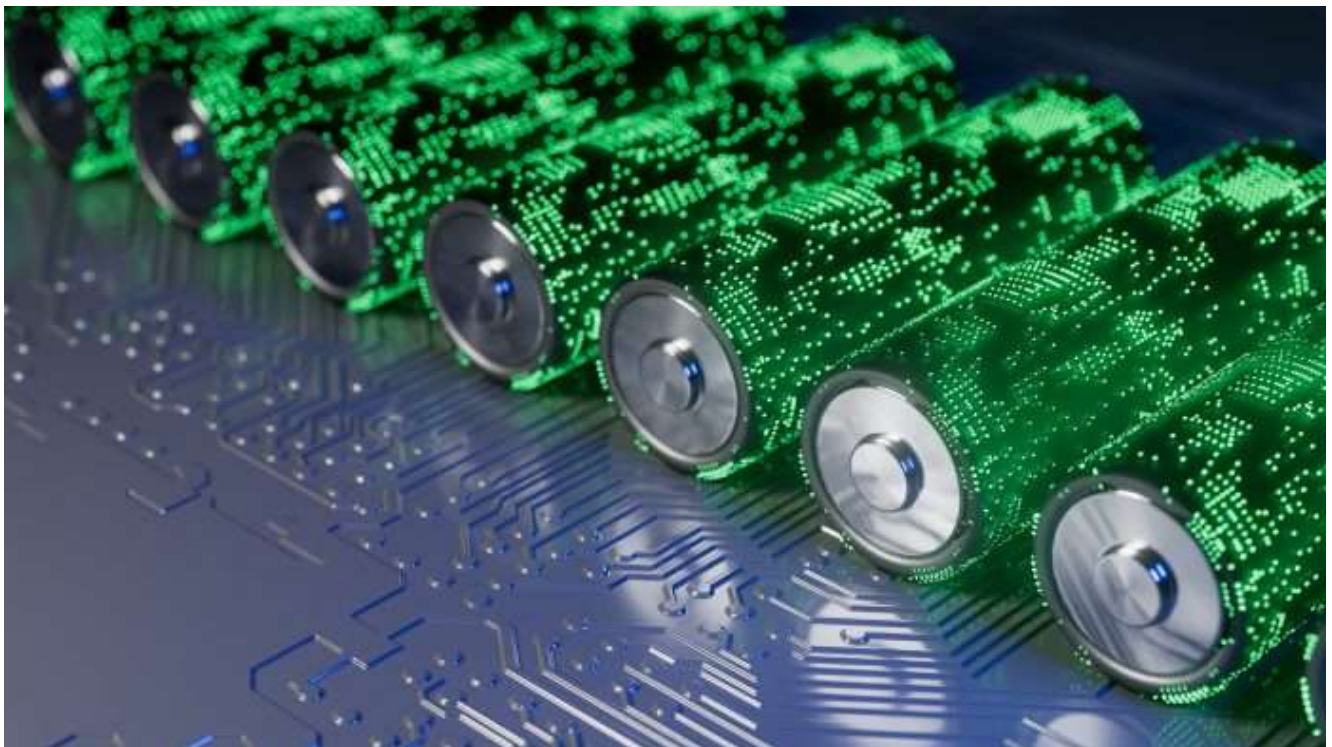


Recent Developments In Silicon Anode Technology

Batteries are regarded as the core of [electric vehicle](#) (EV) technology. Unlike conventional car technology, EVs completely rely on batteries to deliver power ([Hannan et al., 2021](#)). In line with this, lithium-ion battery (LIB) technology is leading to a completely new and [distinctive](#) energy storage and application paradigm. LIBs have distinguished themselves as an essential option for energy operations, storage, and modifications, both now and in the future. The [volumetric energy and higher gravimetric densities](#) of LIBs, compared to other [electrochemical energy storage](#) technologies, are widely utilised as power supplies for portable electronic devices. We also use them as power supplies for EVs and hybrid electric vehicles (HEVs), making life simpler for humans. Researchers have extensively investigated silicon anode technology as a high-performance alternative to replace existing graphite anodes.



Researchers have extensively investigated silicon anode technology as a high-performance alternative to replace existing graphite anodes.

Source: [iStock](#)

Lithium-Silicon Batteries

The existing system of LIBs is far behind what is actually needed. We must produce and improve growing electrodes to meet the rapidly rising need for energy storage devices with high energy density. This is relevant to the resurgence of electric cars.

The quality of these electrodes has an outstanding effect on the efficiency and performance of a LIB. This implies that any innovation leading to an enhancement in the capacity of the electrodes would generally improve the overall quality and efficiency of the [battery](#). This is both in its energy density, cyclability, and lifespan. This may ultimately lead to the full deployment of LIBs in [electric-powered automobiles](#) (EVs and HEVs). The popularity of other [energy storage](#) applications, (both large-scale and small-scale) has grown ([Nzereogu et al., 2022](#)).

Specifically, the nature and properties of the anode material are cardinal to the overall battery performance. The capacity and performance of the battery not only depends largely on the [intrinsic characteristics of the anode](#) material, but also on its morphology. Many high-performance anode materials have been explored as novel [materials](#) for the next generation of LIBs. [Among](#) them are alloy materials, conversion-type transition metal compounds, carbon-based compounds, and silicon-based compounds.

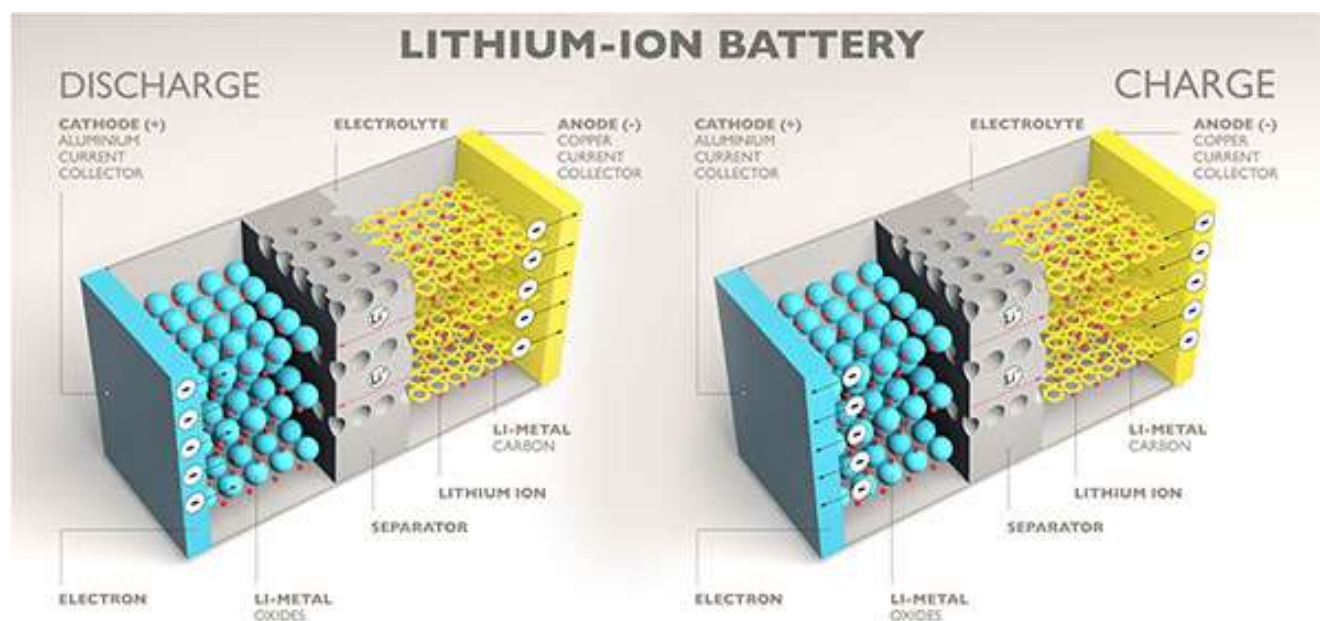


Batteries play an increasingly significant role in our lives, for instance through electric cars. Source: [Pexels](#)

What are Silicon Anode Batteries?

[Silicon anode batteries](#) are a type of lithium-ion battery that uses a silicon-based anode and lithium ions as charge carriers. Any typical lithium-ion battery today [consists](#) of a positive electrode (cathode) made up of a lithium-containing compound, a negative electrode (anode), and an electrolyte—[the layer in between the electrodes](#) through which ions flow.

Humans used lithium as the [anode material](#) in early Li-Ion batteries. Following a series of widely [reported](#) overheating and explosion accidents, this was replaced with graphite. For a long time, most commercially accessible anodes in lithium-ion batteries have been made of carbon/graphite because of their distinctive hierarchical structure ([Osiak et al., 2014](#)). However, as battery use increases, graphite-based [electrodes](#) are due for an upgrade.



A 3D-printed silicon grid within lithium-ion battery electrodes facilitates the efficient movement of lithium between electrodes. The silicon columns play a crucial role by acting as electrodes for lithium-ion batteries, separating from the surface of the battery cell.

Source: [University Wafer](#)

Replacement of Graphite with Silicon

Lithium-ion batteries offer higher energy densities, higher operating voltages, limited self-discharge, and lower maintenance needs. However, they suffer a [significant drawback](#): the current commercial [graphite](#) anode fails to meet the growing demands for energy density. There are inconsistencies in operational reliability and system integration, posed by extended-use portable electronic devices, long-range [electric vehicles](#), and expanding [energy storage](#) applications. As a result, researchers have extensively investigated silicon anode technology as a high-performance alternative to replace these graphite anodes.

Why the automotive industry is placing its bets on silicon anode technology.

Source: [YouTube](#)

How can we benefit from the development of Silicon Anode Batteries?

There are [many reasons](#) for which silicon is the preferred technological option.

- Silicon is less expensive, non-toxic, environmentally friendly, and an abundant earth element.
- Silicon has the highest volumetric capacity (9786 mAh cm⁻³), and the highest gravimetric capacity (4200 mAh g⁻¹). Contrary to carbon, silicon has some intrinsic properties. These include a lattice structure that may expand by up to 400% with complete lithiation (charging).
- On average, at 0.4 V, a suitable voltage is discharged by Silicon. This holds a stable balance between avoiding the plating process of adverse lithium and retaining reasonable, open circuit voltage.

Shortcomings

Despite its benefits, silicon anode technology has a serious drawback. Its particles enlarge and break apart as a result of [repeated](#) charging and discharging. As a result, a thick solid-electrolyte interface (SEI) develops between the electrolyte and the anode. This prevents lithium ions from moving freely between the electrodes.

To improve the performance of silicon anodes in LIBs, researchers at the Japan Advanced Institute of Science and Technology (JAIST) have [developed a binder for silicon particles](#) to enhance their stability and uphold a thin SEI layer in LIB silicon anodes. In contrast to a dense SEI layer, a thin one is [advantageous](#) because it inhibits the anode and electrolyte from reacting spontaneously.



Researchers are continuing to improve and decrease the cost of lithium-ion batteries, making significant technological adjustments to increase performance and cut expenses. This is all in the name of beneficial silicon anode technology.

Source: [Pexels](#)

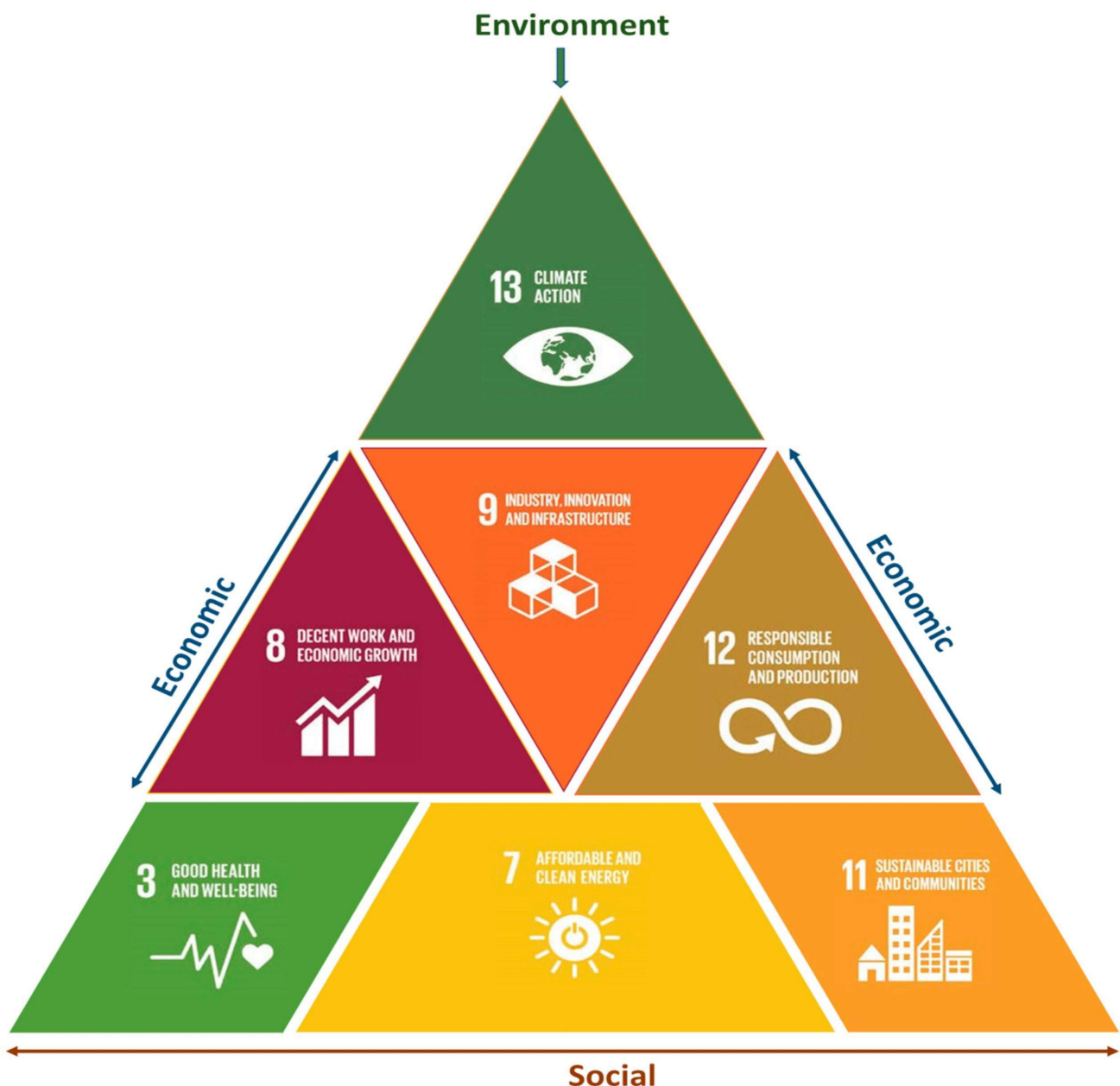
moving forward

Conclusively, While many believe silicon has great possibilities, further research is needed to determine the practical capabilities of this material. In light of rising [EV](#) and [renewable energy](#) demand (as well as a surge in battery research), one thing is sure: batteries are [essential](#) to the green transition and climate change mitigation.

achieving the United Nations Sustainable Development Goals (SDGs) and how they link to the development of silicon anode

technology

Battery technology is [key](#) to achieving the energy transition and expanding energy access, in line with the [UN Sustainable Development Goals](#) (SDGs). Sustainable development requires sustainable, secure, and clean transportation available to all, and EVs [fulfil](#) all these features. Electric vehicles have recently been linked to [renewable energy](#) and batteries, all of which have [improved environmental](#) implications and can help achieve the relevant SDGs.



Silicon anode technology, and in particular, EVs, have an impact on three aspects of sustainability. These include social, economic, and environmental sustainability, as well as a significant association with seven of the 17 SDGs.

Source: [Lipu et al., 2022](#)

A Thrivable Framework

At [THRIVE](#) we believe that there is no truly [sustainable energy system](#) in an unsustainable world. While [renewable energy](#) sources such as [solar](#) and [wind power](#) are increasingly replacing [fossil fuels](#), batteries have emerged as a viable storage option for portable electronics, automobiles, and power grids. Vehicle battery and [energy storage](#) can significantly contribute to reducing [greenhouse gases](#) and hasten the green transition. The transition to carbon neutrality and renewability is well underway—and [batteries](#) have a significant role to play. [Renewable energy](#) should be at the centre of [global efforts](#), particularly with regard to more practical applications.

At its core, sustainability simply means the ability to continue and to survive. ‘[Thrivability](#)’, by contrast, is the next step, beyond sustainability. THRIVE believes that humanity can do better with the knowledge currently available to us. We want to instil the idea that sustainable solutions will not only prevent [climate disasters](#) but offer the potential for societies to flourish.

[THRIVE Framework](#) constantly seeks to find solutions aimed at environmental, social, and economic [sustainability](#) through various informative activities such as [webinars](#), [blogs](#), and our [podcast series](#). THRIVE invests in a wide range of initiatives addressing important global concerns such as energy, [human rights](#), [gender equality](#), science, [innovation](#), sustainability, and global events. [Sign up for our newsletter](#) for regular updates on issues that concern us all.