WHITE PAPER

POWER BATTERY

Pioneers in scalable energy solutions

Battery lifespan better than originally thought

Battery lifespan better than originally thought, don't cheer yet

The biggest reason people refused to buy an EV was never capability, never drivability, never the lack of sound or performance. The bottleneck has always been the battery. Especially the battery lifespan. People are terrified of ever having to replace one. It's a worry when they buy an EV new and it's a reason why people usually stick to petrol cars on the second hand market. This week you'll read everywhere that it's not as bad as it seems. However, it is important to put it into context.

INTRODUCTION

In this whitepaper, some of the key topics we cover include:

- Research Findings
- State of Health (SoH)
- WLTP Testing
- Recycling Challenges
- Recycling Processes
- Future Outlook

Battery Lifespan Research

Findings from P3 on State of Health (SoH) of EV batteries.

New research form P3 shows that batteries in EVs can last longer than originally thought. The SOH (State of Health) of a battery pack is a lot more constant after the initial drop as you can see in the figure below.

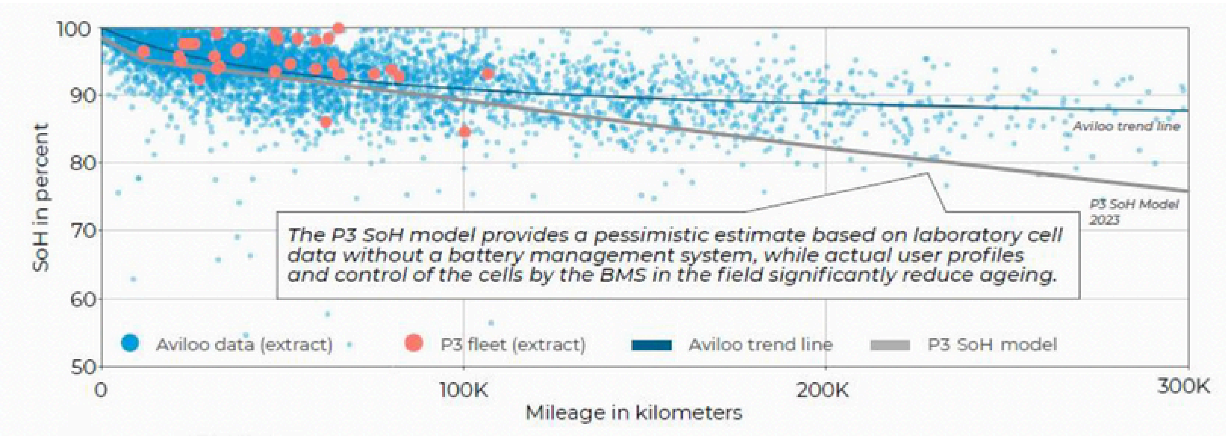

Fig. 1: SoH vs mileage for EVs with batteries >30 kWh.

Almost all of the P3 tested vehicles are above the 90% SOH before or even after the 100k km. Don't get me wrong that is great news. That means that it is quite safe to buy a second hand EV and having confidence it will run for another 100k km. It is just not exact science. The differences are quite large. A battery with 150k km can be of almost 100% SoH and a battery with 10k km can be below 65% SoH according to the Aviloo data.

Determining State of Health (SoH)

- Definition and significance of SoH.
- Explanation of the WLTP testing procedure.

However, what does this mean? A state of health is commonly accepted term to determine the quality of battery cells, mostly with respect to the degradation over time. There is no standard for this and no rules or guidelines that determine what a state of health is.

There is however, a standardized testing protocol used to assess the energy consumption of vehicles called WLTP, or "**Worldwide Harmonized Light-Duty Vehicles Test Procedure**,". This procedure aims to replicate real-world driving conditions by accounting for a range of influencing factors. It is a transparent and universally comparable method that can be used for determining the SoH of a vehicle's battery. [2]

Although the term "real-world driving conditions" remains subject to debate—given that the actual range of many vehicles often falls short of the WLTP figures—the advantage of this approach is its consistency. By standardizing the method worldwide, WLTP provides comparability and eliminates dependencies on individual driving styles.

WLTP-Based SoH Formula

The fundamental formula for SoH determination in this context is:

SoH (%) = (WLTP current) ÷ (WLTP new) × 100

Determining State of Health (SoH)

Here, the "WLTP new" value corresponds to the manufacturer-specified range of the vehicle in its original state. To calculate "WLTP current," the vehicle would ideally be tested under WLTP-defined conditions. However, this approach is both cost-prohibitive and time-intensive, making it impractical for individual users. Fortunately, the WLTP new value can be easily retrieved from the manufacturer's specifications, providing a convenient reference point.[2]

An alternative approach is to rely on measurements taken during the charging process. At first glance, this appears to be a straightforward solution: simply measure the amount of energy supplied to the battery during charging. However, this method is heavily influenced by external factors, such as the charging protocol used, energy conversion losses, and environmental conditions. As a result, the measured energy tends to exceed the actual amount stored in the battery, making it unsuitable for accurate SoH determination.

The critical parameters that define a battery's performance include its nominal voltage (measured in volts, [V]), capacity (measured in ampere-hours, [Ah]), and the resulting storable energy (expressed in kilowatt-hours, [kWh]). These parameters are not static; they degrade over time due to factors such as usage, environmental conditions (e.g., temperature fluctuations), and discharge characteristics (e.g., driving profiles). These influences make it challenging to isolate a single method for determining SoH that is both precise and universally applicable.[2]

Real situation

This uncertainty in the SoH is one of the reasons why LiBs (Lithium ion batteries, most common EV batteries) typically face disposal after just 1 to 3 years of use, posing grave environmental risks and safety risks when mishandled. And shockingly; only about 5% of LiBs are currently recycled [1], leaving a staggering 95% as pure waste. However, that is not the end of the story. That 5% that does get recycled doen't necessarily get recycled.

STOKKERMILL RECYCLING MACHINERY developes recycling machines for, amongst other things, Lithium-Ion Batteries or LIBs. We inquired about the proper methods for recycling batteries. For NMC and NCA they use a process of separating that happens in 2 stages.

1. The battery cells are safely shredded and sorted. This will give you a lot packaging materials like plastics, steel casings and metal foils (copper, aluminium). Next to that it will give you black mass, a composition of the remaining materials.
2. The Black Mass will now undergo a hydrometallurgical process to extract materials. The Black Mass material is dissolved into a solution using an appropriate solvent, often involving acids, bases, or other chemicals. Then the solution is concentrated and purified to remove impurities and unwanted materials. The desired metal is recovered from the purified solution. The desired materials for instance are: cathode materials (nickel, cobalt or manganese), Lithium chemical solution, Carbon.

Recycling challenges

The recycling processes currently in use fall short of the ideal scenario described earlier. The main challenge is achieving the necessary purity levels, both in the black mass and the materials extracted from it. The separation processes (stages 1 and 2) do not produce battery-grade materials suitable for the production of NMC or NCA battery cells. A 2023 study published by the Royal Society of Chemistry identified several potential solutions, and many companies claim to sell machinery capable of producing battery-grade materials. However, none of these solutions have proven commercially viable. This was evident both in the research findings from 2023 and at the 2024 Battery Recycling Expo. Experts from Duesenfeld, Green Li-ion , and Elemental Battery Metals concurred that no company has yet achieved closed-loop battery recycling to produce battery-grade materials.

Fortum Recycling & Waste - Part of NG Group, a company based in Finland, claims to have developed a solution. They assert that they have achieved closed-loop battery recycling. Currently, they can produce technical-grade materials and aim to upgrade to battery-grade materials by 2027. They will be able to recycle end-of-life NMC and NCA battery cells and produce battery-grade materials in an in-house facility. However, they are currently encountering some chemical issues that need resolution.
The new findings about EV battery life are a major step forward in easing concerns for both new and used EV buyers. With data suggesting most EV batteries maintain a State of Health above 90% even after 100,000 km, this research debunks one of the largest fears surrounding EV adoption.

Future outlook

However, it's not the end of the story. The inconsistencies in SoH across batteries, coupled with the dismal recycling rates and the lack of capability to produce new batteries from recycled batteries in Europe, underscore that challenges remain.

As the EV industry matures, improving battery consistency and expanding recycling infrastructure will be critical to both consumer confidence and environmental sustainability. While the battery bottleneck may no longer be the dealbreaker it once was, there's still work to be done to ensure a future where EVs are not only viable but also responsible. [1]

[1]
B. R. Y. S. K. Rahul Rautela, "A review on technologies for recovery of metals from waste lithium-ion batteries," Power sources, 2023.
[2]
Nikolaus Mayerhofer, " SoH / Battery health status", Aviloo, 2024.

Conclusion

In conclusion, recent advancements in electric vehicle (EV) battery technology reveal that many batteries can maintain a State of Health (SoH) above 90% even after extensive use, alleviating concerns about battery lifespan and replacement. However, significant challenges remain, including inconsistencies in battery performance and low recycling rates for lithium-ion batteries, which pose serious environmental risks.

To foster consumer confidence and ensure the sustainability of the EV market, it is essential to improve battery consistency and expand recycling infrastructure. Innovations in both battery technology and recycling processes are crucial for addressing these challenges. Ultimately, enhancing these areas will be vital for the future viability and environmental responsibility of electric vehicles as a sustainable transportation solution.