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A JELENLEG PIACON LÉVŐ ILLETVE A JÖVŐBEN PIACI BEVEZETÉSRE KERÜLŐ LÍTIUM ALAPÚ AKKUMLÁTOROK (VÁRHATO) PIACI ÁRÁNAK VIZSGÁLATA – FŐBB TENDENCIÁK

EXAMINATION OF THE (EXPECTED) MARKET PRICE OF LITHIUM-BASED BATTERIES CURRENTLY OR IN THE FUTURE ON THE MARKET - MAIN TRENDS

ABSTRACT

Current trends show, that lithium-ion batteries are expected to remain the dominant energy storage devices in the near future, but new, conceptually different batteries are expected to appear on the market in medium to long term period. Lithium technology has its own limitations with special regards to complex electrochemical processes, occasionally appear some safety issues, varying lifetimes and efficiencies and hard to recycling these kind of batteries due to diversity. Researchers are constantly looking for opportunities to further develop existing technologies, and also looking for other ways to introduce completely new technologies. Improvements are usually aimed at achieving higher capacities, faster charging and greater reliability, but there are also growing goals related to environmental protection, such as reduced material use compared to capacities, longer service life, or the need to dispose of used batteries.

Firstly, we will examine the lithium-based batteries market are which processes had on effect with regard to price developments, and we will make an attempt to gather expected trends in the battery market based on advanced lithium and other technologies.

INTRODUCTION

In the last few years, battery developments have been driven primarily by increased sales of hybrid and electric cars (EVs) and the widespread use of renewable energy sources (RESs), which require increasing energy storage due to as energy is not produced and used at the same time. Lithium-ion batteries often have to operate in fairly harsh conditions, therefore may occur overcharging, operating at extreme temperatures, charging too fast, and short-circuiting, which can lead to damage in more severe cases and even an explosion. Some of the improvements are aimed at eliminating the problems mentioned before and creating battery management systems (BMS) to extend cell life.

PRICE OF LITHIUM - ION BATTERIES AND NEW TRENDS ON THE MARKET

Lithium-ion batteries are the most common and one of the most efficient energy storage devices worldwide. Over recent years, the large volume production and lots of capital investments into the battery production process made lithium-ion battery packs more cheaper and more efficient. Li-ion battery pack costs are expected to drop to some 135 U.S. dollars per kilowatt hour in 2020. (Figure 1.) By 2025, the global lithium-ion battery market is expected to double in size, reaching about 71 billion U.S. dollars [1].

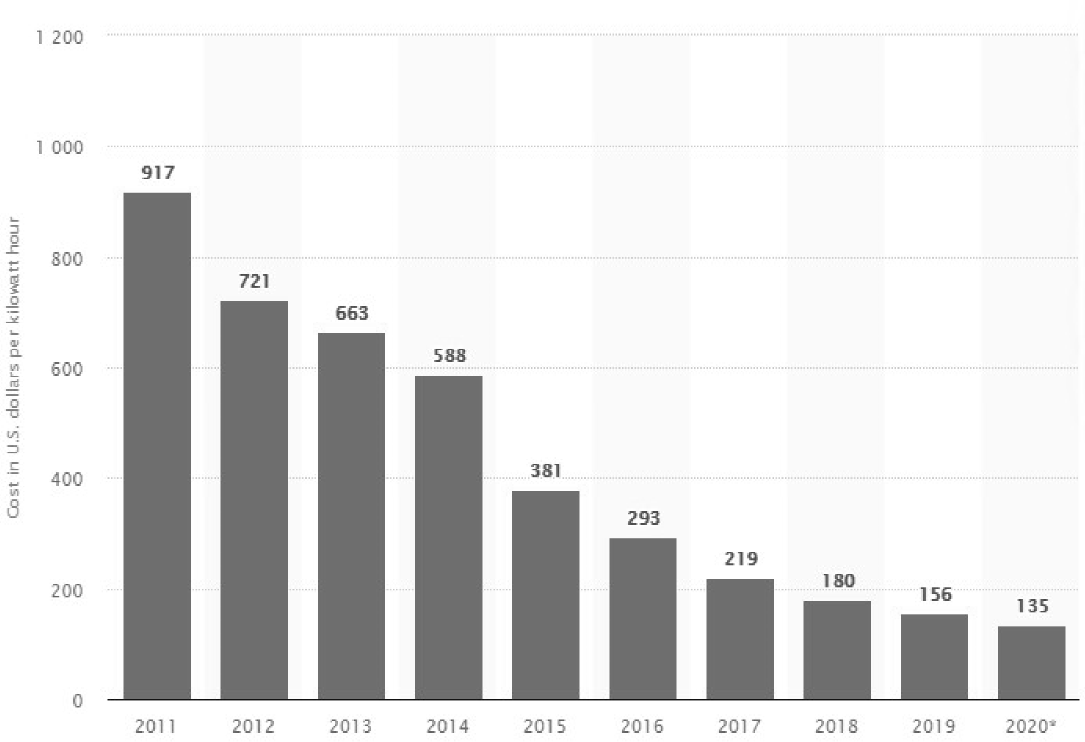

Figure 1: Lithium-ion battery pack costs worldwide between 2011 and 2020(in U.S. dollars per kilowatt hour) Source: [1]

This demonstrates a big demand for energy storage worldwide and could be attributed to the fact that the world is moving towards a renewable energy-based economy where electric vehicles play an increasingly large role [1].

On Figure 2. we can see the evolution of Li-ion battery price from 1995 to 2019 and the vertical lines show how much time was needed to double the cumulative capacity. The first lithium-ion batteries on the market were released by Sony in 1991. In the early stages of the technology, the capacity of the batteries was doubled in every year, and as the technology will became more advanced, it takes more and more time to double the capacity [2].

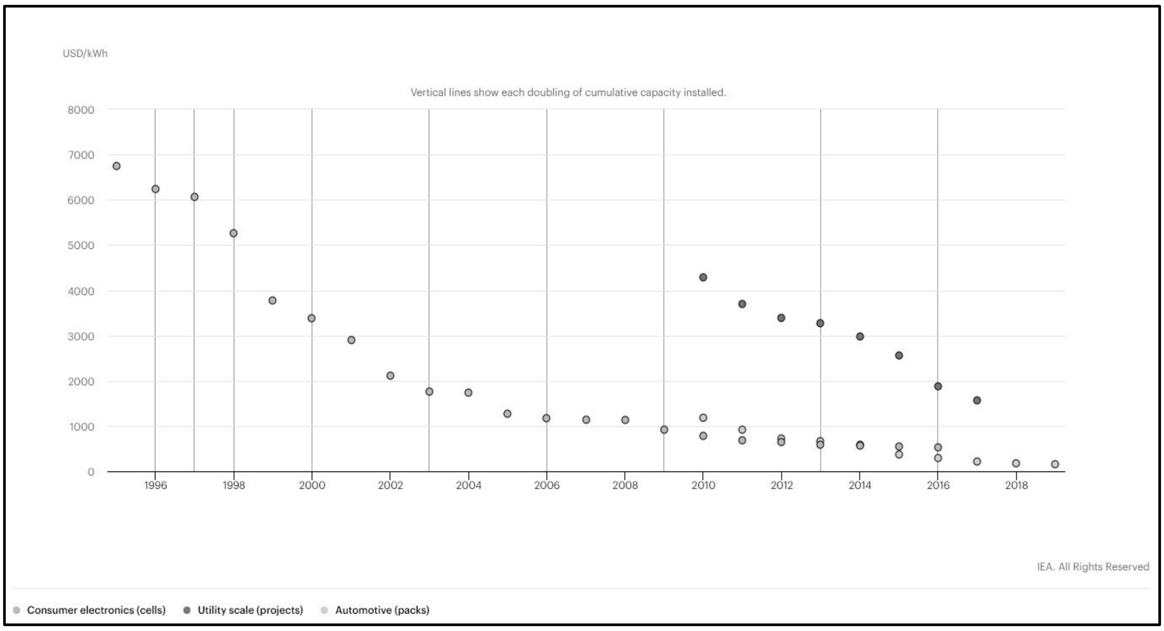

Figure 2.: Evolution of Li-ion battery price, 1995-2019
Source: [2].

Major changes are expected in the battery market trends, with more and more people supporting the production of **cobalt-free** batteries. Recently cobalt has become an in-demand mineral today thanks to its importance in rechargeable batteries used in electronics and electric vehicle market, but the battery industry developed a big cobalt dependency. Cobalt is a rare raw material that is found in the negatively charged electrode—or cathode—of almost all lithium-ion batteries used today. It's expensive (Figure 3.), heavy, and it has some social problems too. Nearly two-thirds of the world's cobalt is mined in the Democratic Republic of Congo as a secondary product of large-scale nickel and copper mining. But the DRC also has a large contingent of independent or artisan miners that effectively operate without any oversight. This has led to a multitude of human rights abuses in Congolese cobalt mines, including the use of child labor [3].

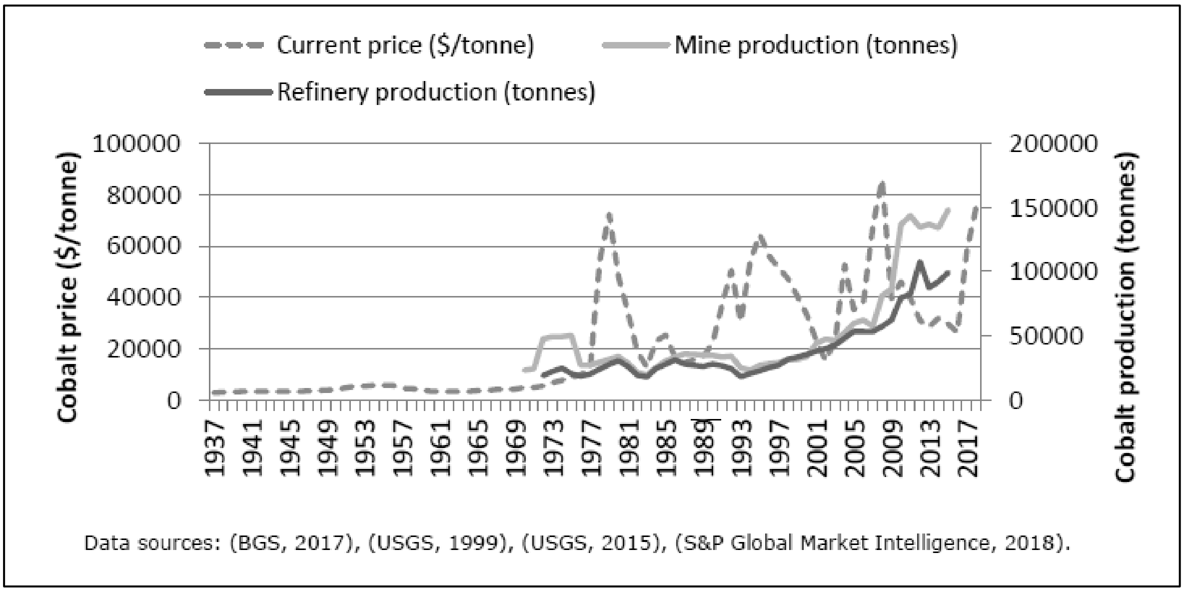

Figure 3.: Cobalt prices mine and refinery production in the past
Source: [4].

Several large companies have recently announced that they want to remove cobalt from their batteries (Tesla, LG, CATL). For now, it seems they not to be able to completely replace cobalt yet, but Tesla, for example, is on a very good way, and already uses very good quality low-cobalt batteries in their electric cars. The NCA (Lithium) -nickel-cobalt-aluminum battery cell still contains a little cobalt, specifically in Tesla version 8-1-1 the ratio between the three components [5].

In a new study, researchers at the University of Texas announced that they had found a solution for completely cobalt-free high-energy lithium-ion batteries. The team reported a new class of cathodes -- the electrode in a battery where all the cobalt typically resides anchored by high nickel content. The cathode in their study is 89% nickel. Manganese and aluminum make up the other key elements. Most cathodes for lithium-ion batteries use combinations of metal ions, such as nickel-manganese-cobalt (NMC) or nickel-cobalt-aluminum (NCA). Cathodes can make up roughly half of the materials costs for the entire battery, with cobalt being the priciest element. At a price of approximately $28,500 per ton, it is more expensive than nickel, manganese and aluminium combined, and it makes up 10% to 30% of most lithium-ion battery cathodes, so they found a solution, which decreasing the prices of the battery production, and the dependency on imports for key battery materials for the United States [5].

Graphene-based batteries could be the batteries of the future in the market. It has several advantages over conventional li-ion batteries. Nanotechnology graphene-lithium batteries primarily provide much more energy (two and a half times more than Li-ion batteries), much faster charging (about 50% faster, than Li-ion batteries), lighter weight, and stable operation even at higher temperatures. At present, the cost of production is still very high, it is not yet worth mass production. Despite these, several large phone companies have already indicated that they are experimenting with the introduction of the technology (Samsung, Huawei). On the electric car market, WV wants to apply this technology in its cars in the near future [6].

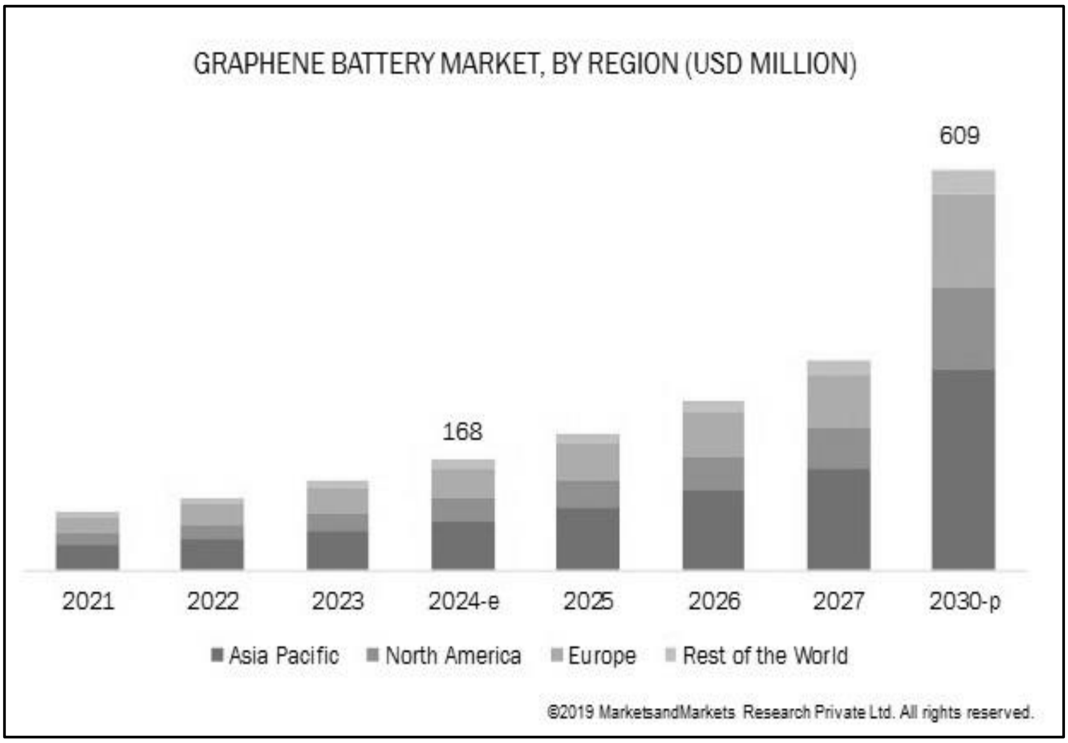

Figure 4.: Graphene battery market, by region (USD million)
Source: [7]

There are lots of attractive opportunities in the graphene battery market according to experts:

- the graphene batter market is projected to grow from USD 168 million in 2024 to USD 609 million by 2030 (Figure 4.),
- the growing demand for graphene batteries from industries such as automotive and consumer electronics is expected to drive the market,
- increasing research in graphene battery technology to fulfil the never ending demand for advanced consumer electronic products is expected to boost the demand for graphene batteries [7].

RESULTS AND DISCUSSION

One of the main developments in lithium ion-based batteries in recent years has been the deployment of battery management systems. The technology is already in its third generation. While in the beginning such 'battery management systems' did not exist at all, later developments can be called 'simple' and then 'advanced' systems. [8]

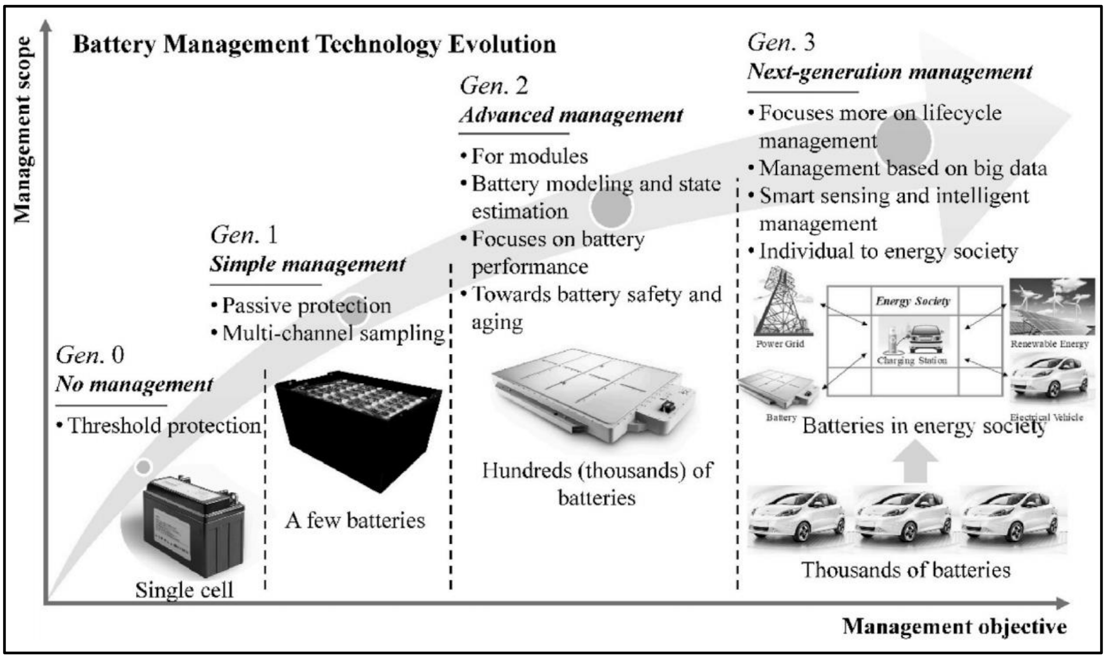

Figure 5.: Battery Management Systems (BMS)
Source: [8]

The lack of battery management was only conceivable for lead-acid batteries. First-generation systems are primarily focused on protection and reliability and are capable of measuring certain external parameters for safety and consistent performance, as well as monitoring internal parameters online.

With the increasing number of onboard batteries, advanced management is needed for battery modules. Advanced management systems take different forms, including centralized systems and distributed

The advanced management system focuses on improving the battery performance and the user's driving experience, and enables the monitoring of battery system dynamics. Battery modeling and state estimation, thermal management, battery equalization, charging control, and fault diagnosis are all possible with the appropriate optimization algorithms and control strategies. In the later development of advanced management systems, battery safety and aging are also considered. Advanced management represents the leading technologies in current battery management; however, there is still much room for further development. In addition to the thousands of batteries already installed in vehicles, the batteries in the entire energy society are also the management objects of “next-generation management” systems. Next-generation management will serve as the vital link between EVs and the energy society, which consists of numerous EVs, charging stations, and power plants , and the features of this generation are data and intelligence. This generation of battery management focuses more on battery lifecycle management, from manufacturing to recycling. With smart sensing and intelligent management, more accurate models and advanced algorithms can be applied in battery management [8].

RECONFIGURABLE BATTERY SYSTEMS

Reconfigurable Battery Systems are Next-Generation Battery Management Systems. RBSs, conceptually, are capable of changing the battery interconnection pattern in response to the battery behaviour, state of controllable hardware components, and user demands (Figure 6.).

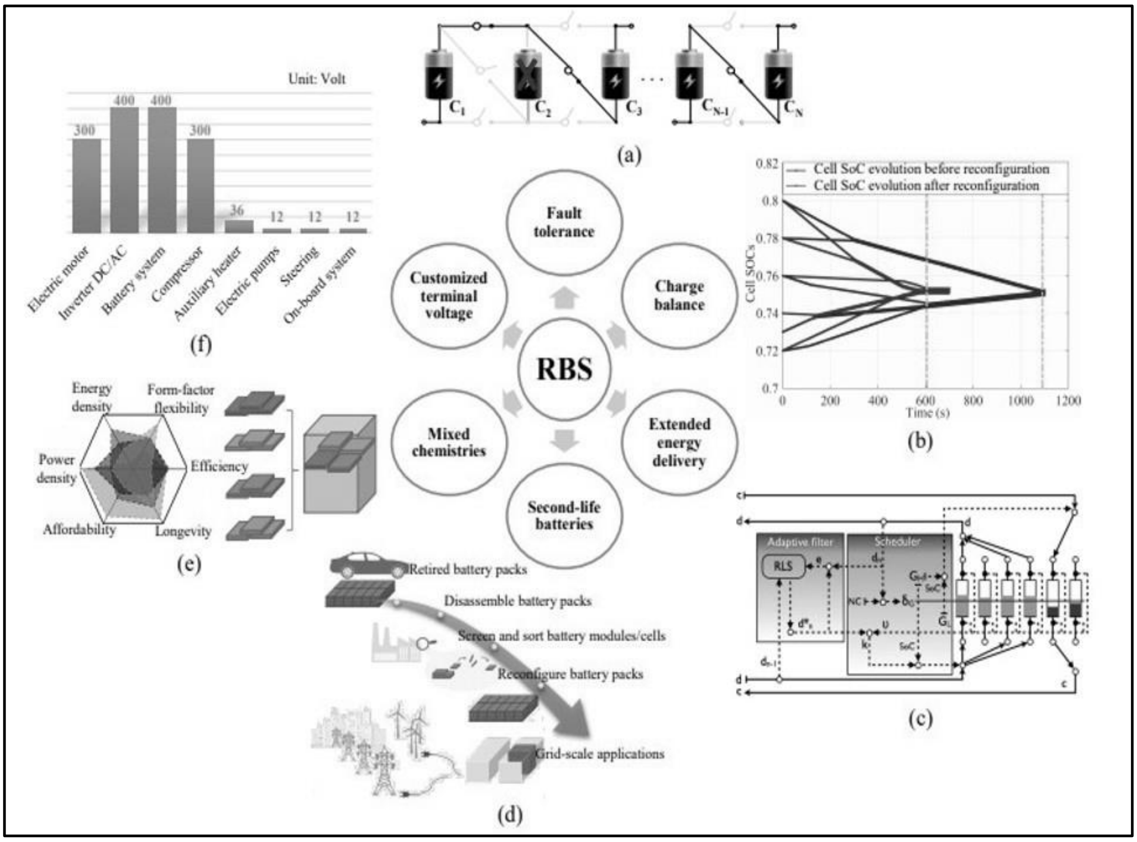

Figure 6.: Typical functionalities and benefits of reconfigurable battery systems (RBSs).
(a) Faulty cell isolation, (b) Expedited charge equalization for battery cells (c) A scheduling framework proposed for extended energy delivery and operation time. (d) Coordination of second-life batteries (e) Mixed battery chemistry (f) Component voltage levels in electric vehicles
Source: [9]

Potential benefits of reconfigurable battery systems (RBSs):

1. Enhanced Fault Tolerance:

If one cell fails it can be immediately disconnected by the system from the others thus saving them.

2. Charge and Temperature Balancing:

The thermal imbalance will cause different cell aging rates and reduce the longevity of the battery system, as well as potentially trigger overheating and threat battery safety.

3. Extended Energy Delivery:

"Motivated by the idea of battery balancing without auxiliary balancing modules, the dynamic reconfiguration can also be used to schedule the operation of batteries for faster and enhanced energy conversion during both charging and discharging." Thanks to this technology, batteries can be charged much faster without damaging them. A design of such a scheduling framework is illustrated in Fig. 6 (c) for extended energy delivery and operation time, where the arrowed solid lines c and d represent the charging and discharging currents, respectively [9].

4. Coordinating Batteries of Different Age or Chemistry:

With the intrinsic merit to balance batteries, RBSs cannot only prolong the first-life usage but also become imperatively important for second-life applications as shown in Fig. 6 (d).

An RBS is capable of customizing the terminal voltage, current, and power in a wide range [9].

5. Other Benefits:

Share battery modules and packs among different applications, enabling a new battery business model not otherwise economically justifiable, and further enhancing the economy- and resource-efficiency [9].

CONCLUSION

Demand for lithium-based batteries has grown exponentially in recent years, somewhat contradicted by the fact that demand for lithium has different characteristics. After all, more and more large companies or countries are rejecting the production and purchase of li-ion based batteries that contain large amounts of cobalt. There are two reasons for this, one is that it is a very expensive raw material, and the other is that it is produced in an unethical way (use of child labor). More and more so-called next-generation batteries are appearing on the market, such as the nano-graphene li-ion battery, which, if successfully introduced into the mass production process, can quickly replace the traditional batteries on the market.

The development of battery management systems has also been key factor in recent years. With the development of battery management technology, batteries have a longer lifespan and are equipped with smart sensors. As a result, they are already based on big data and have made batteries much safer.

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