Applications of high-tech metals

Mobile phones

The first call on a mobile phone was made on 3 April 1973 by Motorola employee Martin Cooper. In 2019, the total number of mobile phone users is expected to exceed 5 billion (this equals over 7 billion mobile phones), attributed mostly to the increasing popularity of 'smartphones' (Statista 2018). This phenomenal increase in the number of mobile phone users over the past 45 years is one of the key driving forces behind the increased demand for high-tech metals, such as gold, copper, cobalt and nickel.

Sea of smartphones in concert crowd.

Batteries

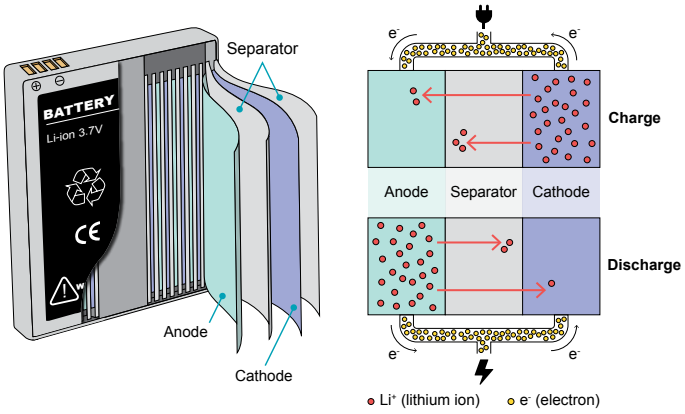
The first battery (voltaic pile) was invented in 1800 by Alessandro Volta. In 1859, French physicist Gaston Planté invented the rechargeable lead-acid storage battery. The first commercial zinc-carbon dry cell batteries were developed in the 1880s and are still used in 'low drain' or intermittent-use devices such as remote controls, torches, clocks and transistor radios. The first common alkaline battery was invented in the 1950s, the rechargeable nickel-metal hydride battery in the 1970s, and the more-rapidly recharged lithium-ion (Li-ion) battery in the 1980s, which made it possible to develop mobile consumer electronic devices, such as mobile phones, cameras and laptops.

Li-ion batteries also play a vital role in renewable energy (grid storage batteries), and clean fuel efficient transport (electric vehicles).

Grid storage batteries may play an essential role in clean energy generation and distribution, by storing excess generated energy for later use. This may be at a national level or at a household level, with the development of new household battery systems, such as the Tesla power wall.

Lithium is not the only metal in a li-ion battery. In fact, lithium makes up only a small portion of the battery, driving the demand for several other high-tech metals (graphite, nickel, copper and cobalt).

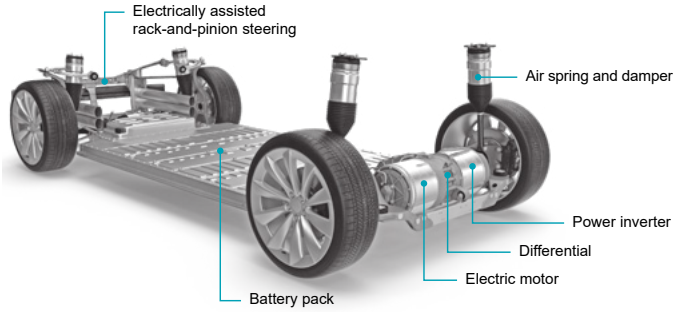
Lithium-ion battery



Electric vehicles

Electric vehicles (EVs) have been around a lot longer than you may think. Several different inventors have been given credit for inventing the first electric vehicle: Anyos Jedlik of Hungary (1828), Robert Anderson of Scotland (1832), Professor Stratingh of Holland (1835) and Thomas Davenport of Vermont (1835). In 1891, William Morrison of Des Moines, Iowa, built the first successful electric automobile in the United States. The first commercial EV application was a fleet of New York City taxis in 1897. In 1900, 28% of the cars produced in the United States were powered by electricity (Public Broadcasting Service 2009).

Electric car



During the 1920s, electric vehicles ceased to be popular, as consumers wanted longer travelling distances and more horsepower, gasoline became readily available, and the cost of an EV was US$1750 compared to US$650 for a gasoline-powered car (Bellis 2017).

Concerns over pollution and the soaring price of oil saw interest in EVs start to grow again in the 1960s and 1970s, but again limitations in range and speed prevented them from being adopted on a mass scale, and their popularity declined in the 1980s.

In 1997, Toyota unveiled the 'Prius' – the world's first commercially mass-produced and marketed hybrid car. The 'Prius' helped create interest in fuel efficient cars with Toyota selling more than 10 million hybrid vehicles between 1997 and 2017.

In 2006, Tesla publicly unveiled the all-electric 'Roadster', with the first cars sold in 2008 at a starting price of $US98 950. Nissan released the all-electric 'Leaf' in 2010, which quickly became the bestselling electric highway-capable vehicle in the world, in part due to its starting price of around $US30 000.

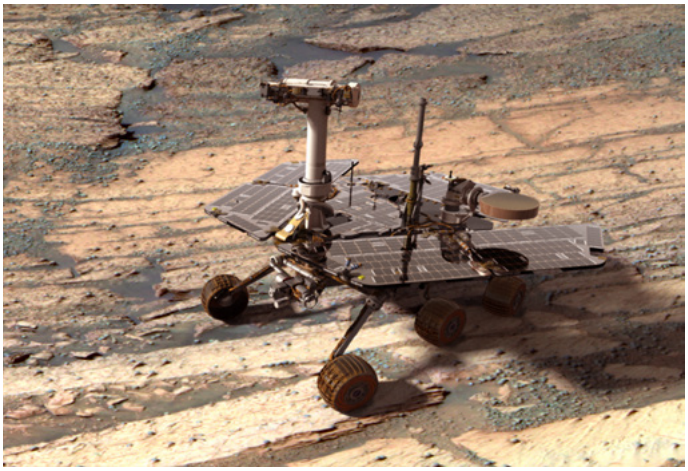
Over the next few years, in response to the demand for EVs, we can expect to see a number of new electric cars come to the market from some of the traditional car makers.

Super magnets

Neodymium magnets were first developed in 1982 by General Motors and Sumitomo Special Metals as an economical, high performance replacement to the very expensive samarium-cobalt magnets. They are also called rare-earth magnets, because neodymium is part of the rare-earth family of elements.

They are extremely versatile and have become part of our everyday lives. What makes them so versatile is their strength – they are the strongest magnets in the world, able to support thousands of times their own weight. Their super strength allows them to be miniaturised and made in many shapes and sizes, even as small as 1 mm in diameter. They have made possible many of the technologies we take for granted today, including medical imaging machines, electric motors, wind turbines, computer hard drives, speakers, microphones, jewellery and mobile phones.

Did you know that they are also used to hold together dentures where several teeth are missing, in magnetic levitation trains, and to collect dust from the surface of Mars?



Mars Exploration Rover 'Opportunity' has been using magnets to explore the Red Planet since 2004. Image courtesy of NASA.

Wind turbines

Wind turbine generators are the latest evolution of the simple windmills that have been used since the 11th century. Instead of grinding grain or pumping water, they are now used to generate electricity.

The 1973 oil crisis spurred much research into renewable energy sources, with government policies in countries belonging to the Organisation of Economic Cooperation and Development, providing targeted tax incentives for renewable energy projects.

The first modern electrical wind turbine was developed in 1985 with an average rating of 100 kilowatts, supplying electricity for up to 60 average households. Since then, wind turbines have become larger, cheaper and more efficient.

Most new wind turbines installed in Australia have the capacity to generate approximately 3 megawatts (MW) each; enough power for up to 2000 average households, and a life span of 20–25 years (Clean Energy Council 2018).

In 2017, more than 33% of renewable electricity generated in Australia was from wind power; almost the same as that produced by hydro energy. By the end of 2017, 15 large scale wind projects were either under construction or financially committed. Wind power is the lowest cost form of large scale renewable energy (Clean Energy Council 2018).

New South Wales has 8 major wind farms operating, with a total capacity of 827 MW. Another 4 farms are under construction, adding 674 MW of capacity, and 13 more wind farms (3268 MW) have planning approval.

Wind farms in NSW

	Name	No. turbines	Capacity (MW)
Operational	Boco Rock	67	113
	Capital	67	141
	Cullerin Range	15	30
	Gullen Range	73	166
	Gunning	31	47
	Taralga	51	107
	White Rock	70	175
	Woodlawn	23	48
	Total	**397**	**827**
Under construction	Bodangora	33	113
	Crookwell 2	28	91
	Sapphire	75	270
	Silverton 1	58	200
	Total	**194**	**674**

The White Rock and Sapphire Wind Farms in NSW have some of the largest turbines in Australia, with 121 metres and 126 metres rotor diameters respectively. (Clean Energy Council of Australia 2016).

Medical applications

Metals have been used in medicine for hundreds of years. The first written account was in the Ebers Papyrus from 1500 BC which described the use of copper to reduce inflammation and iron to treat anaemia. Today, various metals are used for medical applications, including:

- gold in diagnostic testing (e.g. pregnancy testing, Salmonella detection, HIV testing) and treatments for cancer, microbial infections and rheumatoid arthritis
- platinum in chemotherapy drugs to treat testicular, bladder, ovarian, lung and several other types of cancers
- lithium to treat bipolar disorder.

Without high-tech metals, many of the treatments we take for granted (joint replacements, pacemakers, heart valves and stents) would not be possible. Their resistance to

corrosion, strength, durability, and biocompatibility (not toxic) with human tissue, makes them critical to modern medicine.

The number of joint replacements, particularly hips, is growing rapidly due to the aging population, and the prevalence of osteoarthritis, rheumatoid arthritis and musculoskeletal disorders. In Australia there were 63 300 knee and 47 254 hip replacements in 2017 (Australian Orthopaedic Association 2017). Globally, more than 1 million joint replacements are performed each year. Prosthetic parts are made from or contain metal because it is durable and non-corrosive. Chromium, nickel, cobalt, titanium and molybdenum are among the metals most commonly used in implants (Watson 2017).

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Manual insertion of copper windings into the generator stator of a wind turbine. Around 9 t of copper strands are formed into bundles during this step.