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Towards more sustainable EV batteries through transparency and data analysis

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Executive Summary

Since 2020, Volvo Cars publicly share life cycle assessments of the vehicles introduced on the market, presenting the carbon footprint of production, use-phase and end-of-life of the cars. Since 2019, block-chain traceability has been implemented on critical battery raw materials, which means that a digital record is kept of every kilogram of material that ends up in the cars. It started with cobalt and today also nickel, lithium, graphite and mica are traced. During 2024, 28 on-site supplier audits were conducted on companies involved in the supply chain for the batteries. With the EX90, a first version of a battery passport was released, including information about carbon footprint, recycled content and country of origin of critical raw materials. These examples show how Volvo work with transparency and data analysis to improve the sustainability of the supply chains, with special attention to the battery.

Keywords: Electric Vehicles, Supply and value chain, Batteries, Climate change, Life-Cycle analysis

1 Introduction

Since the start of Volvo in 1927, safety has been the core guiding principle. This was early stated by one of the founders Gustaf Larsson: “Cars are driven by people. The guiding principle behind everything we make at Volvo, therefore, is and must remain – safety.” Today, safety has been extended to include protection of people as well as the planet, and Volvo cars’ company purpose is:” For life. To give people freedom to move in a personal, sustainable and safe way.”

Within sustainability, three areas are in focus: climate action, circular economy and responsible business. For climate action, the long-term ambition is to reach net zero greenhouse gas (GHG) emissions by 2040. In the near-term, Volvo aim to reduce the GHG emissions per average car by 30-35% in 2025 and 65-75% by 2030, both compared to 2018. Electrification is essential in reaching climate ambitions and by 2030, the aim is to sell at least 90 % fully electric and plug-in hybrid vehicles. The target is also set towards being a circular company by 2040, and an increased amount of recycled content going into the cars is an important part of that. For 2030, the target is 30% recycled content on average in the cars.

To fulfil sustainability ambitions, there is a need to continuously collect and analyze data to assess the impact of cars on the environment and society, to be able to reduce them and mitigate risks. Transparency towards the customers on sustainability makes it easier for them to make conscious choices. In addition to following up the progress in annual and sustainability reports, further transparency is provided towards stakeholders by disclosing the life cycle impact on climate change of new vehicle models, also known as their carbon footprint. In addition, tracking critical raw materials through block-chain technology helps to keep track of source and origin of material in the cars. This information is shared with the customers in the early first introduction of a battery passport. The carbon footprint report, block-chain material tracking and battery passport are all good examples of work with data analysis and transparency to improve the sustainability of the cars made today and in the future.

2 Life cycle assessment

The first Volvo vehicle for which a carbon footprint report was published was the fully electric EX40 (launched as the fully electric XC40 Recharge) in 2020. In the assessment of the EX40, and later also the EC40, a comparison was made with an XC40 internal combustion engine (ICE) variant. In Spring 2024, the carbon footprint report for EX30 was released, showing how different battery sizes and battery cell types influence the carbon footprint. With the release of the EX90 by Summer 2024, a comparison of its carbon footprint with that of an XC90 plug-in hybrid (PHEV) and mild hybrid (MHEV) variants was presented in the report, along with multiple sensitivity analyses. All reports can be accessed from Volvo’s website [1].

Conducting a life cycle assessment requires various data in large amounts, and the data availability largely limits what is possible to consider and account for. Over time, this has been improved and expanded by increasing the share of primary data from suppliers, incorporating data on recycled content, considering future energy scenarios for the use phase, and applying regional instead of global generic LCI datasets when the location is known. Thereby the accuracy and representability of the results from the studies have also improved. As illustrated in Fig. 1, the results show that the carbon footprint over 200 000 km driving of the fully electric EX90 is roughly half of the petrol driven XC90 MHEV, when using European electricity mix for charging. Electricity mixes with low shares of fossil energy sources, for example the Swedish grid mix, enables an even lower carbon footprint for the EX90.

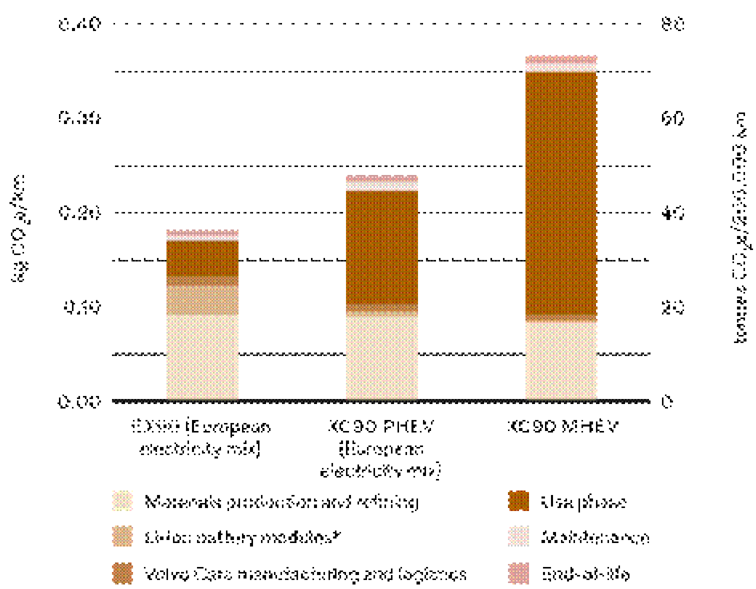

Figure 1: Carbon footprint when charging with European electricity mix.

The carbon footprint from materials production and refining is higher for BEVs and PHEVs when compared to MHEVs or conventional ICE vehicles, mainly because of the materials used to produce the traction battery. However, as shown in Fig. 2, the emissions per distance driven are lower for BEVs, and after 33 000 km and 63 000 km the accumulated emissions from EX90 will be lower than for XC90 MHEV and PHEV respectively.

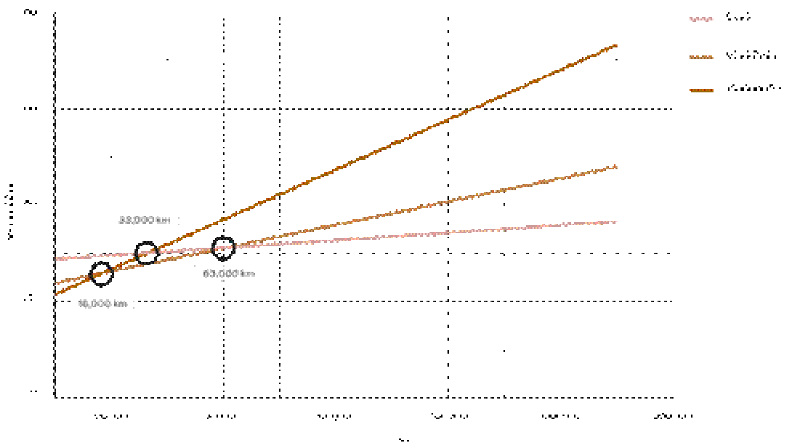

Figure 2: Accumulated emissions, when charging with European electricity mix.

By transitioning towards electric vehicles, the major contribution shifts from tail pipe emissions in the use phase to emissions occurring during raw material extraction, refining and production. A closer look at how much different types of materials contribute to the carbon footprint, as illustrated in Fig. 3, enables the identification of hot spots.

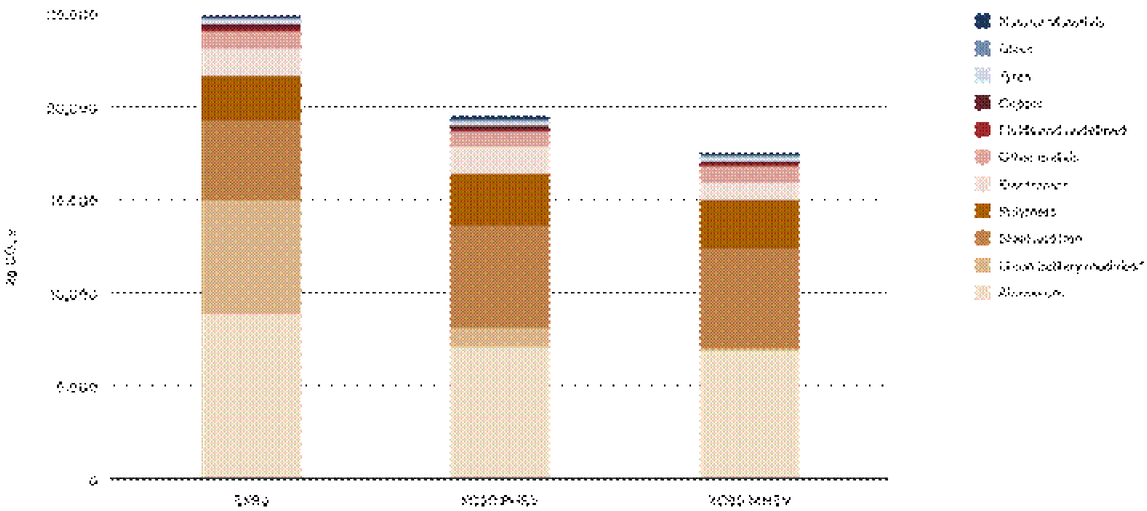

Figure 3: Carbon footprint from materials production and refining.

Common hot spots for all three vehicles are aluminium, steel and iron, and polymers, while for EX90 the battery modules are also among the top contributors. Requiring companies in the supply chain to utilise renewable energy and to increase the share of recycled content is the overall approach to reduce material related emissions, which also contributes to reaching the circular economy ambitions.

To address the carbon footprint of primary aluminium, work with suppliers is on-going to utilise aluminium produced with renewable electricity in the alumina smelting process, which is typically the most emissions-intensive stage in aluminium production. For steel a collaboration with Swedish steel firm SSAB has been extended by signing a new agreement for the supply of near zero-emissions steel used in selected components on the forthcoming fully electric EX60 SUV, starting from 2025. When it comes to battery modules, various improvements are explored and implemented together with suppliers, such as renewable energy utilisation at cathode, anode and cell manufacturing and increased shares of recycled active materials.

Some assumptions come with inherent uncertainty which can highly influence the final results, such as the future energy scenario, the vehicle lifetime distance and the real-life vehicle energy use per kilometre. For EX90, these different factors and their impacts have therefore been investigated further in sensitivity analyses, giving the reader the possibility to conclude what the outcome could look like if they do not agree with these fundamental assumptions. The relative outcome however, with EX90 having the lowest carbon footprint followed by XC90 PHEV and then XC90 MHEV, remains in all analysed cases.

3 Block-chain material traceability

While Volvo cars buy battery cells and modules, the battery raw materials are not directly sourced. Battery supply chains are complex and the materials they contain are associated with significant environmental, social and governance (ESG) risks. Hence, establishing traceability is key since it allows to identify supply chain actors, assess their ESG performance and promote good practice. Starting with cobalt in 2019, Volvo cars have been working together with Circulor [2], establishing traceability of the raw materials used in the batteries. So called blockchain technology is applied to keep a digital trace of the material flows, and this is now implemented for cobalt, nickel, lithium, graphite and mica.

Circulor's solution tracks the actual, physical flow of critical materials, from source to manufacturer by:

- Creating a digital twin of the material itself at the source
- Connecting all supply chain participants together, creating accountability and reliable proof
- Collecting CO_2 emission data, both from the supplier's operation and the incoming materials
- Collecting ESG metrics and attach this activity from every participant to the product itself

This is illustrated in Fig. 4, which shows where data from different suppliers and processes is being continuously gathered and uploaded to Circulor's database and platform.

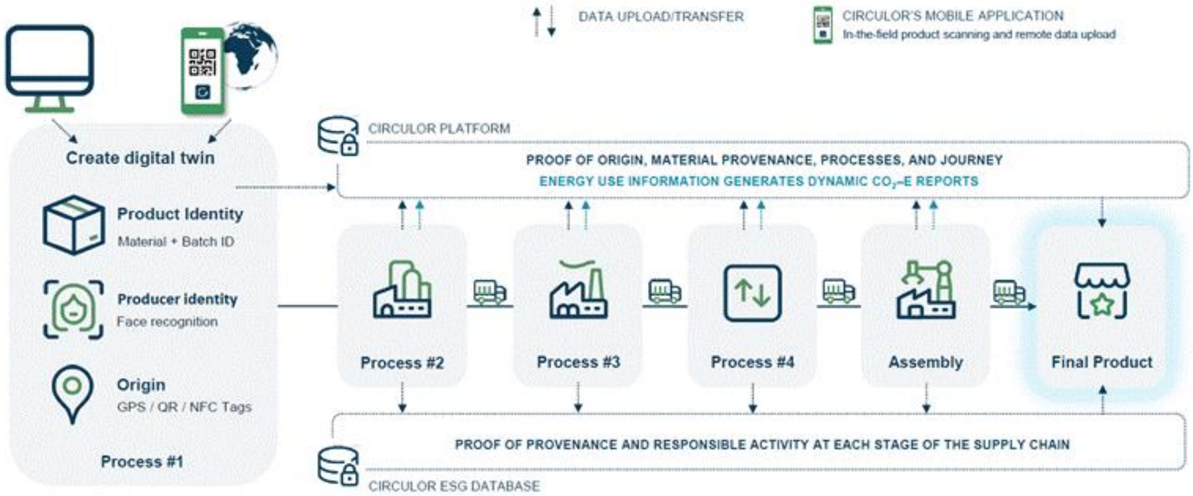

Figure 4. End-to-end supply-chain transparency with block-chain technology.

Work with suppliers is on-going to understand the flow of materials between goods-in and goods-out and then track and connect input material to output product. A digital unique identifier is attached/allocated to each batch of material, to follow it through the facility – creating the digital chain of custody.

Circulor's data is the backbone in creating full visibility of supply chains and proof of sustainable and responsible sourcing by:

- Thousands of data points, underpinning entire supply chains, end-to-end
- Full visibility of supply chain activity with actionable insights
- Empowering companies to prevent, mitigate and improve performance

4 Responsible and ethical sourcing

Volvo Cars' requirements and guiding principles for suppliers globally, with regards to human rights and the environment, are expressed in Volvo Car Group Code of Conduct for Business Partners. This code of conduct follows e.g. the OECD guidelines for responsible business and the United Nations guiding principles on business and human rights. Suppliers are also required to ensure that their subcontractors, through all tiers, are made aware of and comply with the principles in the code.

4.1 Human rights risk assessment of the value chain

In 2023, a risk assessment was conducted based on salient human rights risks in the global value chain. Using risk indices, due diligence results and consultation with experts and rightsholders, a plan was developed for 2024 that aimed to prevent, mitigate, cease, and remedy potential or actual human rights infringements in the value chain.

The due diligence plan for 2024 included expanded due diligence in the supply chain, people policy assessments in the operations and human rights due diligence processes for retailers and importers. External risk indices for identified salient human rights issues, previous due diligence results, and consultation with experts and rightsholders, combined with value chain presence, compiled the human risk assessment. 17 countries were identified, where people were at higher risk: China, The Democratic Republic of the Congo, India, Turkey, Mexico, Malaysia, Indonesia, Brazil, Vietnam, Philippines, Colombia, Myanmar, Egypt, Zimbabwe, Sudan, Ukraine, Yemen. Enhanced due diligence activities were then performed during 2024. The human rights risk assessment of salient human rights issues was repeated at the end of 2024 to form the due diligence plan for 2025.

4.2 Enhanced due diligence

Enhanced due diligence is carried out on suppliers associated with heightened environmental, social and governance risks. Activities include auditing, training and consultation and aim at giving a deeper understanding of the supplier's responsible sourcing practices as well as to drive for improvement where needed.

Volvo have identified a number of ***raw materials of concern***, associated with adverse environmental, social and governance impacts during their extraction, processing, trade and transportation. Volvo seek to increase transparency in supply chains containing raw materials of concern and ensure responsible sourcing in line with industry standards, good practice frameworks and regulatory requirements. Tin, tungsten, tantalum and gold were included in 2017, then cobalt added in 2019. The efforts were then increased to include the battery raw materials lithium, nickel, graphite and mica. Fig. 5 is a simplified picture of the complex supply chain for cathode material used in battery cells. In the real case there are multiple mines and smelters. In 2024, enhanced due diligence measures were also introduced for copper, leather, natural rubber and rare earth elements.

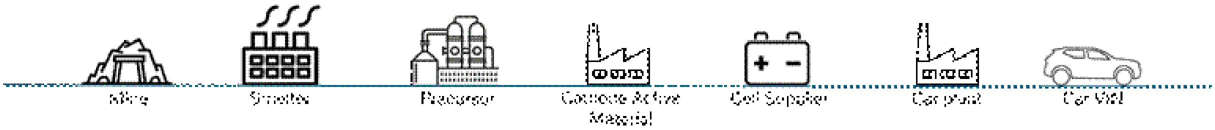

Figure 5: The supply chain for the cathode material in batteries.

4.3 Audits in the battery supply chain

Since 2019, independent audits of suppliers in the battery supply chain have been commissioned from RCS Global [3]. Between 2019 and 2023, 61 audits of suppliers in the cobalt, lithium, nickel, graphite and mica supply chains were conducted. The aim is to ensure that suppliers in all tiers of the battery supply chains are compliant with relevant standards for responsible sourcing and the newly adopted EU Battery Regulation. The purpose is also to help ensure continuous improvement of responsible sourcing performance across the battery supply chain by monitoring the implementation of corrective action plans.

In 2024, with support from RCS, the audit standard was expanded to also include a module aligned with the EU Battery Regulation, in addition to the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas (OECD Due Diligence Guidance). Audits of mine sites are conducted against the IRMA (Initiative for Responsible Mining Assurance) Standard for Responsible Mining Critical Requirements or equivalent schemes. The audit scopes allow a broad understanding of the environmental and human rights performance of the suppliers (including at the mine sites), to drive for improvements where needed, and meet stakeholder expectations for due diligence in the battery supply chain.

In 2024, 28 audits in the battery supply chain were conducted. These included four directly contracted suppliers, five anode/cathode producers, eight refiners, six treatment units and four mine sites. In the mica (battery insulation) supply chain, one audit was conducted at a treatment unit. The audits were conducted in China, the Democratic Republic of Congo, Indonesia, Turkey, Sweden, Poland and Madagascar.

In 2024, the most common findings in audits were related to risk assessment, management system, labor and working conditions e.g. working hours and emergency preparedness. Findings from audits at mine sites, against the IRMA Standard for Responsible Mining Critical Requirements, mostly concerned management system and risk assessment.

Volvo work closely with suppliers and RCS to ensure that corrective measures are implemented within agreed timeframes. To help suppliers in the battery supply chain fulfil their commitments, a training program on the concerned audit standards was launched in 2023. 190 attendees from 17 suppliers joined in 2023 and 2024. Monitoring the progress of closure rate of corrective action plans will be used to evaluate this training.

4.4 Other activities in the battery supply chain

In addition to the audit and traceability programs in the battery supply chain, additional activities are undertaken. Volvo Cars had a representative that participated in a travel arranged by Drive Sustainability and IndustriALL Global Union to Indonesia to visit nickel mines and treatment units, engage with rightsholders, particularly workers and trade unions, and government representatives to further increase the understanding of the challenges and opportunities in this area. To ensure continuous improvement of the due diligence efforts throughout the battery supply chain, Volvo Cars gathered representatives from suppliers across the complete Volvo EX90 battery supply chain to discuss traceability and the execution on audit program. The event provided insights into challenges and deviations that could jointly be resolved in an efficient manner.

5 Battery passport

The transition to electrified propulsion systems is driven by the will to provide to the customers the freedom to move in a sustainable way. The notion of sustainability covers several dimensions, each characterized by its specific metrics and targets, and implying a shared commitment by all parties to address and reach these objectives. But how to trigger this commitment and drive the needed common efforts? A fundamental step lies in transparency, in the capacity to communicate easily and clearly to all involved stakeholders, including the end user, key information that is verified and updated. The concept of Passport aims at fulfilling this need by providing a common media through which all required data could be shared. In 2023 actions were taken with the promulgation of the EU Battery Regulation 2023/1542 which includes requirements on a Battery Passport.

5.1 Data

The EU Battery Regulation establishes the list of data that must be shared via the Passport. They can be either static – linked to the type of the battery – or dynamic – related to each individual battery and its usage – and their access can be public or restricted. They address the content defined by the other articles of the Regulation, from technical characteristics to due diligence.

With its world-first implementation of an initial battery passport version on the fully electric EX90 car, Volvo Cars shared publicly available and verified static data, including the battery carbon footprint, recycled content, and the country of origin of critical raw materials.

5.2 Data structure and flow

For the data to be created and made available, a complete information chain needs to be established, synchronized and maintained. It implies that each stakeholder is in capacity of uploading the required documentation, on time and in a secured way, following a format and protocol that ensure seamless communication to the downstream receiver. Regarding the raw materials traceability, the blockchain technology provided by Volvo’s partner Circulor allows the display of consolidated information on the country of origin and the recycled content. For static and dynamic data, Volvo Cars relies on its enterprise data architecture to provide at all times the dataset matching each battery assembly. These information flows are then coordinated to ensure the creation and maintenance of the Passports.

5.3 Acess

The access to the Passport is made via a unique QR code placed on the battery and linked to the dedicated Passport page. In a way to improve accessibility and hence transparency, Volvo Cars is also mounting a QR label on the driver's door, see Fig. 6. The synchronization of the information printed on these labels and its maintenance through time and life-events come with digital and physical challenges. Taking yet another step towards enhanced transparency, Volvo Cars has also implemented a link to the Passport within the Volvo Cars App, allowing the customer to read its battery data without having to be in physical proximity with the vehicle.

Figure 6: The battery passport QR code in the EX90, placed at the inside of the driver's door.

5.4 Interoperability

The EU Battery Regulation requires the interoperability of the Passport between all potential concerned parties during its lifetime. It represents a major challenge as it implies the exploitation of formats and protocols compatible between every stakeholder of the chain through all events. As an official standard is currently lacking, Volvo Cars is carefully scanning the trends and initiatives developed by other actors - like the recent publication of DIN DKE SPEC 99100 – and trying to align its set-up to the data engineering best-practices. It is by sharing them with partners across the industry that the consistency of the procedures will grow.

5.5 EX90 First version

Volvo Cars introduced a first version of the Battery Passport along with the launch of the EX90 in 2024, see Fig. 7 and 8. This first version focuses on static data, displaying 43 public data points, distributed in 5 chapters:

-Battery characteristics
-Manufacturer information
-Battery material
-Instruction for circularity
-Carbon footprint

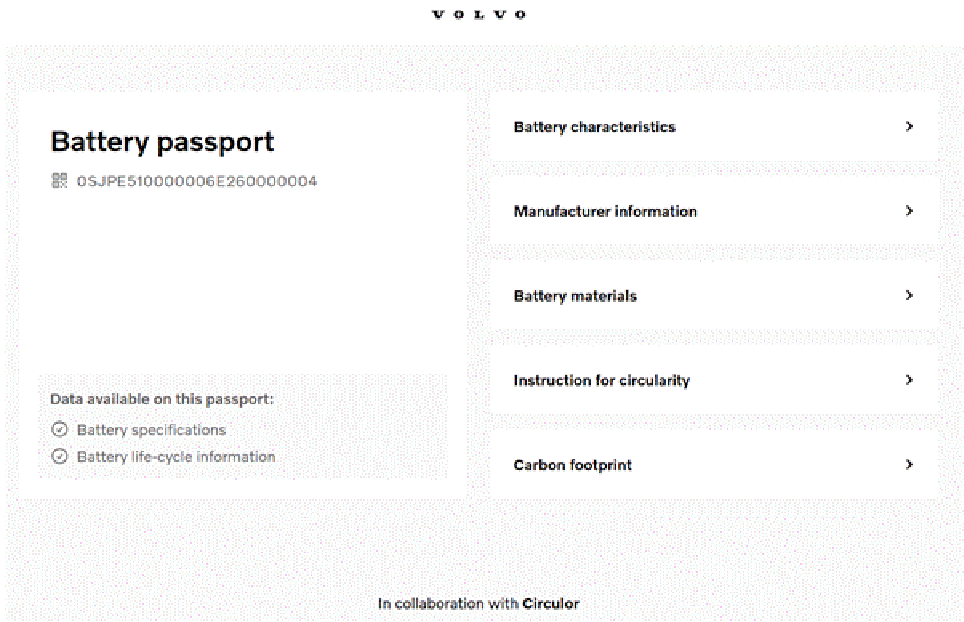

Figure 7: Battery passport information for the battery in the EX90.

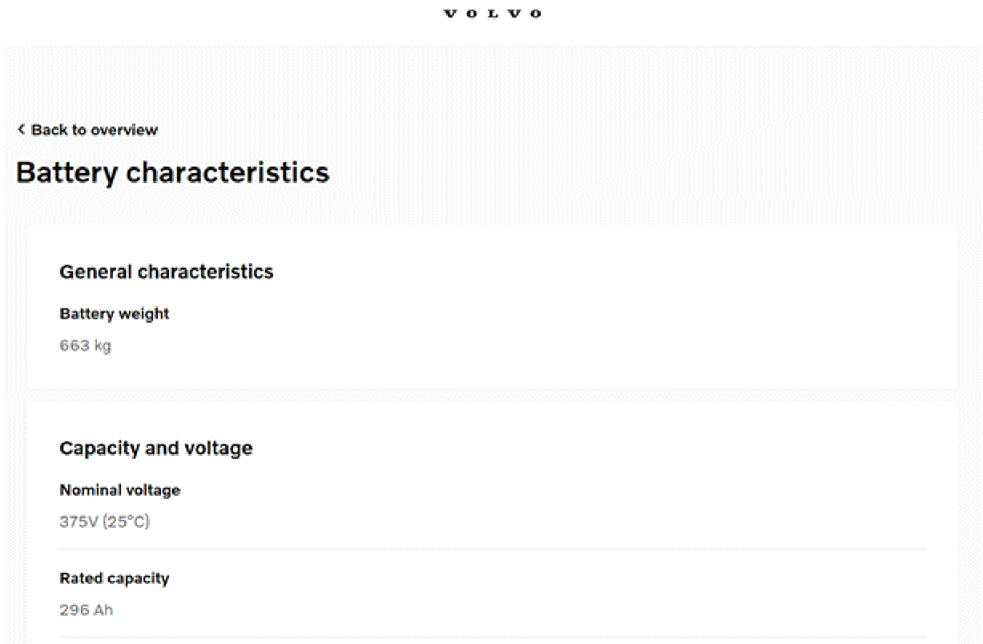

Figure 8: Battery characteristics of the battery in the EX90.

Within this data set, the CO_2 Footprint as a specific transparency initiative from Volvo Cars is worth mentioning. It is indeed calculated according to the JRC CFB [4] rules, and it goes beyond the current legal framework as the delegated act clarifying the method to be applied is not published yet. Also standing out, the Country of origin (mines) and the recycled content for lithium, nickel, cobalt and graphite are data tracked and consolidated via the block-chain technology provided by Circulor. As mentioned above, the access to the passport is possible via a QR code on the battery and on the driver's door pillar, as well as a link in the Volvo Cars App [5].

5.6 Deployment

Following the release of the first version of the Battery Passport on EX90, an evolution will be introduced during spring 2025. Regarding the content, this version will continue to focus on static data, and include the information required by the ACCII regulation in California. In terms of scale, it will represent a major step forward as the batteries of the Volvo Cars' pure electric vehicles, but also plug-in hybrids and mild-hybrids will receive their passport. As the Article 77 of EU Battery Regulation enters into force in February 2027, Volvo Cars aims to introduce a fully compliant version of the Passport, including all required static and dynamic data, during 2026. Beyond that point, the Passport will continue to evolve and exploit its potential for enhanced transparency.

6 Conclusions

The public carbon footprint reports of the cars, the blockchain tracking of battery raw materials and the battery passport, are all good examples of how Volvo work with data analysis and transparency to improve the sustainability of today's and future cars. All these tasks are complex and require a lot of hard work in collecting and assessing data from a large number of sources. By continuously measuring and evaluating the most relevant metrics, legal compliance with for example EU battery regulation can be ensured, and it gives valuable guidance on where and how to improve the sustainability performance.

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Presenter Biography

Anna Hägg, Ph D in Chemical reaction engineering from Chalmers University. Working at Volvo Cars since 2000, currently as a technical expert in battery research and development, with focus on sustainability.

Rei Palm, MSc Mechanical Engineering from Chalmers University of Technology. Works at Volvo Cars within the Global Sustainability Team with guiding and following up initiatives to reduce the company climate impact, partly by conducting life cycle assessments on new vehicles.

Thomas Bernichon, engineer from Ecole Centrale de Lille and IFP School, works at Volvo Cars within the Propulsion & Energy strategy department and led the Battery Passport first introduction.

Jan Carlson, MSc EE from Chalmers University of Technology. Working within Volvo Cars Procurement Sustainability Team with Battery material and Responsible Sourcing.