

State of Health Is a Lie

Introducing EOLHC: End Of Life Health Cycle

The metric the industry never gave you

Based on 5 years of independent research and approximately 2,000 high-voltage battery repairs across the EV Clinic network. This elaborate demonstrates the absence of correlation between State of Health (SOH) and battery failure, defines the EOLHC parameter set, and evaluates the Digital Battery Passport against real field data.

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1. State of Health is a lie

We will say it out loud: **State of Health is a lie.**

Not because the number is fake. Because the name is fake. SOH is not "State of Health". It is **State of Capacity**. It tells you one thing only: how many kWh are left compared to day one. That's it. It tells you nothing about whether the battery is healthy, nothing about when it will fail, and nothing about how much usable life is left in the pack you are about to pay 30,000€ for.

Capacity is not health. Degradation is not a fault. And a single percentage on a screen is not a diagnosis.

2. Three years of looking for a correlation that doesn't exist

For the past 3 years we tried to find the connection between SOH and battery failure across our repair database. The conclusion is simple: **there is none.**

Our statistics from ~2,000 HV battery repairs show:

- The majority of EV battery failures happen between **5% and 15% capacity degradation**, exactly where SOH says "this battery is excellent"
- Once degradation passes **50%**, the system declares the battery faulty on its own: internal resistance rises and an industry standard kicks in where the **system limits itself and reports a fault**, even though the cells are still perfectly capable of driving (Renault Fluence, Kangoo ZE, Smart, Twingo, eGolf and similar platforms from our records)
- A battery above 50% remaining capacity is a usable, functional battery, yet packs die long before that point, and packs survive long after it

In not a single case could we take SOH as a parameter of current health. Zero correlation with failure.

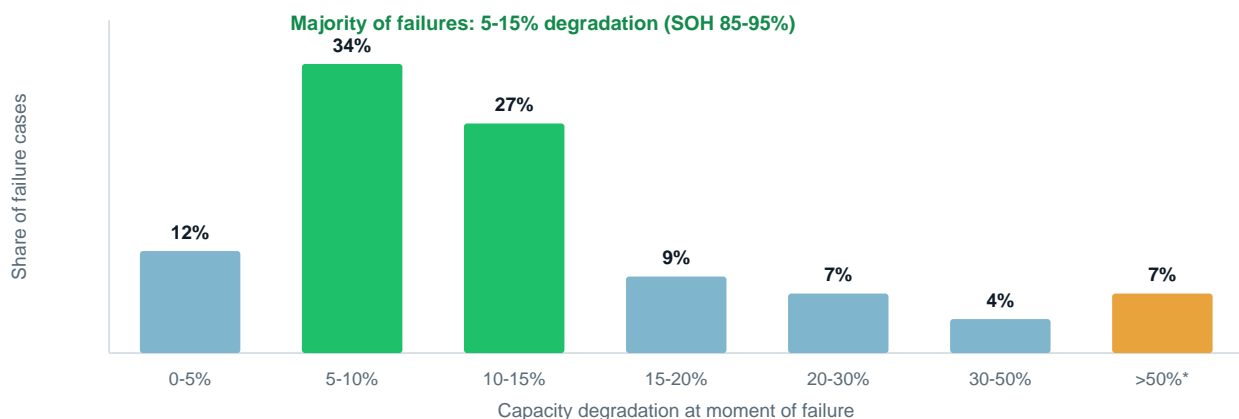


Figure 1 · Distribution of HV battery failures by capacity degradation at the moment of failure, EV Clinic repair database (illustrative shares). * >50% bin: system self-limiting, cells still functional.

3. 30% SOH, 600,000 km, and the battery was healthy

A Model S 85 taxi, DC fast charged every single day. SOH dropped to 30%. The owner panicked. Most workshops would say: wreck it, replace the pack.

We opened it and measured properly:

- Cell balancing: excellent
- Voltage delta between modules: minimal
- Internal resistance: homogeneous across the entire pack
- Pressure test: no leakage

The battery was functionally healthy. Degraded in capacity, yes. Failed, no. This taxi from Vienna arrived with a BMS_u029 fault, we repaired it, and the car is still driving on the same pack today. Why? Because every other parameter was moderate: low average speed, low load, low consumption. The pack lived an easy life, and the parameters that actually matter proved it, while SOH screamed "replace me".

Now the opposite case. LG 10s16p packs (Model 3/Y) failing **completely and irreparably at only 8% degradation**. Across six of our workshops, we have not managed to repair a single one. Internal resistance imbalance triggers a chain reaction. Capacity still looks fine. The pack is dead.

Same metric, opposite outcomes. That is not a health indicator. That is noise.

4. The LG vs Panasonic paradox: better SOH, worse battery

Here is the case that destroys SOH logic completely.

Panasonic cells in Model 3/Y often drop to around 80% capacity by 100,000 to 200,000 km. Relatively fast degradation, ugly SOH number. LG cells in the same models hold capacity noticeably better, with degradation comparable to a Model S.

By SOH logic, LG is the better battery. Reality says the opposite. The LG packs are the ones that **fail completely and irreparably**, even at only 8% degradation, while the "degraded" Panasonic packs keep driving. The buyer comparing two listings would pick the LG car because of the higher SOH, and pick the worse battery.

And one more detail nobody tells you: there are **two different Panasonic cells** in European Model 3 Performance vehicles, Nevada production and China production, with a noticeable difference in characteristics. Same model, same SOH display, different battery.

A metric where the better number points to the worse product is not a metric. It is a trap.

5. EOLHC: the metric we actually needed

Because the abbreviation "SOH" is permanently compromised, we will not even try to fix it. We formulated a new parameter as part of our internal research, and it is the core of our ongoing study:

END OF LIFE HEALTH CYCLE (EOLHC)

EOLHC is expressed in **kilometers remaining until battery repair is no longer technically or economically viable**. After that point, the HV battery is only usable for solar storage and other powerbank second-life applications.

SOH is misleading twice. First because it measures capacity and calls it health. Second because it only looks backwards: how much capacity was lost. It tells you about the past of the battery and nothing about its future.

EOLHC looks forward: **how much repairable life is left**. And that makes it the single most important parameter of trust in the product you are buying. When you spend 30,000€ on a used EV, you are not buying its history. You are buying its remaining future, and EOLHC is the only metric that measures it.

Real EOLHC values from our field data:

Vehicle / Pack	EOLHC (km)	Capacity loss at EOL
Kia Soul EV	80,000	varies, often only 10-25%
Nissan Leaf	120,000	varies
Tesla Model 3 LG pack	200,000	as low as 8-10%
Tesla Model Y LG pack	160,000	as low as 8-10%
eGolf 2015	280,000	~30%
Tesla P85D (resealed)	350,000	only 14%
Renault Twingo 2022	390,000	–
Tesla Model S 85 (resealed, serviced)	640,000	up to 70% and still functional

Table 1 · EOLHC field values, EV Clinic network. Model S 85 value is the calculated maximum EOLHC without deviations (see Section 7).

Look at the P85D line carefully. 14% capacity loss, SOH says 86%, looks like a great buy. The pack is unrepairable and at end of life. Meanwhile a Model S 85 with 70% capacity loss is still driving a taxi. The "lying SOH" tells you exactly the wrong story in both cases.

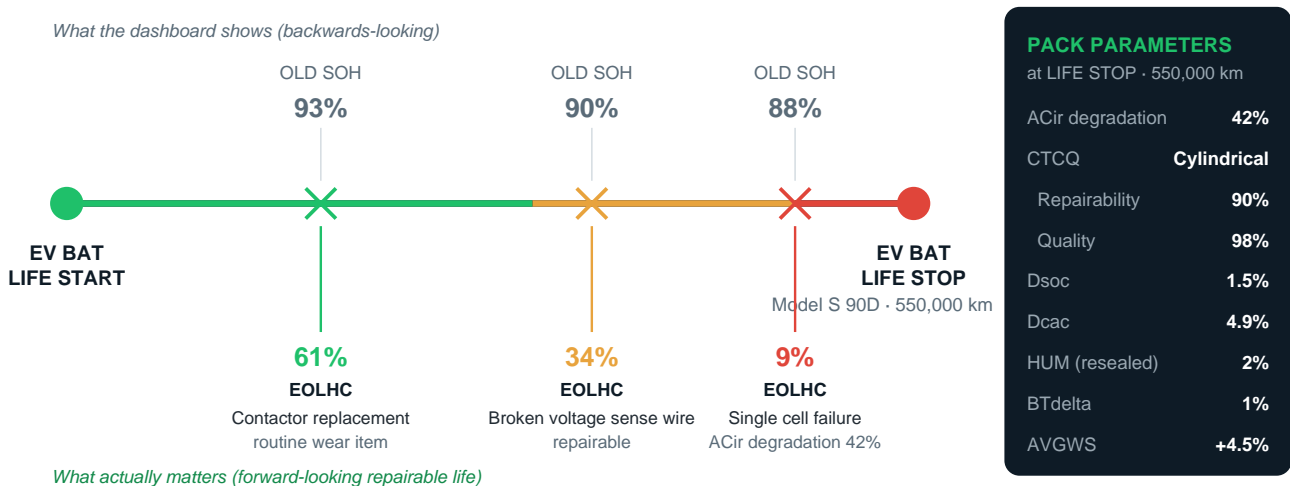


Figure 2 · The EOLHC life scale, Model S 90D example. Dashboard SOH stays in the high 80s/90s while forward-looking repairable life collapses from 61% to 9%.

6. The parameters behind EOLHC

A serious health assessment requires at least 10 parameters. For a Model S we can pull up to 19,000 datapoints into our AI lifetime prediction model. The core parameters that define EOLHC:

CTCQ (Cell Type and Cell Quality)

The single biggest factor. Cell format (pouch, prismatic, cylindrical), manufacturer (LG, Panasonic, Samsung, CATL) and the actual production quality of that cell generation. The worst offenders are pouch cells, which sometimes show "100% SOH" forever because manufacturers hide degradation behind a software buffer. We consider pouch cells a total failure for automotive use: 98% of all cells we send to recycling are pouch.

Dsoc (Delta SOC)

Constant growth of charge-state deviation between cell groups. A rising Dsoc trend is an early failure signal that SOH will never show you.

Dcac (Delta Capacity)

Capacity delta between cell groups, tracked over time. The trend matters, not the snapshot.

HUM (Battery Humidity Percentage)

Humidity is always present inside a pack, but deviation means moisture ingress: bad seal or damaged breathing valves. Once a pack breathes moisture, cell shoulder isolation caps corrode through galvanic action, electrolyte leaks, and internal cell structure is damaged across all modules. From that point degradation accelerates permanently. This is why resealing is critical.

BTdelta (Temperature Delta)

How much temperature deviated between modules over the pack's lifetime. One single overheat event permanently damages cells and triggers degradation, sometimes only in one module, but that one module defines the EOLHC of the entire pack.

AVGWS (Average Watt Stress)

If your vehicle is rated at 189 Wh/km and your real average is 220 Wh/km, you are running 15% above design load, charging and discharging alike, and your EOLHC shortens by roughly the same factor. Someone racing a car for 100,000 km on a pack with 200,000 km EOLHC will hit an unreparable internal resistance state long before any capacity warning appears.

ACir (AC Internal Resistance)

The deviation of internal resistance per cell, and the deviation versus the new-cell baseline. This is the closest and most accurate single value of true cell health that exists. Bonus: measuring ACir across the complete pack also reveals the quality of every busbar and connection, because deviation means a bad joint or a bad cell. From a safety standpoint this is one of the most important parameters in existence, and manufacturers never implemented it. It still requires removing the pack and measuring by hand.

7. The data nobody will give you

Three parameters would make EOLHC prediction almost exact, and every manufacturer has them:

- 1. Maximum charge/discharge cycle count from aging tests.** This is the most relevant datapoint of all, more relevant than anything else in this elaborate. Every manufacturer determines it through aging simulation, available even at prototype stage. With it, EOLHC would give you the **literal exact mileage** at which the battery reaches end of life and must be replaced. Battery replacement would become a predictable, planned cost instead of a financial surprise. That is exactly why you will never get it.
- 2. Simulated EOL mileage from aging simulators.** Derived from the above, never published.

3. Cell Failure Parts Per Million (PPM). The holy grail. The single most honest number about cell reliability that exists. Every cell manufacturer tracks it. Nobody outside will ever see it.

Here is how powerful the cycle count is. The first generation Tesla Model S 85 has roughly **2,000 allowed cycles**. Multiply by a realistic average range of 320 km per cycle and you get an EOLHC of **640,000 km**. And that is precisely what we confirmed in the field, in cases where the wire sense bonding was not destroyed by moisture and the pack was resealed at least twice along the way. Wire bonding corrosion is that pack's only Achilles heel. The cells themselves were among the highest quality ever produced, and they still are, even today.

2,000 cycles × 320 km = 640,000 km EOLHC. One number from a manufacturer's drawer, one multiplication, and a used EV buyer would know exactly what they are buying.

The industry knows exactly how long their batteries last and exactly how often their cells fail. They simply decided you don't need to know.

8. When the BMS simply lies

Everything above assumes SOH is at least an honest capacity number. Sometimes it isn't even that.

Korean manufacturers display **95% SOH** on certain models while a real discharge test, driving from 100% to empty and measuring actual energy, shows around **80% real capacity**. That is not measurement tolerance. That is a systemic BMS lie, and dealerships use exactly that number in warranty decisions. Without an independent discharge test, every warranty claim gets rejected because "SOH is 95%".

The textbook case is a first generation Korean EV with pouch cells under the front seat, where temperature delta between cells kills the pack. When one row goes, everything goes. The result is vehicles with **40 to 50% real capacity** that the manufacturer refuses to repair, while the dashboard still shows a healthy battery. In Norway these cars sell for 3,000€, and now you know why.

And it gets worse. These batteries were never globally recalled, even though the pouch cells **swell, tear the housing open and potentially endanger the passengers** sitting directly above them. This is exactly the type of technical defect for which the industry's own guidelines mandate a recall. The recall was carried out only in Norway and the USA. The rest of the world got nothing. Same battery, same defect, same risk, but apparently your safety depends on your postal code.

So the situation is worse than "SOH is the wrong parameter". The parameter itself can be manufactured. And this is the data foundation the Digital Battery Passport intends to build on.

9. The Digital Battery Passport: bureaucracy disguised as transparency

The Digital Battery Passport sounds like a step toward sustainability. In reality it is on track to become another bureaucratic document that gives buyers a feeling of safety with no technical substance behind it.

The entire system is built on parameters like SOH, which, as shown above, is just remaining capacity. A battery at 90% SOH can fail tomorrow. A battery at 70% SOH can drive hundreds of thousands of kilometers. We analyzed hundreds of battery systems from different manufacturers and found no reliable correlation between SOH and actual failure probability. The critical failure drivers are moisture, corrosion, cell internal resistance, thermal stress, cell quality, pack architecture and future repairability. The Battery Passport shows the buyer none of them.

A used EV buyer does not want to know the CO₂ footprint of a battery produced ten years ago. The buyer wants to know one thing:

"How long, and to how many kilometers, will this battery remain technically flawless and economically repairable?"

The Battery Passport does not answer that question. Here is what else it doesn't tell you:

- It doesn't tell you that **pouch cell vehicles are practically unrepairable** and are the most common reason for total vehicle write-off
- It doesn't tell you that with **cell-to-pack and cell-to-body architectures**, one failed cell condemns 17,000 healthy cells to recycling, and that in case of failure you will personally pay around 2,000€ for a scrapyard to even accept the car for recycling
- It doesn't tell you whether **basic consumable battery components are purchasable at all**. Most manufacturers refuse to sell parts. We have seen cases where an externally mounted coolant temperature sensor forces a 16,000€ battery replacement
- It doesn't tell you the **warranty rejection rate** for that manufacturer and model, so you can't know whether to send the car straight to scrap before the warranty even expires because you didn't read the small print, or after warranty expiry at the first minor fault
- It doesn't tell you **the price of a new battery out of warranty**

The Passport was written by people who come from paper, not from practice. It doesn't protect anyone. It exists to strengthen authority and shift blame. In its current form it doesn't solve the problem, it makes it worse, by training the market to judge batteries by one marketing-friendly number while ignoring every real indicator of long-term viability. That is not circular economy. That is the opposite: it actively obstructs informed decisions and increases risk for used EV buyers.

If Europe genuinely wants sustainability, the focus must be repairability, parts availability, module replaceability, and remaining repairable life. Everything else is administration that looks good on paper and solves nothing on the road.

10. Design is destiny

After ~2,000 repairs, the verdict on architecture is final:

- **Sustainable:** Cell-to-module with cylindrical or prismatic cells (Tesla Model S/X/3, VW ID.3). In every single case so far we were able to swap a defective module or cell for a matched used one, laser-weld it, and return the vehicle to the road without replacing the entire battery
- **Unsustainable:** Pouch cells in any configuration (Kia, Nissan Leaf, Porsche Taycan, Renault). Impossible to repair, no replacement supply, the number one reason vehicles get written off
- **Worst in class:** Cell-to-pack and cell-to-body (structural Model Y, Cybertruck, BYD Blade). The manufacturer saved roughly 1,000€ in production cost. The customer inherits a battery where a single defective cell means the entire pack, and often the entire car, goes to recycling

The Battery Passport will not tell you any of this either.

11. Field notes: not all original packs are equal

A few concrete EOLHC datapoints from our workshops that no SOH display and no Passport will ever show you:

Model S 85 originals (2013-2016) are the champions. Taxi vehicles with 600,000 km on the original pack are not a myth, we service them. The problem: Tesla often replaced these packs under warranty with **remanned packs that are worse than the originals**, due to a mistake in fuse bonding during the remanufacturing process. Depending on stock, a warranty replacement gets you either a remanned 85 kWh pack with old degraded cells, or a new 90 kWh pack software-locked to 85, which is actually an upgrade. Tesla doesn't tell you which one you will get.

Quick trick: **if your Model S pack housing is black, it is one of the better originals. Do not replace it under warranty**, because you will most likely get a worse one back.

Model S 75D: across six EV Clinic workshops, not a single original 75D pack failure. Zero.

Model S 100D: caution. Poor fuse soldering, problems typically appearing around 250,000 km.

This is what real battery intelligence looks like: pack generation, production batch, cell origin, known design defects. Not one percentage on a screen.

12. What this means for you

1. **Forget SOH as a health metric.** It is a starting point, never an answer
2. Demand a full diagnostic extract (Tesla Toolbox or equivalent), not a percentage
3. Check voltage delta between modules: must be minimal
4. Check internal resistance homogeneity across the pack
5. Pressure test the housing: any leak is immediate disqualification
6. Identify cell type, manufacturer and pack architecture before you buy. Avoid pouch. Avoid cell-to-pack
7. For a Model S: check the pack color and whether it is original or remanned
8. Unexplained high consumption (300+ Wh/km) is a red flag for hidden pack problems

The EV industry still sells cars as if batteries are a black box. They are not. The tools exist, the data exists, the experience exists. What's missing is transparency and a standardized, consumer-grade assessment protocol.

Until then: trust the percentage on the screen less. Trust the people who have actually opened the pack.

EOLHC is part of our ongoing research elaborate, and we will publish deeper methodology and datasets as the study progresses.

EV Clinic operates Europe's first independent EV and PHEV repair network, with ~2,000 HV battery repairs across 6 workshops. Component-level repair, not unit replacement.