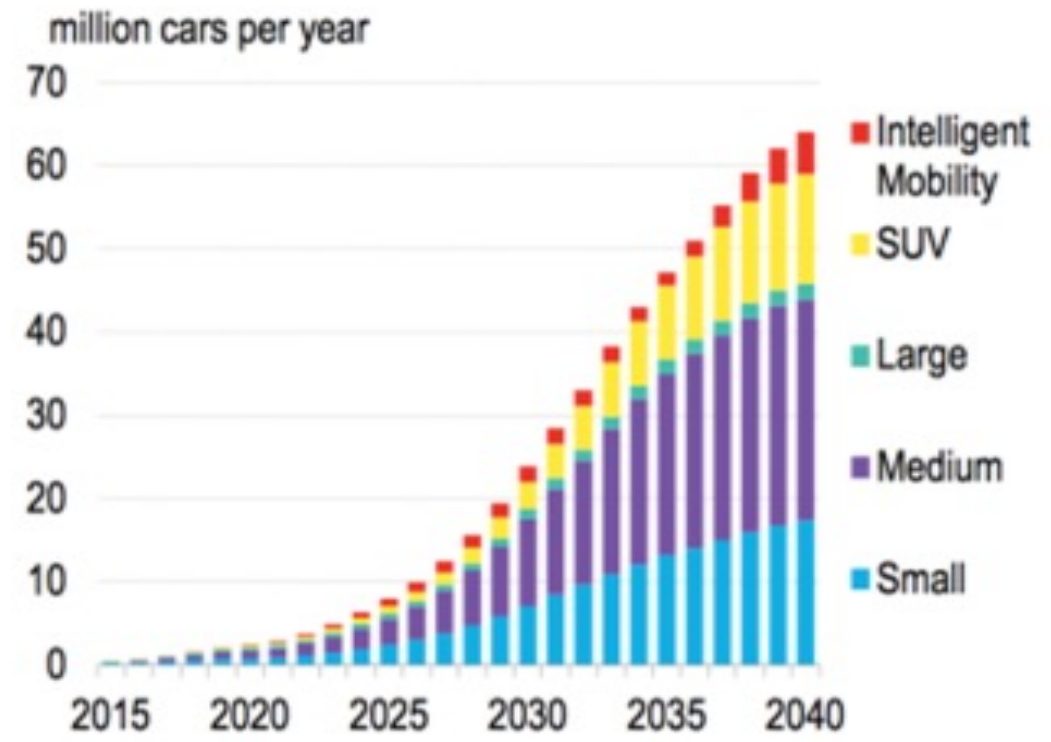


# EV sales projection: ~65m EVs per annum by 2040

Annual global EV sales by market



Annual global EV sales by vehicle class





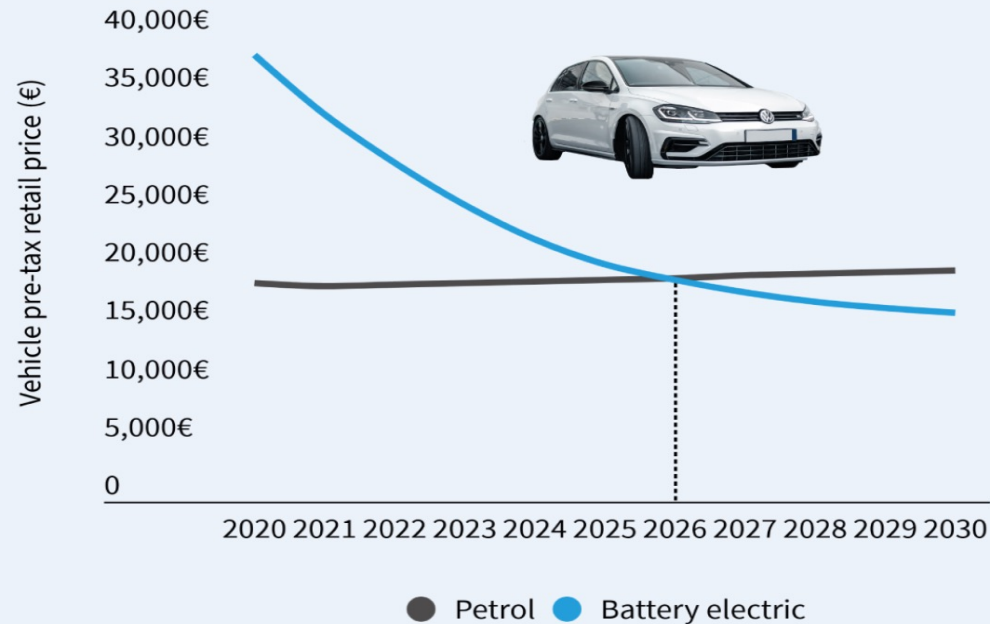
# EV affordability to drive EV consumption



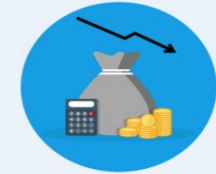
Sales of EVs continue to progress, but the pace of growth is hobbled by their cost, still at a premium in comparison with those of equivalent gas-powered vehicles. Analysts predict that the tipping point will be between 2025 and 2027.<sup>1</sup>



**EVs will be cheaper than fossil-fuel vehicles in Europe by 2025-2027**



**Main cost drivers:**



**Battery cost decrease**



**Electric vehicles dedicated production lines**

<sup>1</sup> [www.auto123.com/en/news/ve-costs-dropping-batteries-subsidies/65433/](https://www.auto123.com/en/news/ve-costs-dropping-batteries-subsidies/65433/)

# Go small or go home

- In the race to go electric, carmakers have focused on range to ease consumer anxiety over charging infrastructure, but battery makers are already working on the smaller, longer-lasting and cheaper batteries of the future, which also charge more quickly.
- The battery is an EV’s most expensive part, so true fast charging coupled with widely available chargers would allow automakers to build cars with smaller batteries at more affordable prices, yet boost profit by selling more vehicles to a broader audience.
- “We are in the larval stages of battery development,” said Lincoln Merrihew, vice president at data analytics firm Pulse Labs.<sup>1</sup>

- According to startup data platform PitchBook, EV battery technology investments jumped more than sixfold to \$9.4 billion in 2021 from \$1.5 billion in 2020 as carmakers focused on the future.

## Battery tech investments jumped in 2021

Investors poured six times as much money into battery technology startups in 2021 as they did in 2020 — but investments have tailed off in the first half of 2022.



2022 figures through July 7  
Source: PitchBook

<sup>1</sup> [www.reuters.com/technology/ev-battery-makers-its-go-small-or-go-home-2022-07-11/](https://www.reuters.com/technology/ev-battery-makers-its-go-small-or-go-home-2022-07-11/)

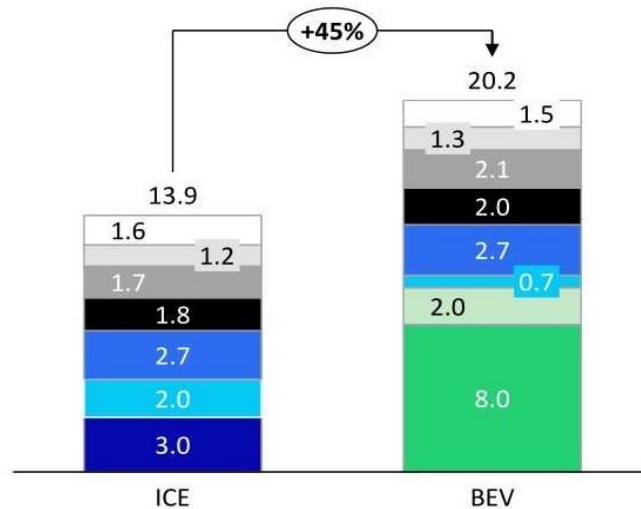
# EV battery: currently ~40% of EV build cost

## Vehicle cost development

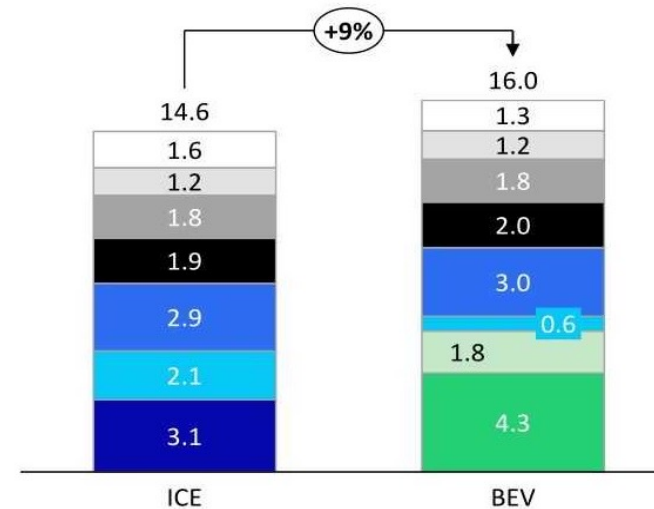
Battery electric vehicles are expected to almost close the gap to internal combustion engine powered vehicles by 2030

**Comparison of direct costs ICE vs. BEV – European compact-class vehicle<sup>1</sup>**  
In thousand EUR

**2020**



**2030**



Assembly
  BiW/Exterior
  Interior
  Engine and Auxilliary
  Battery<sup>2</sup>

Chassis
  E/E
  Powertrain/Drivetrain
  E-drive

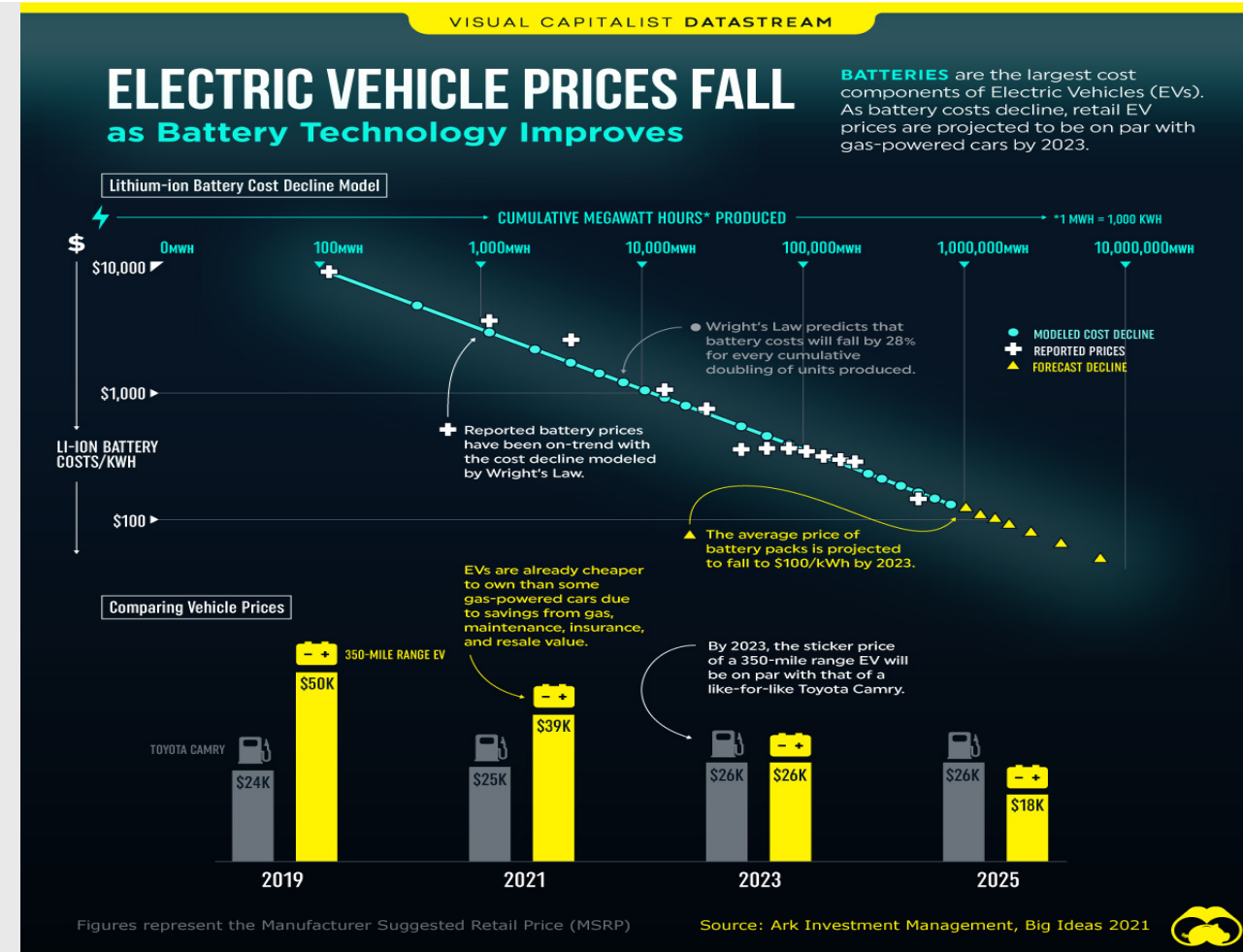
1. Does not include indirect costs (e.g. ramp-up, CAPEX, relative SG&A etc.)  
 2. Equals a 50kw/h battery with 160 €/kWh in 2020 and Equals with 85 €/kWh in 2030  
 Sources: Oliver Wyman FAST 2030 proprietary model, Bank of America, IEA Global EV Outlook, expert interviews, Oliver Wyman Research



# Reduction in EV battery cost to drive fall in EV price



- Niobium battery technology is well placed to be at the forefront of technologies to be introduced to revolutionise the EV battery market and facilitate EV battery costs to fall.
- The race is on to make EV batteries smaller, lessening the requirement for critical metals such as nickel, copper, cobalt whilst maintaining range and power.
- Niobium battery technology companies such as Nyobolt, Echion, Nano One and Battery Streak are meeting this challenge.



# Niobium

A photograph of an electric car being charged at a station. The car is white and the charging cable is plugged into the charging port. The background is a blurred outdoor setting with a blue sky and some greenery.

**A new discovery in  
battery technology that  
solves a massive problem**

# E-batteries

## Issues facing the EV industry

- The major issues facing the e-vehicle industry are widely stated as: fast charging, range and cost.
- The expected transition to electric vehicles away from internal-combustion-engine (ICE) vehicles that rely on fossil fuels is expected to increase rapidly from the point at which the cost of buying and operating an electric vehicle is neutral with that of ICE vehicles.
- Bloomberg New Energy Finance (BNEF) in their **2018 Electric Vehicle Report** predicted that *'the upfront cost of EVs will become competitive on an unsubsidized basis starting in 2024. By 2029, most segments reach parity as battery prices continue to fall'*.
- Prices of battery metals have spiked and are expected to push battery costs up in 2022 for the first time in more than a decade.
- Amounts vary depending on the battery type and model of vehicle, but a single car lithium-ion battery pack (of a type known as NMC532) contains around 8 kg of lithium, 35 kg of nickel, 20 kg of manganese and 14 kg of cobalt.
- Niobium has the potential to be part of the solution to fast charging, range and cost.








# Niobium's use in e-batteries

## Solving the fast charging, range anxiety and cost issues

Niobium addresses almost all of the major barriers to EV adoption

### Why is Niobium important for LIB development?

Barriers to EV adoption		Niobium's Role
	<b>RANGE ANXIETY</b>	
Consumers worry that an EV will not travel as far as an ICE vehicle and that performance will vary		<b>Niobium</b> helps increase the energy density of batteries, giving more power and increased range, and improves performance at low temperatures
	<b>CHARGING TIME</b>	
Charging times can vary significantly depending upon the car and charging station but can take several hours		<b>Niobium</b> materials can increase the rate with which batteries charge and discharge
	<b>PERFORMANCE/LONGEVITY</b>	
Batteries have a relatively short operating life as materials degrade during charge/recharge cycle		<b>Niobium</b> increases the stability of the battery so it can withstand more charging cycles
	<b>COSTS</b>	
Even with subsidies, BEVs are more expensive than equivalent ICE vehicles		<b>Niobium</b> is readily available and cost effective compared to other battery materials
	<b>CHOICE</b>	
There are few BEVs on the market		This is changing rapidly

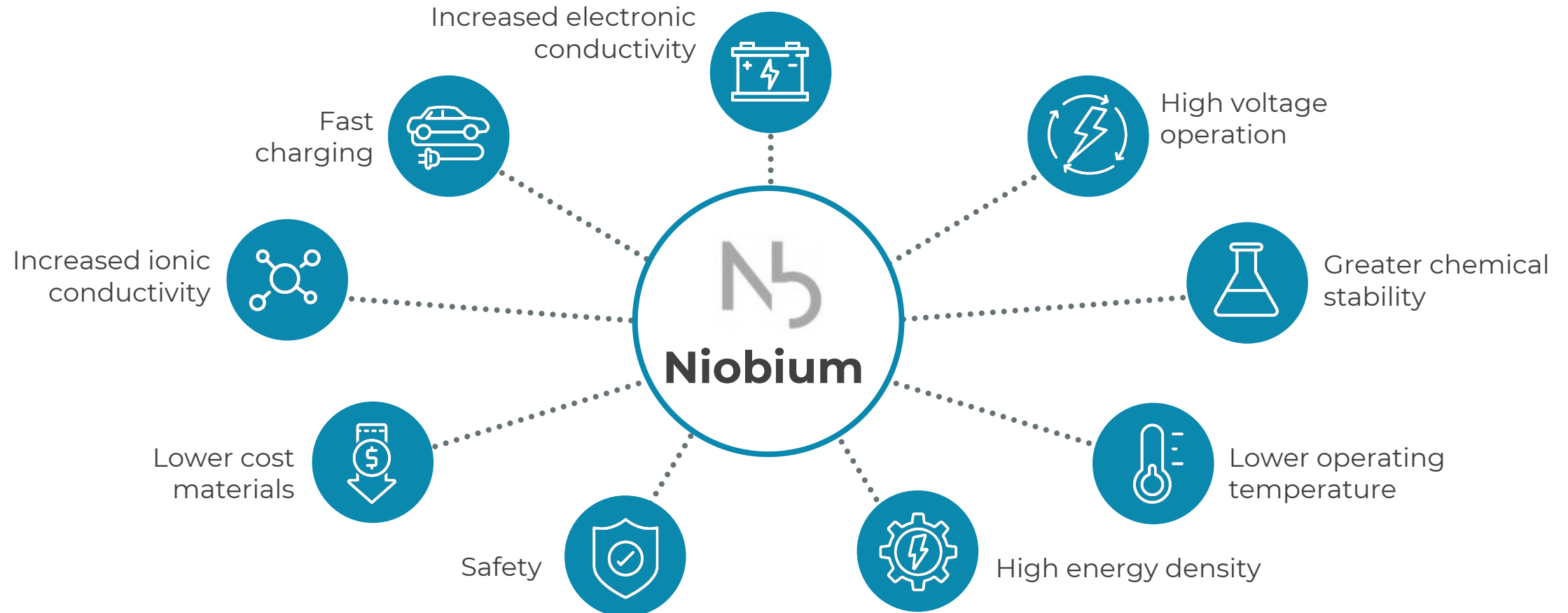


# Niobium's use in e-batteries

## Solving the fast charging, range anxiety and cost issues



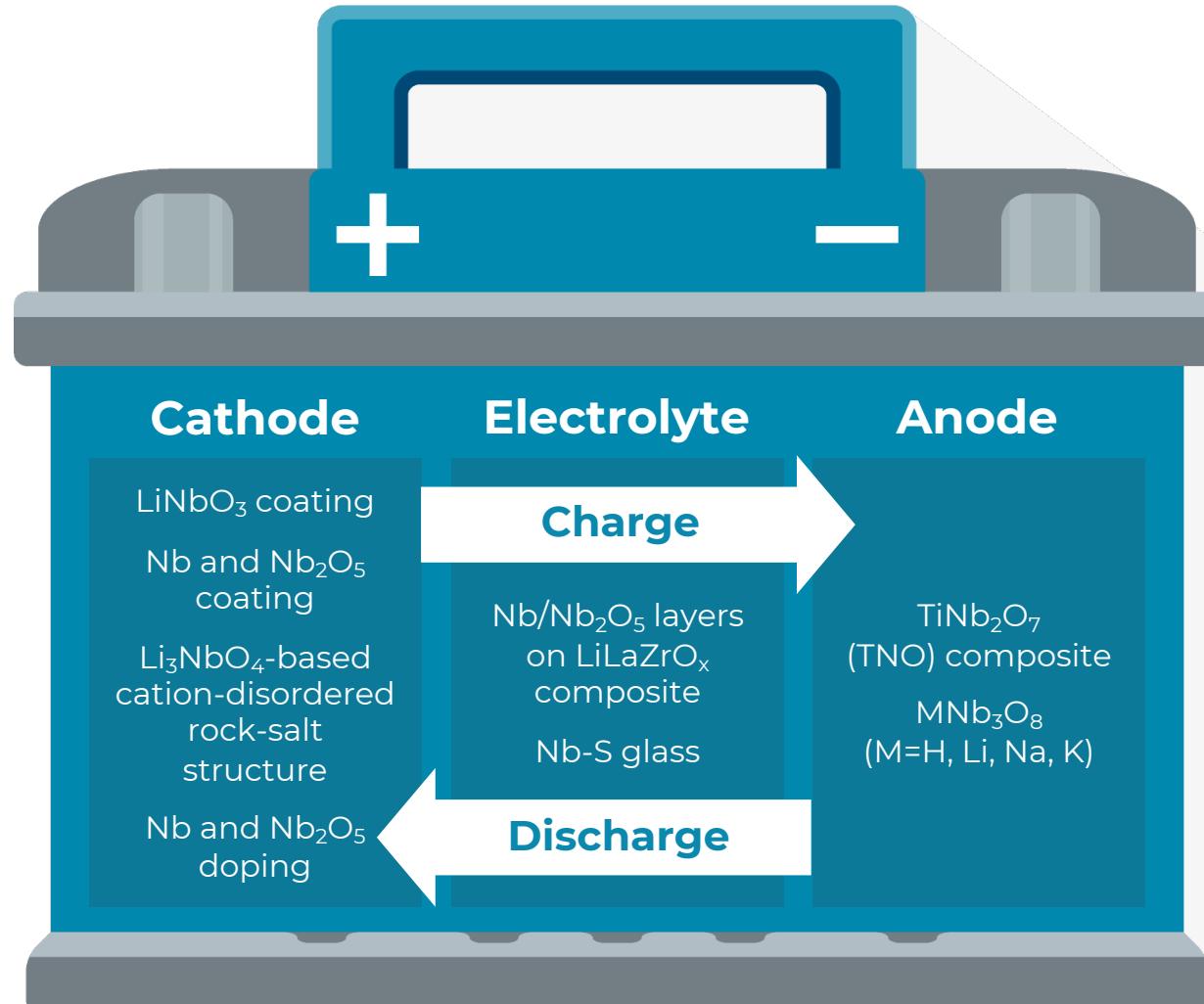
Niobium addresses almost all of the major barriers to electric vehicle adoption



# E-batteries

## Issues facing the EV industry

### How does Niobium work in lithium ion batteries?



# Niobium effect on Li-ion e-batteries

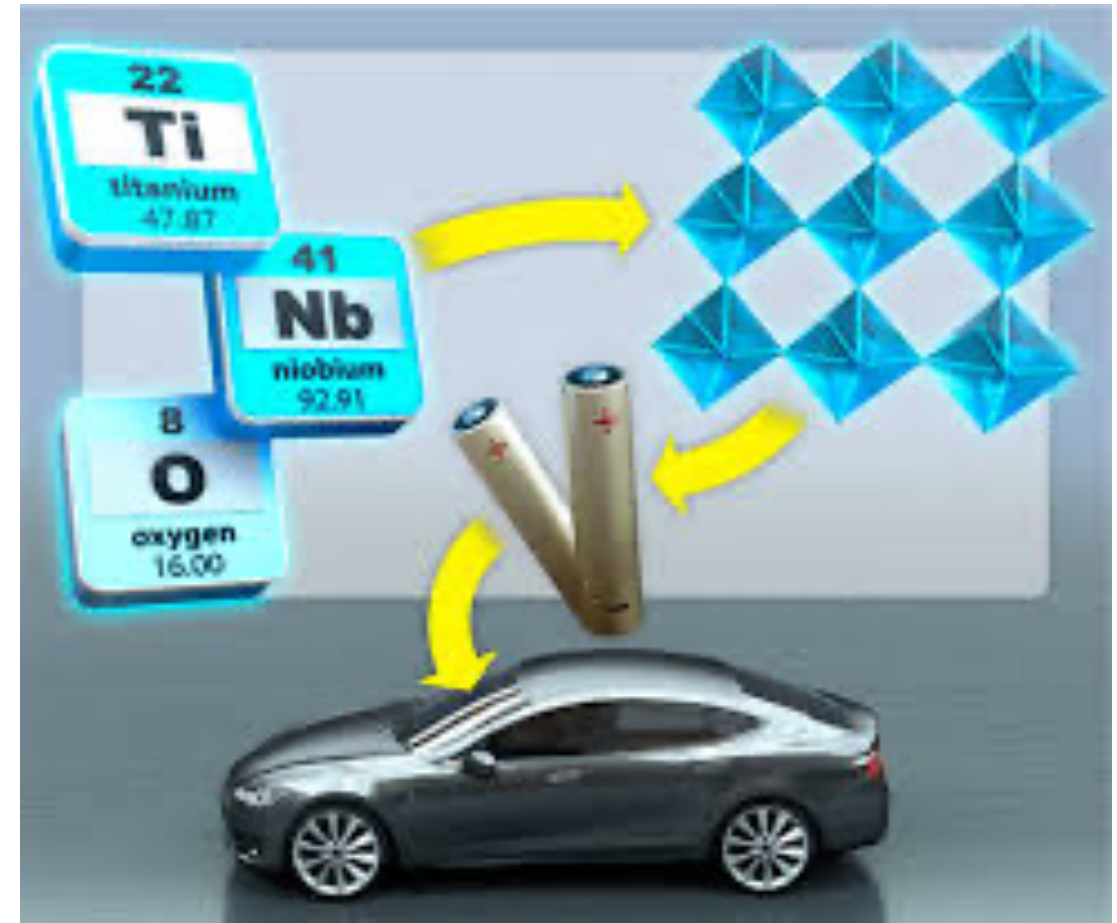
## Explained in layman's terms

- When charging a traditional battery, positively charged lithium ions start at the lithium metal cathode and migrate to a negatively charged anode. The anode is usually made of graphite – a crystalline carbon structure that traps and holds the ions in a process known as intercalation. This works well enough, but it requires the lithium ions to penetrate deep into the graphite lattice and undergo a chemical phase transition, releasing heat which can cause batteries to short circuit, overheat and catch on fire.
- The process can also get bogged down if the metal ions don't penetrate deep enough into the carbon matrix and instead clump to form a metal coating. This is what is referred to as lithium plating. The lithium metal grows and forms “dendrites” that can pierce the separation barrier and short circuit potentially causing fire.
- Replacing the graphite in the anode with niobium solves – or at least improves – both of these problems. Due to the larger surface area of the niobium oxide molecules, lithium ions don't need to penetrate deep into the crystal lattice or undergo any phase transitions to remain in place. Instead, the lithium ions “nestle” onto the surface of the niobium lattice.

# Fast charging revolution

## Niobium based anodes

- High-power energy storage devices are required for many emerging technologies. The charging rate capability of existing energy storage devices is inadequate to fulfill the requirements of fast charging and discharging while maintaining suitable long-term stability and energy density. This is readily apparent when evaluating the current anode of choice, graphite, which does not have an acceptable high-rate capability using traditional electrolytes.
- Tungsten Niobium (TNb) and Titanium Niobium Oxide (TiNbO) anode materials have been shown to provide high charge/discharge rates, excellent stability, and reasonable capacity.





# Industry leader: CBMM – banking on EV demand

## CBMM is spending big on R&D and banking on electric vehicle demand

- **February 2021:** CBMM's Vice President Ricardo Lima announces that CBMM is predicting that its sales of niobium oxide, used in the production of batteries, will reach 45,000 tons by 2030, up from just 100 tons currently. Lima also said that if CBMM's forecasts were met, sales of niobium oxide would rise to represent about 25% of CBMM's revenues.

<https://www.reuters.com/article/brazil-mining-batteries/brazil-miner-cbmm-seeks-to-sell-45000-tons-of-niobium-oxide-by-2030-idUSL1N2KF2VE?edition-redirect=in>

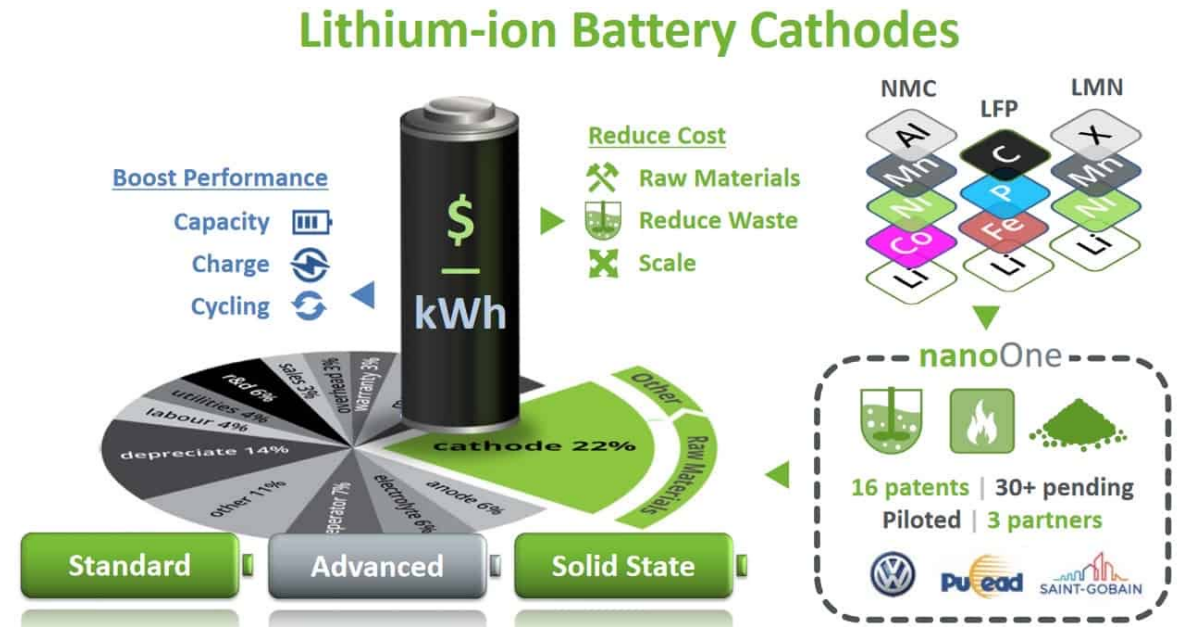
- **March 2021:** CBMM will invest around 200mn reais (US\$35m) in its technology program, with an annual increase of close to 60% for the batteries area.
- CBMM is expanding its niobium oxide production capacity to target electric vehicle makers. In the coming weeks CBMM will inaugurate a new manufacturing area in Araxá, Minas Gerais state, which will allow it to reach a capacity to produce 150,000t of niobium products annually.

<https://www.bnamericas.com/en/news/brazil-niobium-miner-cbmm-eyes-startup-acquisitions>



# Industry leader: CBMM – banking on EV demand (cont'd)

- **May 2021:** CBBM and TSX listed Nano One® Materials Corp announce that they have entered into an advanced lithium-ion battery cathode materials coating development agreement.
- Nano One is a clean technology company with a patented low carbon intensity process for the production of low cost, high-performance cathode materials used in lithium-ion batteries.



“Nano One has successfully demonstrated the use of niobium as a coating for various cathode materials and has several related patents now granted and pending,” “Our One-Pot process enables us to form coatings simultaneously with the underlying cathode material. This avoids extra steps and costs while enabling individual nanocrystals, also known as single crystals, to be coated for increased durability. With the support and partnership of CBMM, we will build on these successes and optimize our One-Pot process for the production of niobium coated nickel rich cathode materials for demanding applications such as electric vehicles.”

## The company fast becoming the first Niobium related EV business major success story

- Nyobolt is a UK based company which has developed battery anodes using niobium and tungsten.
- A spin out of Cambridge University's Yusuf Hamied Department of Chemistry, Nyobolt's technology is based on a decade of research on battery anode materials.
- Cofounded in 2019 by Professor Clare Grey, DBE, FRS and Dr Sai Shivareddy, the company's technology brings end-to-end fast charging solutions to applications ranging from power tools and home appliances to electric vehicles and industrial robotics.
- In July 2022 Nyobolt raised US\$59 million primarily to fund a battery manufacturing plant.

<https://www.electrive.com/2022/07/19/nyobolt-raises-50-million-in-funding/#:~:text=British%20fast%2Dcharging%20battery%20startup,to%20begin%20manufacturing%20at%20scale>

- This investment values Nyobolt in excess of GBP300m (~US350M)

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NEWS www.businessweekly.co.uk news@businessweekly.co.uk

### Nyobolt value hits £300m

Nyobolt, Cambridge's pioneer of end-to-end fast-charging battery systems, has revealed the initial close of a £50 million Series B round which will enable the company to enter a stage of manufacturing at scale. The financing takes Nyobolt's value to £300m.

The Series B is led by German materials power player H.C. Starck Tungsten Powders (HCS), a subsidiary of Masan High-Tech Materials, one of the world's largest tungsten suppliers. Tungsten is a key component of Nyobolt's technology. Nyobolt's existing investor - IQ Capital - is also participating in the round.

The investment is set to drive Nyobolt's market entry by establishing its presence and launching the manufacturing of millions of units next year.

H.C. Starck funding will enable Nyobolt's first materials manufacturing plant in the UK as well as expansion of the US cell engineering facility and the teams' growth across the globe.

Co-founded in 2019 by Professor Clare Grey and CEO Dr Sai Shivareddy, Nyobolt is commercialising high-performance, ultra-fast charging battery anodes to create a world where lengthy charge times no longer exist.

and recycling aims to provide a sustainable solution supporting the transition to net zero in multiple sectors.

The ultra-fast charging battery solution developed by world renowned experts at Nyobolt drastically decreases charge time from hours to minutes, maximising uptime and productivity. Nyobolt's technology will lead the world towards transport decarbonisation, by erasing the greatest barrier preventing drivers from going electric - charge anxiety.

The technology is applicable for devices ranging from home appliances to electric vehicles and industrial robotics, improving performance and revolutionising energy storage markets.

As well as ensuring security of supply of key materials, this strategic partnership will enable Nyobolt to benefit from the established recycling capabilities of H.C. Starck, allowing the efficient use of resources to minimise the environmental impact of Nyobolt's ultra-fast charging batteries.

The collaboration will lead to a sustainable supply chain for Nyobolt's technology, making the technically demanding process of battery recycling easier and more efficient.

966 x 709

# CBMM: Collaborations – Part 1

## Recent R&D has demonstrated the importance of Nb to making highly efficient and rapid charging batteries

### Toshiba banking on Niobium Titanium Oxide Anode to grow its battery market share

- Toshiba's SCiB™ rechargeable battery is presently used in a wide range of fields, from automobile to social infrastructure. Not content, Toshiba's SCiB™ battery's evolution has reached a point of re-examining its core identity—the anode material. Toshiba is focused on working with niobium titanium oxide (NTO) as the next-generation anode material for its outstanding characteristics. The new battery offers high- energy density and the ultra-rapid recharging required for automotive applications and will give a compact electric vehicle (EV) with a drive range of 320km after only six minutes of ultra-rapid recharging—three times the distance possible with current lithium-ion batteries.

<https://www.toshiba-clip.com/en/detail/p=791>



### Bender exploring Niobium as a viable alternative to cobalt

- Developing new battery components is a challenge for electric vehicle manufacturers. In addition to performance and safety, eliminating the need for resources from sources of concern, such as the cobalt present in the positive electrodes (cathodes) of batteries, is essential for the success of the final product. Cobalt consumption is increasingly on the rise. By 2029, the demand for this metal will be equivalent to 300,000 tons compared to the 70,000 tons consumed in 2019, according to estimates by Benchmark Minerals.
- More than 60% of cobalt available in the market is produced in the Democratic Republic of Congo, where its extraction and exploitation has been linked to corruption, environmental destruction, child labor and human rights violations. Bender Motors, on the other hand, will use niobium to develop and manufacture the positive electrodes for the batteries of its electric vehicles.
- Bender has identified that niobium has other advantages when applied to the development of materials for positive battery electrodes, for example, niobium improves thermal characteristics, which favors safety.

<https://bendermotors.com.br/en/2020/06/22/niobio-ingrediente-chave-da-bender/>





## CBMM: Collaborations – Part 2

- CBMM, the niobium industry leader, and Horwin (Brazil), a leader in the motorcycle and e-scooter market, announced in March 2022 that they have teamed up to manufacture fast-charging electric motorcycles.

See: Chinese E-Bikes Built in Brazil to Use Local Battery – Asia Financial News

- CBMM and VW Truck and Bus (Brazil) announced in October 2021 that they have teamed up to manufacture fast-charging batteries for VW's electric vehicles.

See: Volkswagen Caminhões e Ônibus – Press Room (vwtpress.com)



*Horwin EK3 electric motorcycles. The new batteries will lower the charging time from three hours to about 10 minutes and have a longer life when compared to traditional batteries, according to Horwin.*

*Photo: Horwin Global*

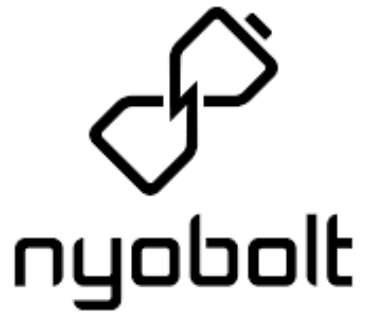
# CBMM: Collaborations – Part 3

- **Aug 2021:** CBMM will acquire a 20% stake in Battery Streak for US\$5 million.
- The investment aims to accelerate new technologies with using niobium in lithium-ion batteries.
- The investment allows Battery Streak to drive development and ramp production of its revolutionary, patented materials for a variety of applications including power tools, drones, medical devices, electric scooters, warehouse robots, and EVs, in civilian and military use cases.

<https://batterystreak.com/battery-streak-nsf-grant-cbbm-investment/>



# Niobium battery technology companies





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