The blue energy miracle

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Originally published in NZZ Magazin on Jan. 7, 2023. Published with permission.

Lithium-ion batteries still dominate the world market. But now there is a new technology that does not require expensive and ecologically sensitive raw materials.

The most popular car in Switzerland last year was once again an electric car: the Model Y from Tesla. Overall, battery vehicles now achieve a market share of over 17 percent - a trend that can be similarly observed in other countries. According to estimates, by 2030 only one in three cars worldwide will have a gasoline or diesel engine under the hood.

So the boom has only just begun. Large factories for lithium-ion batteries will be built all over Europe in the next few years. Tesla founder Elon Musk, who is never at a loss for buzzwords, calls them “gigafactories”. This will also increase demand for the increasingly scarce and expensive raw materials. The price of lithium, for example, has already multiplied. Today, after a brief dip at the turn of the year, it is about twice as high as it was a year ago.

The availability of the metals cobalt and nickel, which are needed for the positive terminal of batteries, is also unpredictable. Nickel in particular is becoming a bottleneck. “We believe that the world’s known lithium deposits will meet demand, even in the long term,” says Stefano Passerini, a professor at La Sapienza University in Rome. “With nickel, however, it will be difficult,” he says. This problem has been exacerbated by the Ukraine war, he says, because Russia has been one of the world’s largest nickel exporters.

Another disadvantage of lithium-ion batteries is environmental risks in their production. The EU may add lithium salts to its list of harmful substances. Behind the scenes, the industry is apparently up in arms against the corresponding decision, which would make production noticeably more expensive.

However, manufacturers cannot do without lithium-ion batteries. No other technically mature battery stores as much electrical energy per kilogram of its weight and volume. Since the Japanese electronics company Sony introduced them to the market three decades ago, they have been continuously improved. In the meantime, however, progress is slowing down because the batteries are approaching their theoretically possible performance limit. Energy density has recently increased by only 2 percent per year, rather than the 7 percent it used to be.

For stationary applications where the weight and size of the battery are not so important, there is now an alternative: the sodium-ion battery. Instead of lithium, it uses the heavy alkali metal sodium as the charge carrier. In the earth’s crust and in the sea, it occurs as a salt thousands of times more frequently than lithium. It is the sixth most abundant

element in the world and is distributed throughout the entire planet. Supply bottlenecks, cartel formations and politically motivated supply stops should therefore be virtually impossible and raw material prices correspondingly lower.

“Several companies have developed sodium-ion batteries in France, the United Kingdom and the United States,” says Corsin Battaglia of Empa in Dübendorf. Most have emerged from universities and government research institutes. But a battery ready for series production has also been developed by the Chinese battery giant CATL, which supplies almost all major car manufacturers with its lithium-ion batteries.

Sodium-ion batteries will probably never be found in luxury class vehicles. Their energy density is too low for that. However, they could be used in less expensive cars or electric motorcycles that only travel shorter distances. “They might also be suitable for public bus transport, because here you know exactly the distances traveled each day,” says Stefano Passerini of the University of Rome.

The first step

Stationary energy storage systems, however, are the first and initially most important step. Here, too, the market will grow in the coming years, because fluctuating power generation from wind and solar power plants will have to be buffered. In addition, the increasing use of electric cars and heat pumps is putting a strain on the electrical grids. Battery storage could smooth out dangerous electricity peaks by temporarily storing energy from the grids locally and releasing it when needed - at a charging station, for example.

One of the first sodium-ion batteries ready for mass production was developed by California-based Natron Energy. The company, which emerged from Stanford University, is also cooperating with ABB. The electrical company does not manufacture battery cells itself, but uses them in modules that provide a short-term emergency power supply for data centers. Here, they replace less powerful lead-acid batteries.

“There are dozens of companies working on sodium-ion batteries,” says François Gabella, Natron Energy’s chairman of the board. “But we’re the only ones offering a production-ready product; everyone else is still in the lab phase,” says Gabella, who studied at the Swiss Federal Institute of Technology in Lausanne (EPFL). In Michigan, Natron Energy is currently moving into an 18,000-square-meter factory building.

The first complete production line is to be set up here this year. This factory will validate the manufacturing processes for a subsequent gigafactory eight times as large, says Gabella, who is also a board member of the Economiesuisse business association and vice president of Swissmem.

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A special feature of the sodium-ion battery is the structure of the two electrodes. Both the positive and negative poles are made of a basic chemical substance related to the pigment Berlin Blue, which is known from dye chemistry. The material in the electrodes belongs to the so-called “Berlin Blue Analogs” (BBA).

The compound is produced by the Swiss company Arxada in Visp (VS), a spin-off of the Lonza Group. The agreed annual production is expected to be sufficient to equip 5 to 10 of the largest data centers with emergency power supplies each year.

The biggest advantage of the BBA compound is that, like the entire battery, it contains only cheap and nearly limitless elements - no cobalt, no nickel, and no copper, which is necessary in lithium-ion batteries. Instead, cheaper and lighter aluminum is used.

There is another advantage associated with this. Sodium-ion batteries can leave the factory in a fully discharged state. This simplifies transport and increases safety because even a damaged battery does not pose a fire hazard. Lithium-ion batteries, on the other hand, must be charged to 60 to 70 percent of their capacity.

Internal short circuits can therefore lead to uncontrollable chain reactions during transport. Sodium-ion batteries, on the other hand, do not burn even when charged if a nail is driven across the battery cell - a common test in battery research.

Charging in five minutes

Daniel Chartouni and Minglong He from ABB's research center in Baden-Dättwil tested Natron Energy's battery in the lab. They confirmed that the energy density of the sodium-ion battery is about 50 percent lower than that of a modern lithium-ion battery. Conversely, however, the sodium battery outperforms its competition in terms of maximum power output. That means it can deliver higher currents. And it can be charged faster.

"You can charge the battery from 0 to 80 percent of its capacity in 5 minutes, and to 99 percent in less than 10 minutes," Chartouni says. No damage is done to the battery cell in the process. Natron Energy claims a lifespan of about 50,000 charge and discharge cycles. That is at least ten times as much as can be expected from a typical lithium-ion battery.

In addition to use in data centers, the two ABB scientists therefore see potential applications wherever high currents and a long service life are important. "It would be conceivable for the battery to be used in lift systems or in cranes," says Chartouni. "Even in train stations, you could temporarily store the braking energy of trains in such batteries and feed it back into the rail network when starting up."

The Biel-Magglingen funicular is already pursuing a similar concept, albeit still with lithium-ion batteries: During the descent, it stores part of the braking energy in order to use it again afterwards for the next ascent. In addition, a photovoltaic system has been installed at the top station, which also feeds into the battery. These measures are said to have reduced the railroad's electricity bill by 30 percent.

According to the scientists, however, there is no such thing as the ideal battery that is best for all applications. "Lithium-ion batteries will not disappear," François Gabella also says. The market share that sodium-ion batteries will conquer in the next few years will depend not only on the potential fields of application, but also on the price development, which is currently difficult to estimate.

Some experts expect savings of 10 to 20 percent. However, these figures do not yet take into account the longer service life of the new batteries, nor do they take into account the development potential of the new batteries that still exists.

Original article:
https://magazin.nzz.ch/nzz-am-sonntag/wissen/natrium-ionen-batterien-das-blaue-energiewunder-ld.1719672

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About the company:

Natron Energy was founded by a group of Stanford scientists and engineers in 2012 to fulfill a singular mission: to offer safer, longer lasting batteries to underserved industrial and grid storage customers.

Today, Natron is a world leader in sodium-ion batteries and the first company to commercialize Prussian blue electrodes. Natron works with established pigment producers and Li-ion cell OEMs to deliver quality products via massively scalable manufacturing processes.