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ỨNG DỤNG CÔNG NGHỆ BLOCKCHAIN ĐỂ PHÁT TRIỂN CHUỖI CUNG ỨNG BỀN VỮNG TRONG NGÀNH CÔNG NGHIỆP XE ĐIỆN TẠI VIỆT NAM: BÀI HỌC KINH NGHIỆM TỪ VOLVO

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Tóm tắt

Khi nhiều quốc gia, bao gồm Việt Nam, đặt mục tiêu đạt Net Zero vào năm 2050, việc ứng dụng công nghệ blockchain trong chuỗi cung ứng của Volvo cho thấy tiềm năng cải thiện mạnh mẽ tính minh bạch trong ngành xe điện. Báo cáo này đánh giá cách Volvo triển khai blockchain trong truy xuất pin và theo dõi khoáng sản có trách nhiệm, dựa trên phương pháp nghiên cứu định tính và nguồn dữ liệu thứ cấp. Kết quả cho thấy blockchain giúp nâng cao minh bạch chuỗi cung ứng, tăng mức độ sẵn sàng tuân thủ quy định, củng cố niềm tin người tiêu dùng và phát triển quan hệ đối tác chiến lược. Tuy nhiên, báo cáo cũng chỉ ra các thách thức như độ tin cậy dữ liệu ở khâu đầu vào,

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sự phối hợp trong mạng lưới nhà cung ứng và mức độ phức tạp của việc báo cáo dấu chân carbon. Từ trường hợp của Volvo, nghiên cứu đưa ra các hàm ý thực tiễn cho ngành EV Việt Nam, đề xuất rằng việc áp dụng các chiến lược blockchain tương tự có thể hỗ trợ phát triển chuỗi cung ứng bền vững và phù hợp với xu hướng chuyển dịch xanh toàn cầu.

Từ khóa: công nghệ blockchain, xe điện (EV), chuyển dịch xanh, minh bạch chuỗi cung ứng, chuỗi cung ứng bền vững, ngành xe điện Việt Nam, Volvo

APPLYING BLOCKCHAIN TECHNOLOGY TO DEVELOP SUSTAINABLE SUPPLY CHAIN IN VIETNAM'S EV INDUSTRY: LESSONS FROM VOLVO

Abstract

As many countries in the world including Vietnam aim to reach Net Zero in 2050, the application of Blockchain Technology into Volvo's supply chain offers opportunities for the EV industry to improve its supply chain transparency. This study assesses the current implementation of Blockchain Technology in Volvo's supply chain, particularly in battery tracing and ethical mineral tracking. Using a qualitative approach based on secondary data, the findings indicate that Blockchain Technology enhances supply chain transparency, increases regulatory readiness, boosts consumer trust, and builds a strategic relationship with partners. However, it also reveals potential challenges such as upstream data reliability, supplier network collaboration and complexity in reporting carbon footprint. The study provides practical implications for Vietnam's EV manufacturers, suggesting that adopting similar blockchain-based strategies could support sustainable supply chain development and align with global green transition trends.

Keywords: blockchain technology, electric vehicles (EV), green transition, supply chain transparency, sustainable supply chain, Vietnam EV industry, Volvo

1. Introduction

At the 26th United Nations Climate Change Conference (COP26) in Glasgow; Viet Nam, together with nearly 150 countries all over the world committed to reach the Net Zero goal in 2050 (Van, 2022). The strong commitment of Viet Nam has opened up many opportunities for developing an economy in a sustainable way. According to Mr. Pham Van Tan, Deputy Director General of the Department of Climate Change (under the Ministry of Natural Resources and Environment) low-emission development will be the main trend for Viet Nam to comprehensively transform its development model from fossil fuels and high natural resource exploitation toward low emissions. Upon that, the Electric Vehicle industry is emerging as one potential sector that offers a pathway to reduce greenhouse gas emissions and dependence on fossil fuels. In China only, this transition toward EV cars is reported to reduce 30 MT of CO₂ emissions in 2018 (IEA, 2022). However, challenges still remain as its newly developed industry requires a transparent and integrated supply chain to ensure sustainability across all stages - from raw material extraction and battery production to recycling and waste management.

Volvo Cars, a Swedish multinational automobile manufacturer, has been a pioneer in integrating sustainability into its vehicle production. The company has committed to becoming a fully electric car brand by 2030 and achieving climate neutrality by 2040. By applying blockchain technology in Volvo's

supply chain, Volvo ensures end-to-end traceability of critical materials such as cobalt, verifying that they are ethically and responsibly sourced for battery production.

Drawing lessons from Volvo's experience, this report aims to analyze the feasibility and strategy for implementing a Blockchain-based sustainable supply chain in Vietnam's emerging EV sector. Thus they can consider adopting similar blockchain-based systems to build a sustainable supply chain aligned with the country's commitment under the COP26 framework.

2. Literature review

2.1. The trend toward developing Sustainable Supply Chain in EV Industry

As the EV industry is expected to grow markedly in the upcoming years, the transition towards developing a sustainable supply chain has become increasingly prominent to align with the need to mitigate the effects of climate change. According to a study conducted by Rajaeifar et al. in 2021, efforts made in integrating sustainable practices into the EV battery supply chain such as recycling initiatives or innovative production process development has shown significant potential in resolving the environmental and social issues related to the processing of critical raw materials such as lithium and cobalt. Through SSCM, businesses can reduce the environmental footprint of battery manufacturing while improving transparency in material sourcing. Moreover, Ahuchogu et al. (2024) have emphasized that the implementation of circular supply chains, green logistics and reverse logistics has minimized the waste generation across production, transportation and distribution stages. Furthermore, the adoption of lean and agile supply chains enables EV manufacturers to optimize resource utilization by rapidly responding to market changes and customer demands. Additionally, in a research in 2023, Torres-Rivera et al. have found that the digitalization of EV supply chain management, involving artificial intelligence (AI) and the Internet of Things (IoT), could increase the efficiency and traceability across the supply networks by improving the information flow across all stages and encouraging proactive risk management.

2.2. Application of Blockchain Technology in EV Industry

The integration of blockchain technology into the EV industry has recently drawn significant attention from both researchers and businessmen due to its potential to increase transparency and efficiency across the supply chain networks. Therefore, analysis of earlier research is essential to provide a foundation for understanding its role in the EV industry and to identify current research gaps.

From a theoretical perspective, several blockchain-based frameworks have been proposed in order to improve the overall performance of EVs. In terms of energy trading, in 2021, Baza et al. had proposed privacy-preserving schemes for Charging station to Vehicle (CS2V) and Vehicle to Vehicle (V2V) energy trading. With the help of untraceable digital coins, their model was capable of enhancing privacy and preventing stolen attacks without the need of a trusted third party. Similarly, Sun et al. (2020) also developed an Energy Fog Computing Node (EFN) to optimize V2V energy transactions in local social

hotspots. By designing a consensus algorithm called DPOSP, they achieved a 30% improvement in correct consensus and 33% higher fault tolerance, thereby saving resources and improving the speed and efficiency of the systems. Regarding battery refueling, Hua et al. (2018) introduced a blockchain-based battery swapping model using smart contracts to foster traceability between EV owners and charging stations. Meanwhile, for charging systems, Kim et al. (2019) presented a secure charging system model for EV based on blockchain and the basic concept of Hyperledger technology, which strengthen mutual authentication and prevent attacks among EVs. Additionally, many researchers have stated the importance of batteries in contributing to the low carbon impact of EV cars and how blockchain technology could play a facilitating role. A work by Minh Cheng et al (2022) also demonstrates how second-life (SLB) applications concretely contribute to extending the useful life of EV batteries: using retired EV batteries in residential stationary storage can prolong their lifespan by 3–5 years while delivering economic savings of over 23% compared to baseline use. Song Hua et al (2018) further extend the application of blockchain technology in EV batteries by suggesting that an objective mechanism based on a decentralized blockchain system is proposed to manage battery swapping and solve the trust lacking issue. With this solution, both battery life-cycle information and all operations histories are permanently saved in the blockchain network.

On the other hand, there remains little research on real-world application into the EV industry. According to a report in 2024, Mohammed et al. have reviewed several industrial applications such as MotionWerk from Germany and Power Ledger in Australia in applying Peer to Peer (P2P) energy trading between EVs. These cases had revealed blockchain's ability to facilitate transparency and flexibility in the EV power market, further reinforcing the potential of blockchain in practical appliance. Furthermore, Elias Ribeiro da Silva et al (2023), by conducting an empirical case study involving multiple companies across different tiers of the EV battery supply chain, has pointed out that while EVs are a key part of sustainable mobility, their environmental benefit depends heavily on how sustainably their battery supply chain is managed - including reuse, recycling, and second-life applications. Blockchain or similar secure IT solutions could help overcome existing barriers to circularity by improving transparency and traceability across supply chain actors.

Although previous studies have explored several aspects of blockchain application in the EV industry, existing literature has reflected significant research gaps. Prior studies mostly focused on theoretical framework or prototyped models, overlooking the empirical evidence confirming blockchain's real performance in actual EV car brands and models. Furthermore, there is still limited research on blockchain technology for developing countries' EV industry such as Vietnam, where the EV market is still in its infancy.

3. Theoretical framework

3.1. Sustainable Supply Chain Management

Sustainable supply chain management (SSCM) is a comprehensive approach that seeks to integrate sustainable practices into the whole supply chain, from sourcing raw materials to final disposal, with environmental, social and financial considerations in mind. The ideal outcome of SSCM is supply chain sustainability, which is determined by the degree to which the business takes into account their products' impact on the environment and society. SSCM works towards minimising this impact while ensuring business efficiency and credibility at the same time.

In recent years, supply chain sustainability has gained increasing attention as modern supply chains have become more complex and environmentally impactful. Sustainable Supply Chain Management (SSCM) helps reduce carbon emissions, waste, and energy use, leading to both environmental and economic benefits. Additionally, SSCM supports companies in meeting CSR and ESG goals, enhancing reputation and regulatory compliance.

The Triple Bottom Line (TBL) theory is what essentially defines SSCM (Sahoo et al., 2022). This model emphasises that businesses should commit to achieving an equilibrium between profit (financial success), people (social duty), and planet (environmental protection). Initiatives for SSCM have been greatly aided by technology advancement with tools such as artificial intelligence (AI), machine learning (ML) in supply chain visibility enhancement, Internet of Things (IoT) in energy consumption control to reduce greenhouse gas emissions, and Blockchain Technology in traceability improvement with transparent and safe record of transactions.

3.2. Blockchain Technology

Seen as a potential game changer for businesses, blockchain technology is currently gaining popularity across various industries. Blockchain was first introduced by an anonymous person (or group of people) called Satoshi Nakamoto in 2008 as a public ledger for cryptocurrency of Bitcoin. Nowadays, IBM defines blockchain as a shared, immutable digital ledger that offers a single source of truth, which supports transaction record and asset tracking for a business network. In simple terms, according to McKinsey (2024), blockchain is simply a decentralized secure database in which all participants get access to updated information simultaneously, and they share the authority to modify the information on blockchain.

Blockchain technology enhances transaction and data management through key features such as distributed ledger technology (DLT), public key cryptography, smart contracts, and immutability. DLT allows shared access among network participants while cryptographic keys ensure secure authorization. Smart contracts automatically execute agreements when conditions are met, increasing efficiency. Nonetheless, what makes blockchain technology particularly desirable is its immutable nature, which means that no changes are allowed after a transaction is recorded, promoting trust and integrity.

There are four main types of blockchain: public, private, hybrid, and consortium. Public blockchain networks are those that are open to every Internet user without any restrictions like the original Bitcoin

blockchain. Meanwhile, private blockchain networks are restrictive ones, where only few people within the controlling organisation of the blockchain are allowed to get access to it. These networks provide privacy that is desirable for uses in internal auditing, voting, asset management, and supply chain management. Hybrid blockchain networks have some parts under management of certain organizations, and other parts made public. Consortium networks, on the other hand, are shared by preselected organizations collaborating with each other.

Blockchain technology is now utilized as one crucial tool in helping businesses achieve their supply chain sustainability goals, and it does so by supporting the TBL theory of sustainable business practices in economic, social, and environmental performance of businesses. However, blockchain technology also poses some challenges to businesses. One serious problem that may hinder the long-term viability of blockchain is its energy consumption. The proof-of-work system, mining, and other algorithms need hundreds of megawatts to run so as to protect data privacy for users, which, unfortunately, can balance the environmental benefits blockchain brings. Furthermore, there are also risks of conflicts among blockchain participants when one or more parties act on their own interests, harming other members of the network financially (Sayal and Khan, 2021).

4. Analysing and discussing Volvo's application of Blockchain Technology

4.1. Overview of Volvo

Table I: Descriptive Profile of Volvo Cars

| | |
|--------------------------|---|
| Company name | Volvo Car Group (Volvo Cars) |
| Brand name | Volvo |
| Year established | 1927 |
| Place of origin | Gothenburg, Sweden |
| Current Ownership | Geely Holding (China) since 2010 |
| Vision | To become a pure electric car company by 2030 and a leader in sustainability and to achieve climate neutrality by 2040. |
| Mission | Synonymous with Safety, Quality, and Sustainability |
| Core Principle | Safety first |

Source: Volvo Cars Official Website

The company's aim is to ensure traceability of all key materials, from raw extraction to final vehicle assembly. This strategy not only strengthens compliance with global sustainability standards but also builds consumer trust and reinforces Volvo's image as an innovative automaker. Volvo Cars is also specifically active in the Responsible Minerals initiative focusing on addressing transparency and ethical sourcing.

Volvo operates a global supply chain that balances international efficiency with regional responsiveness. The company has set up regional supply hubs in Sweden; Belgium; the US and China owing to which it can leverage the operational scale for optimizing transportation emissions as well as logistic risks. This regionalisation enables Volvo to adapt to local regulations, strengthen resilience, and ensure faster market response while maintaining its global brand standards.

Volvo maintains a transparent supplier management framework to comply with its Volvo Cars Supplier Code of Conduct that ensures that its employees, subcontractors and other relevant third parties comply with standards and principles.

According to its 2023 Sustainability Report, 74% of the company’s energy use is climate-neutral, and 92% of its waste is recycled. These goals illustrate Volvo’s commitment to measurable, transparent progress toward a circular and low-carbon manufacturing ecosystem.

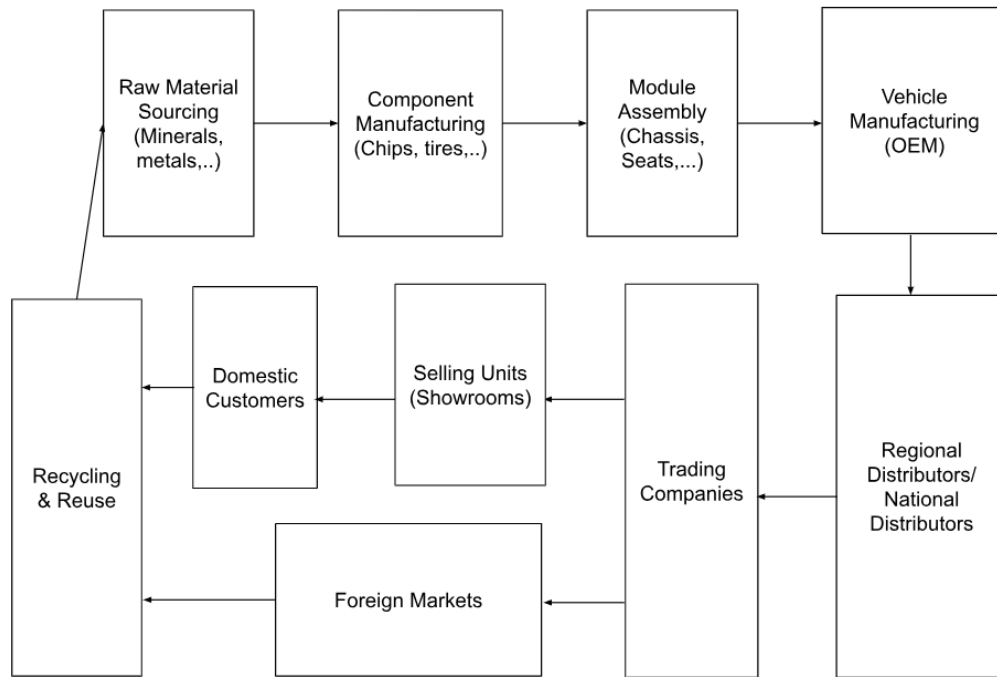


Figure I: Volvo supply chain

4.2. Volvo current application of Blockchain Technology

Volvo Cars is a pioneer in applying Blockchain technology to transform its commitment to SSCM into real action, specifically addressing the core challenges in the EV battery value chain. This strategy boosts the company's TBL performance by enhancing transparency, ethical sourcing and compliance with global standards.

4.2.1. Raw material extraction and responsible sourcing

The initial application of Blockchain focuses on the riskiest stage: sourcing of critical minerals. The main difficulty in dealing with TBL is with People and Planet criteria, whereas materials like Cobalt that are used in electric batteries based on lithium chemistry are often associated with unethical practices, such as child labor and severe environmental degradation, making it difficult to meet Volvo's Supplier Code of Conduct (Volvo Cars, 2025).

To handle this, Volvo worked with Circular and Responsible Sourcing Blockchain Network (RSBN), using Blockchain to establish a Chain of Custody for its batteries, starting with the Volvo XC40 Recharge. Chain of custody refers to the process of monitoring materials at every stage of the supply chain. It relies

on coordinated procedures, technologies and documentation to trace materials from their origin to the finished product and ensure that all inputs and outputs remain consistent and balanced. This solution involves recording unchanged data about the material's origin, including GPS coordinates and extraction volume (Volvo Cars, 2019). Because this data is immutable, the system ensures the information is tamper-proof, eliminating the chance of provenance records. This also allows both companies to expand their focus beyond cobalt, for example by looking at increasing traceability of mica, a mineral used as isolation material in the battery pack of electric Volvos. This not only builds trust but also significantly cuts down ethical and compliance risks while aligning with the company's ESG goals.

4.2.2. Component processing and manufacturing

As raw materials move through complex processing stages, from smelting and refining to the manufacturing production, the primary challenge shifts to maintaining traceability and environmental footprint. Here, there is also a far greater chance of combining unconfirmed materials.

Volvo tackled this problem by utilizing the Blockchain system to keep track of each batch of material. The digital ledger updates automatically whenever a supplier adds or changes something, making sure that the material inputs and outputs match. Moreover, Volvo is expanding this system to cooperate in other areas helping Volvo Cars and Circulor to potentially set standards for ethical sourcing in automotive and other industries (Volvo Cars, 2020). This not only supports its Net Zero ambition but also provides reliable environmental data, strengthening the Planet side of the triple bottom line.

4.2.3. Vehicle assembly and regulatory compliance

In the final assembly stage, the challenge is ensuring that every component meets Volvo's quality and sustainability specifications before it is integrated into the vehicle. This is crucial for risk management and complying with regulations because if any part fails to meet standards, it can cause safety issues, product recalls, or even break environmental laws.

The Blockchain acts as the rules-based verification layer. The solution uses Smart Contract similar techniques to automatically compare the battery's data history with pre-established compliance standards. If any stage of the supply chain history violates the Supplier Code of Conduct or emissions standards, the battery pack is flagged immediately. This automation compliance ensures that every EV leaving the factory meets Volvo's ethical and environmental claims. This innovation turns traceability into a powerful tool for proactive risk management. Importantly, Volvo is introducing the EV Battery Passport for the EX90 SUV, a digital record built on this traceability data, which is set to meet with EU regulations (Reuters, 2024).

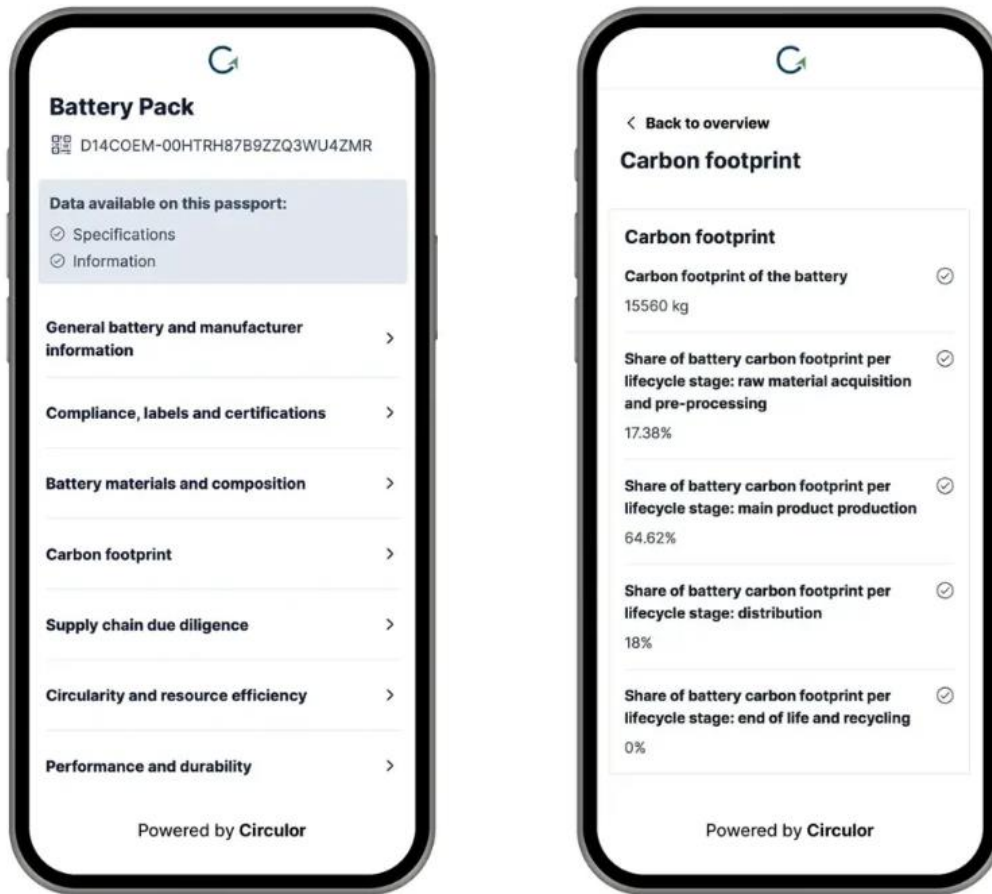


Figure II: Interface of Battery Passports

Source: Circular (2024)

4.2.4. End-of-Life management and brand value

The final application of this Blockchain-based data strengthens both the Circular Economy model and the TBL with Profit goal. The challenge at the end of the product lifecycle is the effective recovery and recycling of expensive, rare materials.

By utilizing the accumulated Blockchain data, Volvo is establishing a foundational data set for end-of-life management. Recyclers can obtain comprehensive, confirmed information about the battery's chemical composition, source materials, and recycling content from the Battery Passport. According to Circular, EX90 owners can now access information on their vehicle's material traceability, embedded carbon footprint and recycled content through the Volvo Cars app or by scanning a QR code on the door frame. Circular's platform tracks battery materials from the mining stage all the way to each individual vehicle by integrating with suppliers' production systems, allowing materials to be monitored across the entire supply chain. It also verifies suppliers' monthly energy-use data, including the proportion sourced from

renewables, to calculate the overall carbon footprint (Reuters, 2024). This transparency makes recycling more efficient and supports the circular economy. For the consumer, it also shows that Volvo is serious about responsible sourcing, enhances its premium brand reputation, and strengthens TBL with Profit criteria by demonstrating the value of a sustainably-sourced EV.

4.3. Evaluation of Volvo's Blockchain Technology application

4.3.1. Strengths

a. Improved supply chain transparency

Volvo's use of blockchain represents a systematic approach to transparency, covering all major stages of the supply chain. Blockchain technology is applied throughout the production process - from raw material extraction and responsible sourcing, to component processing and manufacturing, vehicle assembly and regulatory compliance, and ultimately to end-of-life management and recycling. This end-to-end traceability ensures that every stage of material handling and production is recorded in an immutable ledger, allowing both Volvo and external stakeholders to verify the ethical and environmental integrity of each component. According to Volvo's sustainability disclosures, blockchain enables the company to monitor supply origins, certify supplier compliance, and maintain accurate carbon accounting across global operations (Volvo Cars, 2024a). By integrating blockchain across its supply chain, Volvo establishes a digital infrastructure that promotes trust, efficiency, and long-term resilience in a rapidly evolving green mobility market.

b. Regulatory readiness

Volvo's adoption of blockchain technology demonstrates strong regulatory readiness, particularly in response to evolving European sustainability framework readiness. Volvo electric vehicle battery passport for its EX90 model, developed in partnership with Circular enables detailed tracking of raw material origins, recycled content, and carbon footprint, which align with the European Union (EU) Battery Regulation that will mandate such passports by 2027 (Reuters, 2024). Although the EV industry has not yet been directly affected by Carbon Border Adjustment Mechanism (CBAM), among 5 first sectors that will be affected (iron & steel, aluminium, cement, fertilisers, electricity and hydrogen) supply essential inputs for EV manufacturing. For example, steel and aluminium are critical materials used in EV frames and battery casings, meaning the cost and emissions reporting obligations under CBAM will indirectly influence Volvo's production and supply chain decisions. By proactively adopting blockchain-based traceability, Volvo can ensure compliance with forthcoming EU sustainability regulations and enhance long-term competitiveness in the European market.

c. Consumer trust

Volvo's blockchain-based battery passport directly strengthens consumer trust by making supply-chain data transparent and verifiable. Through a QR code integrated into its EV models, customers can access detailed information on battery provenance, recycled content, and total lifecycle emissions (Circular, 2024). This feature empowers consumers to make informed choices and reassures them about the ethical sourcing and environmental responsibility of their purchase.

d. Strategic partnership

Volvo's blockchain application is reinforced through strategic partnerships with both technological firms and key material suppliers. Rather than developing its own blockchain infrastructure, Volvo collaborates with Circular, Oracle, and the Responsible Sourcing Blockchain Network (RSBN), as well as major battery suppliers LG Chem and CATL (Volvo Cars, 2019). These collaborations enable Volvo to leverage specialized technical expertise and established supplier networks, accelerating project implementation and ensuring scalability. This partnership model reduces development costs and operational risks while integrating advanced traceability solutions directly into Volvo's global supply chain.

4.3.2. Potential challenges for Volvo and future adopters

a. Upstream data reliability

Although blockchain provides an immutable record, it cannot guarantee the accuracy of the data written on-chain; if incorrect or fraudulent information is entered at source, the ledger simply preserves that error - the classic "garbage in, garbage out" problem. Several industry reports and academic studies warn that blockchain must be paired with robust data-governance, IoT validation, and independent audits to avoid immutably storing false inputs (PwC; Ramachandran et al., 2021). Without these complementary controls, Volvo's traceability could be undermined by poor data quality at upstream nodes, especially in jurisdictions with weak regulatory oversight.

b. Supplier network collaboration

Another major potential challenge in Volvo's blockchain implementation lies in achieving effective collaboration across a multi-tier supplier network. The company's supply chain involves numerous partners across different countries, each with varying levels of digital readiness and regulatory oversight. Smaller suppliers, especially those in developing regions, may lack the technological capacity or resources to adopt blockchain systems effectively (KPMG, 2022). If this problem persists or other manufacturers adopting this technology do not fully consider this, full participation across all tiers might remain limited, reducing the overall coverage and representativeness of the traceability data. Ensuring supplier engagement requires continuous technical support, training, and financial incentives - otherwise, blockchain adoption risks becoming fragmented, with only Tier 1 suppliers participating while lower-tier

actors remain unconnected. This partial integration then can diminish the potential for truly end-to-end transparency across the global supply chain.

c. Complexity in reporting carbon footprint

A further issue may arise from the complexity of integrating accurate carbon footprint reporting into blockchain systems. According to Carbon Calqlate, the carbon footprint of an EV car includes: Battery Production, Electricity Production, Manufacturing Emissions, Lifetime Emissions, Break-even Distance.

| ASPECT | ELECTRIC VEHICLE (EV) | GASOLINE CAR |
|--|---|--|
| Battery Production (per 60 kWh) | 3,660 to 6,360 kg CO ₂ e (8,068 to 14,019 lbs CO ₂ e) | N/A |
| Manufacturing Emissions | 8,000 to 12,000 kg CO ₂ e (17,637 to 26,456 lbs CO ₂ e) | 6,000 to 8,000 kg CO ₂ e (13,228 to 17,637 lbs CO ₂ e) |
| Electricity Production | 50 to 200 g CO ₂ e per mile (0.11 to 0.44 lbs CO ₂ e) (depends on source) | N/A (Direct combustion of fuel) |
| Lifetime Emissions | About 50,000 kg CO ₂ e (110,231 lbs CO ₂ e) | About 75,000 kg CO ₂ e (165,346 lbs CO ₂ e) |
| Tailpipe Emissions | 0 g CO ₂ e per mile | 404 g CO ₂ e per mile (0.89 lbs CO ₂ e) |
| Break-Even Distance | 24,000 to 30,000 km (15,000 to 18,600 miles) | N/A |

Figure III: Carbon Footprint of EV Car Compared To Gasoline Car

Source: Carbon Calqlate

First, while EVs produce fewer emissions during operation, the battery production contributes significantly to their overall carbon footprint. The carbon intensity of electricity used in battery production varies widely: if the factory runs on a coal-heavy grid, the embedded carbon will be much higher. If Volvo’s blockchain simply records “emissions per kg battery,” without capturing the detailed context (such as the energy source of the manufacturing plant), the data may mask significant differences or even misrepresent true carbon intensity (CarbonClick, 2023). Second, lifetime emissions is another problem. Often, the assumptions automakers make around how far vehicles will be driven in their lifetime (“lifetime mileage”) vary: different companies use very different estimates, e.g., some assume 150,000 km while others estimate up to 200,000 km. Also, geographic differences further complicate things: driving

behavior, energy mix, and regulation vary significantly around the world, so emissions per kilometer in one market may not reflect those in another. (S&P Global, 2025) These varying assumptions can lead to large differences in reported emissions, even for similar vehicles.

5. Recommendations

5.1. Overview of EV industry in VN

Vietnam's EV market has witnessed significant growth in the coming years, driven by many factors including government incentives and active investments from both domestic and global manufacturers. EV have attracted significant local interest although being relatively new, especially among early Gen Z and Millennials consumers aged 25-44 (KPMG, 2024). According to the KPMG EV 2024 Report, total annual EV sales reached over 23,000 units in 2024 – a 7.1% share of total vehicle sales - and is expected to reach 65,000 units by 2032. Major participants include both domestic players, notably VinFast, as well as international brands such as Hyundai, Toyota, Kia, and BYD.

Regarding the application of Blockchain technology, since 2023, Hyundai Motor Company and Kia Corporation have already introduced its AI-enabled, blockchain-based Supplier CO2 Emission Monitoring System (SCEMS). The system allows stakeholders to track and manage the carbon emissions of its cooperative business partners at their respective workplaces. For BYD, the Chinese manufacturer, a blockchain-based carbon credit system built on the VeChain public blockchain has been in operation since 2018.

Vinfast has also announced its adoption of blockchain technologies since 2022; however, its application has primarily focused on the vehicle reservation process to certify reservations, payments, and, ultimately, vehicle ownership. Through this system, customers who reserve a VinFast EV receive a VinFirst NFT (non-fungible token) that certifies their membership status and allows them to transparently verify their pioneer benefits. However, according to VinFast's 2022 announcement, this blockchain application would be implemented only for reservation activities in the U.S. market. As of now, official VinFast communications and the company's website have not mentioned any blockchain applications in its operations or products in Vietnam.

5.2. Challenges in adopting Blockchain Technology in Vietnam's EV Industry

Vietnam's EV sector is facing many of the same challenges seen in the global industry, especially rising pressure on the supply of critical minerals such as lithium, nickel, and cobalt (OECD, 2023). Because these materials come mainly from a few countries, Vietnam must consider how to reduce supply risks and ensure more sustainable sourcing. The battery lifecycle also creates important challenges, as used EV batteries require proper reuse and recycling to limit environmental impacts. These issues highlight the

need for stronger transparency and monitoring across the supply chain, an area where blockchain can help improve traceability and support more responsible EV production in Vietnam.

Despite strong potential for blockchain application in the EV industry of Vietnam, there are still critical challenges remaining. One of the most important limitations is the lack of technology and infrastructure for applying blockchain technology. To start this application, process automation and data digitalisation are the starting point (Nguyen, 2019). However, while large corporations such as VinFast may possess adequate resources to adopt such technologies, many suppliers in Vietnam are small and medium-sized enterprises (SMEs) with limited digital readiness to adopt this technology. Another challenge is the absence of a comprehensive regulatory framework in Vietnam governing blockchain-based initiatives as this is still a new field in the country.

Fortunately, with the emergence of Vietnamese technology businesses such as Sotatek, Savvycom, Newwave Solutions, or Vietnam Blockchain Corporation have successfully developed effective networks to provide blockchain solutions to renowned organizations such as Microsoft, Mobifone, VCCI, or Hanoi University of Science and Technology (HUST). As for the regulatory framework, Vietnam is in the process of introducing several legal documents governing cryptocurrency in particular and blockchain technologies in general. Among them, it is anticipated that the drafts of the Law on Digital Technology Industry (Draft DTI Law) will lay the ground for a legally enforceable framework for blockchain with the included definition of blockchain and an emphasis on the strategic development of this technology (Tilleke & Gibbins, 2025).

5.3. Lessons learned

Based on Volvo's experience in adopting a blockchain-enabled sustainable supply chain, several key lessons can be applied to Vietnam's emerging EV industry, especially to domestic firms such as VinFast that aim to enhance sustainability, transparency, and global competitiveness.

5.3.1. Strengthening Traceability and Responsible Sourcing

To build a sustainable EV supply chain, traceability must be treated as a core principle rather than a supporting function. It should be implemented as a systematic approach covering all key stages of the supply chain, from raw material sourcing, component processing and manufacturing, vehicle assembly and regulatory compliance, to end-of-life management and recycling.

a. Material Sourcing

Vietnam's EV manufacturers should consider adopting a framework similar to Volvo's "Chain of Custody", to monitor material sourcing, particularly for imported minerals like lithium, cobalt, and nickel.

Blockchain-based supply chain architectures can enable end-to-end traceability of battery materials by creating immutable records that follow raw materials from extraction to final product integration.

In practical terms, this approach can be strengthened through the digital tokenization of mineral batches, as proposed by Moawad et al. (2025), where each shipment of lithium, cobalt, or nickel is represented as a unique digital asset (NFT) using the ERC-721 standard, which contain embedded metadata on origin, environmental certification, and compliance records. These digital records are stored on-chain to guarantee immutability, while large audit documents and laboratory reports can be stored through off-chain systems such as the InterPlanetary File System (IPFS), creating a hybrid architecture that balances transparency with scalability. Furthermore, smart contracts can be used to automate the verification of material provenance and enforce predefined sustainability requirements before materials are accepted into the manufacturing process. This mechanism reduces the risk of unethical sourcing, child labour, and illegal mining entering the EV supply chain.

b. Component Processing and Manufacturing

Vietnam's EV manufacturers can apply blockchain to monitor each batch of materials throughout the production process, particularly to track environmental impact and ensure compliance with sustainability standards. A key lesson from Volvo is that smart contract-based checks can automatically verify production data against ethical, quality, and emission standards, flagging any issues in real time to help manufacturers manage risks proactively.

c. End-of-Life Management

EV manufacturers in Vietnam can also learn from the Volvo's "Battery Passport" model, which provides a transparent, auditable record of each battery's production history and can support regulatory compliance. A standardized model for such a passport records comprehensive lifecycle data, including chemical composition, material origins, manufacturing history, carbon-footprint metrics, state-of-health, and instructions for safe disassembly or recycling (Hristova, 2021). With this "passport", when a battery reaches end-of-life, recyclers and remanufacturers can access verified, immutable data that enables safe and efficient recovery of critical minerals and appropriate disposal of hazardous components, reducing environmental risks and supporting circular-economy goals. For Vietnamese EV companies, implementing such a system from the start would not only ensure sustainable end-of-life management, but also enhance regulatory readiness and consumer trust (Fahimnia et al., 2024).

5.3.2. Promoting Strong Strategic Partnerships among the EV's Supply Chain

Reinforcing collaboration between all stakeholders including automakers, suppliers, recyclers, and government is also important to ensure unified data standards and consistent participation across the

supply chain. Indeed, Volvo's blockchain success is largely due to its strategic partnerships with technology providers, such as Circular, Oracle, and battery suppliers, including LG Chem.

For Vietnam, this underscores the need to cultivate a domestic ecosystem of blockchain developers, IoT solution providers, carbon-measurement platforms, and third-party auditors. Strengthening local technological capabilities would lower adoption costs, encourage innovation, and reduce reliance on foreign technologies. Therefore, Vietnamese manufacturers may consider providing training programs on digital traceability and offering technical support for stakeholders to join the blockchain systems.

5.3.3. Strengthening Regulatory Frameworks

One of the central factors behind Volvo's successful blockchain adoption is the strong regulatory environment in Europe, particularly regarding supply-chain transparency, responsible sourcing, and carbon-footprint reporting. Vietnam currently lacks unified national standards on battery traceability, carbon accounting, and material provenance. Therefore, a key lesson is the need to establish a regulatory foundation that enables digital traceability. This includes developing clear guidelines for battery passports, defining reporting standards for mineral origins and embedded emissions, and aligning domestic regulations with evolving international frameworks such as the EU Battery Regulation. For Vietnamese manufacturers, internal data governance and early standardization of production and environmental metrics will be essential to ensure future blockchain compatibility.

Moreover, government policies play a crucial role in encouraging participation in blockchain-based EV battery traceability systems. One effective mechanism is consumer subsidies, which can incentivize end-users to return used batteries for recycling, thereby increasing engagement with the traceability system (Cheng et al., 2021). At the same time, policy design must consider economic trade-offs for manufacturers: as government-mandated recycling targets increase, the profit margins of EV battery producers may decrease, creating a potential conflict between regulatory objectives and business incentives (Cheng et al., 2021). Therefore, a well-calibrated combination of financial incentives for consumers and support mechanisms for manufacturers, such as tax breaks or technology grants, can align stakeholders' interests, promote circular economy practices, and strengthen the overall effectiveness of blockchain-enabled end-of-life battery management.

5.3.4. Integrating IoT and Digital Monitoring Systems to Improve Data Integrity

Blockchain alone cannot ensure data authenticity; it only preserves the accuracy of information once recorded. To address the risk of inaccurate or fraudulent inputs, blockchain systems must be integrated with IoT sensors, GPS tracking, automated monitoring tools, and verifiable digital workflows.

For Vietnamese EV manufacturers, the adoption of such supporting technologies is critical, as it enhances data reliability and reduces the manual errors that frequently arise in carbon-accounting processes.

Establishing a multi-layered approach that links IoT-based emissions measurement and standardized carbon-reporting protocols with blockchain storage would improve overall system integrity and mitigate the persistent “garbage in, garbage out” dilemma.

CONCLUSION

Vietnam’s electric vehicle industry is developing rapidly, driven by government incentives and increasing consumer demand, yet it faces global challenges such as supply constraints for critical minerals and the management of battery lifecycles. Blockchain technology, particularly when integrated with IoT and digital monitoring tools, offers significant potential to improve transparency, traceability, and data integrity across the EV supply chain.

Providing an analysis of Volvo’s blockchain-enabled supply chain, this report has demonstrated how practices such as transparent sourcing, smart contract-based verification, and battery passport systems can enhance ethical compliance, environmental performance, and consumer trust. These lessons indicate that

Vietnamese EV manufacturers could benefit from adopting similar strategies to track imported minerals, monitor production impacts, and facilitate circular economy practices. Effective adoption will require collaboration across suppliers, technology providers, and regulatory authorities, alongside robust data governance and standardization.

Future research could empirically assess the adoption of blockchain in Vietnam's EV market, quantifying both environmental and economic benefits while exploring how complementary technologies can enhance data reliability and regulatory compliance. By applying all these insights, Vietnam's EV sector can strengthen its operational resilience, ensure responsible production, and advance the country's commitment to achieving Net Zero emissions by 2050.

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