Welcome to the Future of EV Batteries

The race for better electric car batteries is being called the next gold rush. Here's what's coming.

Tony Adcock
Executive Chair
Tungsten Metals Group Ltd

The Battery Revolution

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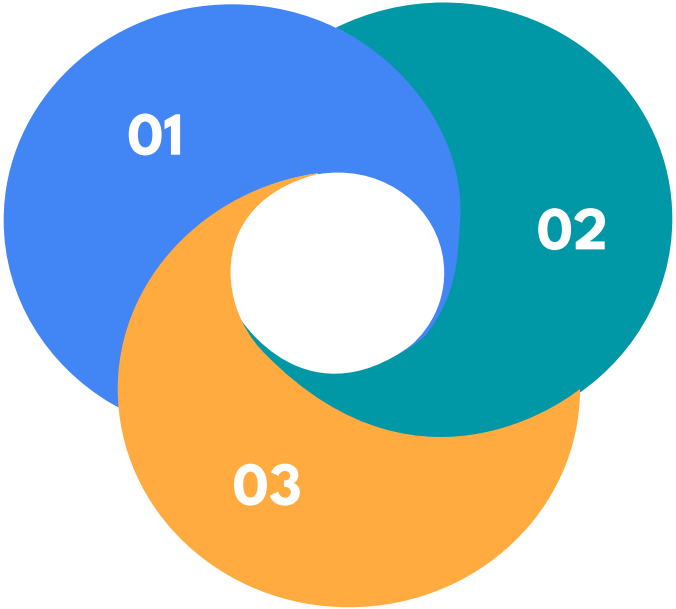
EV makers recognize the need for more range and quicker charging



Current lithium-ion batteries have limitations

Advancements in computer chips and operating systems outpace battery technology

Next generation batteries

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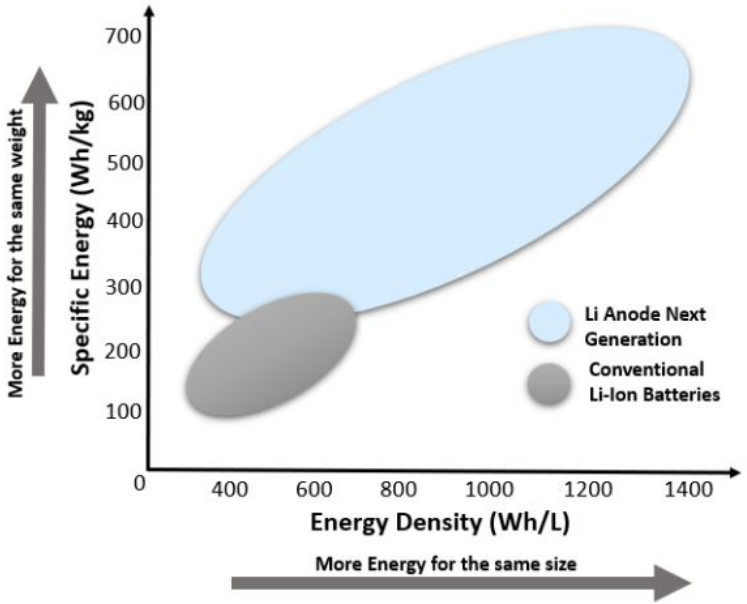
The Opportunity

- *To achieve their performance goals, next-generation battery designs need completely different supply chains, which still need to be created.*

The Promise

1. **Higher Energy Density** - means longer range or more room in EVs, a smaller footprint for stationary storage, and more cargo room in electric ships
2. **Higher Specific Energy** - higher energy in a small weight means longer range, better mileage, and new applications (air mobility, hybrid-electric aircraft, etc.)
3. **Improved Safety** - many next-generation battery designs eliminate flammable electrolytes, which means no fires



WHY NEXT-GENERATION BATTERIES

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Next-generation batteries = better performance - lighter, more efficient cars and higher margins for OEMs

	Today's Lithium-Ion	High-Content Silicon Anodes	% Improvement
System Volume	329 L	**184 L**	**44%**
System Mass	499 Kg	**304 Kg**	**39%**
Range	266 Miles	**304 Miles**	**14%**
Cost	$10,934	**$6,545**	**40%**

	Today's Lithium-Ion	Lithium Metal Anodes	% Improvement
System Volume	329 L	**184 L**	**44%**
System Mass	499 Kg	**269 Kg**	**46%**
Range	266 Miles	**308 Miles**	**16%**
Cost	$10,934	**$6,545**	**40%**

LITHIUM METAL BATTERY FORECAST

Lithium Metal Demand

The lithium industry currently produces **3,000** tpa of battery-grade lithium.

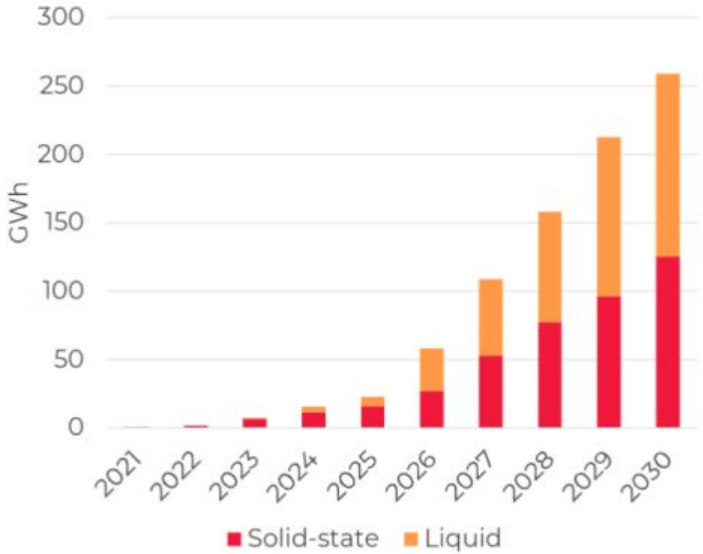
21,800 tpa of lithium metal is needed by 2030 to meet demand (taking current capacity announcements into account)

Approx. 90% of lithium metal is produced in China today.

Unlikely all battery-grade lithium metal capacity will come online by 2030.

Source: Benchmark Minerals Intelligence

Lithium Metal Battery Capacity Forecast



Li-Metal is targeting an anode market expected to exceed **$10B** annually by 2030 and **$40B** by 2035.

New Technologies for Zero-Emission Vehicles

There are many new technologies coming that may make it easier to own and run a zero-emission vehicle. The woes of “range anxiety” and “long charging times” will soon be a thing of the past with battery packs offering over 500 miles of range between charges that only take a few seconds, and power available to you over the air.

We are at the threshold of a battery revolution. Electric car makers know that in order to get an EV in every garage, EV buyers demand more range and quicker charging. They are well aware of the limitations of the current lithium-ion batteries that power today’s EVs. While computer chips and operating systems continue to advance in saving power, battery packs have been the weak link… until now.

Let’s take a look at research that may lead to an exciting new world of battery technology for tomorrow’s electric cars.

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New Research

- Using new battery tech as structural components of future electric cars
- Carbon fibre as the negative electrode, lithium iron phosphate as the positive electrode
- Resulting batteries are extremely stiff and rigid

EV Batteries as Structural Components

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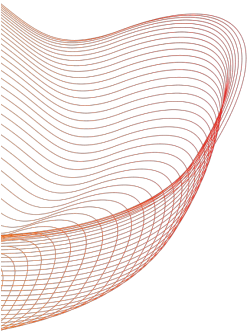
Technology has been focusing on using new battery tech as a structural component of future electric cars. This could lead to lighter vehicles in which body parts are the batteries. Using carbon fibre as the negative electrode while the positive is a lithium iron phosphate, these batteries would be extremely stiff and rigid for structural components



NAWA Technologies: Ultra Fast Carbon Electrode

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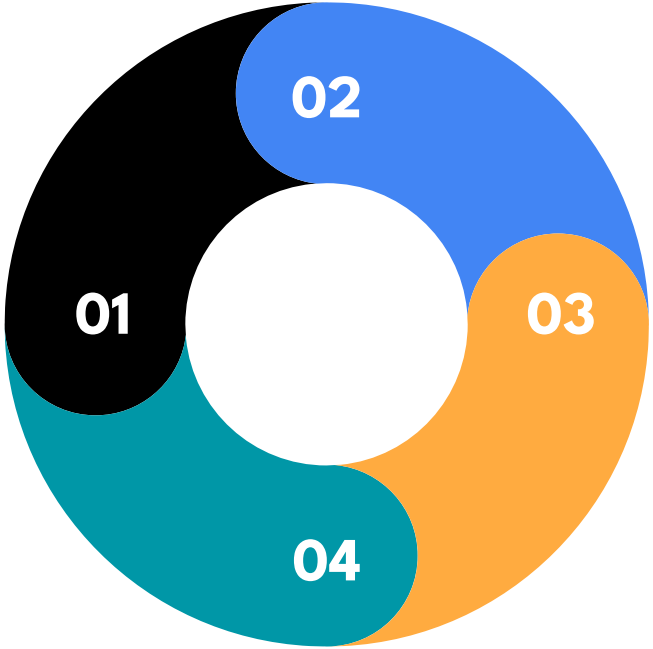
Vertically-aligned carbon nanotube boosts battery power ten times

Increases energy storage by a factor of three



Lifespan of batteries extended five times

Charging time reduced to just five minutes for 80% charge

Cobalt-Free Batteries

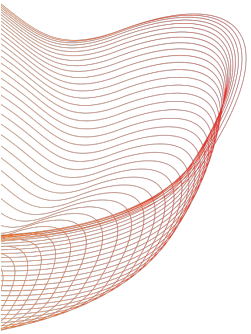
The University of Texas is working on a lithium-ion battery that doesn't use cobalt as a cathode. Instead, it uses up to 89 percent nickel as well as aluminum and manganese. The motivation is that cobalt is rare, expensive, and harmful to source. The team at U of T say their batteries produce a more elegant distribution of ions as well.

A Chinese company called SVOLT is manufacturing cobalt-free batteries for the EV market. They claim to have a higher energy density, resulting in a vehicle range of up to an estimated 500 miles on a single charge.

Silicon Anode Batteries

Looking for a cure to unstable silicon in lithium-ion batteries, researchers at the University of Eastern Finland have developed a method to produce a hybrid anode that uses mesoporous silicon microparticles and carbon nanotubes. They hope to replace graphite as the anode and replace it with silicon, which has ten times the capacity.

The goal is that this will improve battery performance. Best of all, the sourcing of this silicone is earth friendly as it is made from barley husk ash.



A Battery Extracted from Seawater

IBM Research has discovered a new battery chemistry that is free of heavy metals and can out-perform lithium-ion batteries. The materials are extracted from seawater.

IBM says these batteries will be cheaper to make, can charge faster, and pack in higher energy density and power. The company is currently working with Mercedes-Benz to develop the technology.

Sand Batteries Offer More Life

Researchers at the University of California Riverside are working on battery technology that uses sand in order to create pure silicon to achieve three times better performance than current graphite-based lithium-ion batteries.

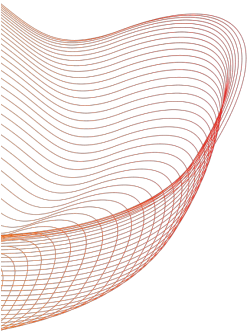
This new pure silicon also advances the lifespan of batteries

A battery startup company called Silnano is bringing this technology to the market through funding by Daimler and BMW promising a 40 percent boost in battery performance in the near future

Charging Electric Cars by Wi-Fi?

Imagine powering your car over Wi-Fi while you drive. You'd never have to recharge your battery by plugging in. While this technology is still a way off, researchers have developed a radio wave harvesting antenna that is only several atoms thick, that may be used to recharge future EVs over electromagnetic waves.

The concept involves incorporating the molybdenum disulphide rectenna so that AC power can be downloaded from Wi-Fi and converted to DC power to recharge a battery or to power an EV directly. Let's just hope it doesn't fry your brain at the same time.



Over the Air Ultrasound Charging

Another way to possibly transmit rechargeable power over the air is through ultrasound. A company called uBeam turns power into sound waves that can be beamed to your EV and then turned back into power. Right now, uBeam is experimenting with using this technology to power smartphones and laptops, but who knows where this might lead?

Charge Your EV in 5 Minutes

Speaking of smartphone charging, a start-up company called StoreDot that was born from the nanotech department of Tel Aviv University, has developed a charger that uses biological semiconductors. These use organic peptide compounds which are the building blocks of proteins.

The result is a charger that can recharge your smartphone in just 60 seconds, and the organic compounds are non-flammable for safer charging. StoreDot is currently building batteries for EVs that will charge in five minutes and offer an estimated range of 300 miles.

Batteries that Never Die

Scientists at the University of California are working on nanowire batteries that will never die. The gold nanowires are a thousand times thinner than a human hair and sit in a gel of electrolyte to keep them from breaking down during recharging.

They have been tested recharging over 200,000 times over three months and showed no sign of degradation.

Solid-State Batteries

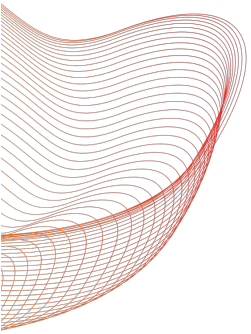
Traditionally, solid-state batteries offer stability but at the cost of electrolyte transmissions. However, scientists at Toyota are testing a solid-state battery that uses sulfide superionic conductors for a better battery that can operate at super capacitor levels to charge in just seven minutes. Plus, being solid-state makes it safer than current battery options.

Solid Power Inc. is producing solid-state batteries for EVs using sulfide-based all-solid-state cells. Meanwhile, QuantumScape is developing solid-state batteries for Volkswagen. The hope is that these game changing batteries will be used in electric vehicles by 2026

Zinc-Air Batteries

Researchers at Sydney University have found a way to make zinc-air batteries for much less than the costs of current methods. Zinc-air batteries are superior to lithium-ion batteries as they cannot catch on fire.

The problem has been that Zinc-air batteries are made from very expensive components, but the University has found a way to use much cheaper alternatives. So, cheaper and safer batteries may soon be on the way.



Twenty Times Faster EV Charging

Ryden dual carbon technology allows batteries to last longer and charge faster than lithium but can be made using the same factories where lithium batteries are produced. Power Japan Plus says the batteries are more sustainable, last longer, are environmentally friendly and can charge 20 times faster than conventional batteries.

New EV Batteries and Increased Range

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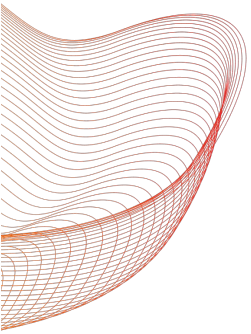
A company called Graphenano is developing a Graphene battery that it says will offer an estimated range of 500 miles and can be recharged in just a few minutes. The company says its batteries will charge and deplete 33 times faster than lithium-ion batteries.

An experimental car recently drove 1,100 miles on a single battery charge. This was possible thanks to aluminum-air battery technology that uses oxygen from the air to fill its cathode - making it much lighter than liquid-filled lithium ion batteries - to give the electric car greater range.



Tungsten

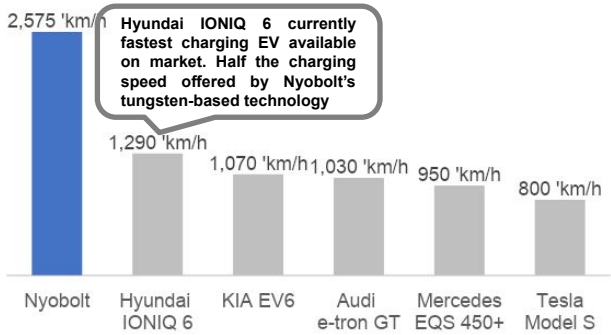
Emerging applications in battery technology

Nyobolt's new technology is a case study in the future importance of Tungsten in battery technology

Technological breakthrough[1]

- **Nyobolt, a UK based developer of battery technology, recently revealed a new 35kWh battery which is able to fully charge in under 6 minutes**
- **New technology utilises niobium and Tungsten-based anode systems to achieve ultra-fast charging**
- **The battery offers**
  - ✔ **Long-term capacity retention;**
  - ✔ **Greater durability and energy density;**
  - ✔ **Higher heat resistance; and**
  - ✔ **Greater safety for users.**
- **The new-generation battery compensates for the shortcomings of conventional batteries such as hyper-sensitivity, thermal stress and high costs**
- **Expect higher demand for tungsten goes into production in 2024 and ramps up over the next 5 years**
- **Demonstrates the increasingly important role of Tungsten in future technologies**

EV battery charging speeds[2]



Source: (1) [illegible] https://e.vnexpress.net/news/business/tech-champions-2022-acclaims-nyobolt-s-fast-charging-tungsten-battery-technology-4538728.html (2) https://nyobolt.com/, https://www.ev-database.org

Better and Cheaper EV Batteries: The New Gold Rush

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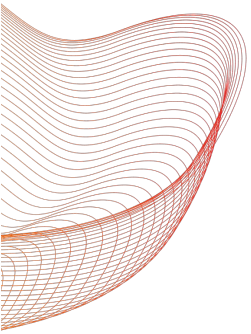
According to numerous statistics, electric vehicle sales will jump in America in the next five years, climbing from 3 percent of car sales today to about 10 percent in 2025 and almost 30 percent by 2030. Demand for better and cheaper EV batteries is creating a new gold rush as university research teams, start-up companies and automakers delve into exciting new technologies and hurry to meet demand.

The goal is to develop improved EV batteries that charge faster and last longer while switching to less expensive and more environmentally friendly materials. With our fingers on the pulse of all things in the zero-emission vehicle universe, check in with GreenCars often for information on the latest technologies that are driving the EV transportation revolution.



THANK YOU

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