



Understanding battery lifetime factors through accumulated data

Life expectancy is central when estimating the total cost of transition to lithium-ion batteries. A more accurate answer can be found when weighing in use patterns and optimization.

What 5000 batteries on the market for more than 15 years has taught us about maximizing battery lifespans

Battery lifespan is the million-dollar question when it comes to lithium-ion batteries. Since battery cost is such a huge part of an electric vehicle's total cost, even small improvements in battery life span can have outsized effects on the cost of ownership.

A battery's true life expectancy can only be confirmed using a combination of lab tests and verification through field data. Fifteen years and more than 5000 batteries on the market have provided us with a wealth of data. And our knowledge of battery systems, cells, and software has given us the ability to distill from that data key insights in battery lifespan. Here are our key learnings.

The importance of calendar time

Having more than 5000 battery systems running in industrial environments since 2010, both our knowledge – and calendar time – are increasing rapidly. One key insight has been the irreplaceable value that our accumulated data add to our simulations and testing.

Our real-world experience allows us to answer questions about how cells, electronics and other components wear over time with greater

credibility. When it comes to wear and tear, spare parts such as cables and contacts stand apart from cells, which don't suffer wear and tear almost at all. Since the cells are meticulously checked before being mounted into modules and batteries, and are capsuled in the battery to keep them safe from user interference, we see a very low rate of defects in the cells.

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Human behavior plays a big role in the lifespan of battery-powered vehicles

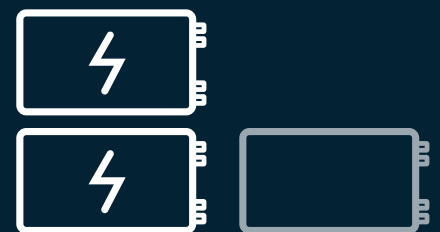
A key difference between internal combustion engines and electric vehicles is the impact that human behavior has on the performance of the electric drivetrain.



Calendar time

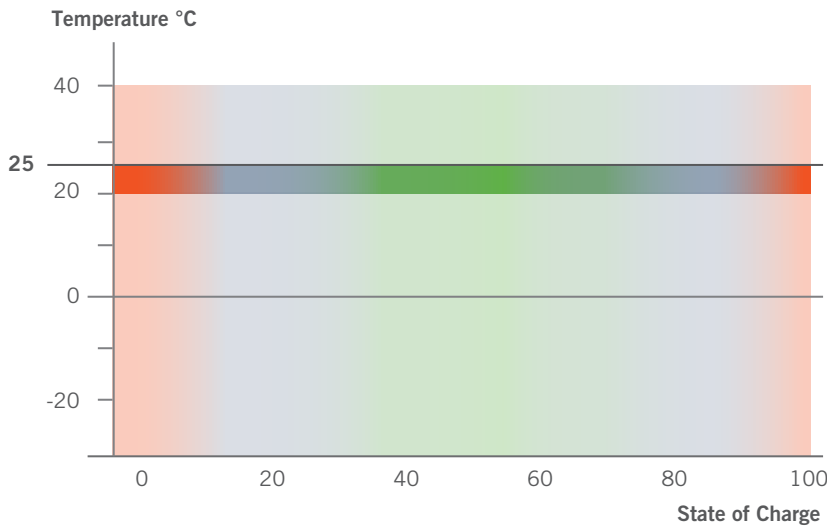


Driving pattern

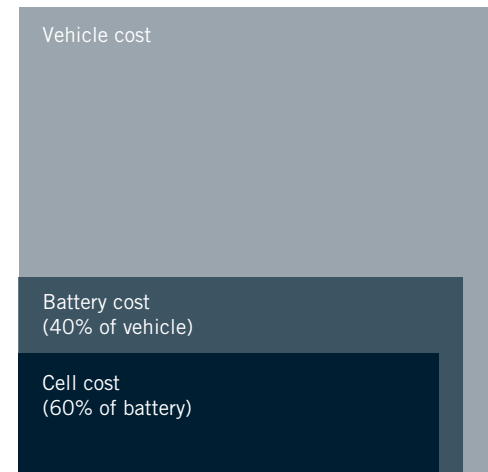


Over dimensioning

Optimized charging – temp ratio for lifetime prolongation



Cost ratio cell, battery and vehicle



The foundation for an optimal battery system solution is knowledge and understanding of the customer's driving pattern, as well as the ability to translate a previous fossil fuel-based driving pattern into a battery system. This is vital for the battery system's overall health, lifetime expectancy and consequently the total cost of ownership. Optimizing the use of a battery solution still needs technical training as behaviors are difficult to change.

Over dimensioning is an environmental risk

All battery systems must be considered a limited resource. Over dimensioning to hedge against unknown risks drives environmental costs that the world cannot afford. Through data analysis of the battery system it's possible to confirm the true technical requirements and optimize the solution to those requirements, thereby removing the temptation to over dimension.

High lifetime performance is all about temperature control

Temperature, both in storage and in usage, has a vital impact on several degradation mechanisms, which affect the lifespan of the battery in a negative way. Temperature control is therefore a critically important aspect of maximizing battery life expectancy.

Batteries used only in indoor environments tend to maintain temperatures of between 20-25°C regardless of battery size, usage, storage, and ambient temperatures. Therefore, vehicles destined for continuous work in temperature-controlled environments can afford not to have climatization systems, others can not. If the customer wants greater flexibility and the ability to use their vehicle also in uncontrolled environments, climatization becomes a critical feature.

Why you should let intelligent software systems be the mastermind

To optimize the total energy use of a battery system, intelligent software should govern the system with built-in flexibility for handling peaks and lows. In addition, total system energy usage over time should be the ultimate driving force instead of instant power, while ensuring maximum life span. With the wrong drivers and improper dimensioning, the total cost of ownership will ultimately end up higher.

How charging affects aging

Changing customer charging behavior is a difficult task. In the case of electric vehicles, behavioral change is made harder by customers' unrealistic expectations about being able to transition to fossil-free vehicles without giving up any of the flexibility they are used to.

Observation of our batteries in the field confirms that a wider State of charge-window (SoC) will lead to a reduced maximum battery life expectancy. Constantly maintaining a fully charged battery has been shown to cause both mechanical changes due to premature physical swelling of the cells, as well as aging due to this premature swelling.

Our findings show clearly how to achieve maximum life expectancy for lithium-ion batteries:



Avoid extreme temperatures

Both high and low. Extreme temperatures should be avoided during storage, transportation, and operation of the battery and vehicle.



Avoid extreme charging

Charging a battery to 100% is directly damaging from a cell perspective, and therefore also from a cost perspective. A more conservative charging approach is recommended, charging to a lesser degree but with greater frequency to keep the battery charged in the middle of its range. Avoiding both fully charging the battery as well as letting the battery empty completely will improve cell life considerably.



Don't speed charge

But if you have to, keep in mind that speed charging is directly damaging to the lifetime of the battery.

Alelion – Sharing knowledge and experiences

Alelion is an established developer, manufacturer, and supplier of advanced battery systems for off-highway vehicles in a number of different segments. With more than 15 years of experience, we now share our key learnings in a series of white papers.



Alelion Energy Systems AB
Sörredsbacken 4, SE-418 78 Göteborg, Sweden

alelion.com | +46 31 86 62 00 | info@alelion.com