GLOBAL BATTERY ALLIANCE
BATTERIES POWERING SUSTAINABLE DEVELOPMENT

Global Battery Alliance

WORLD ECONOMIC FORUM

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Battery Passport

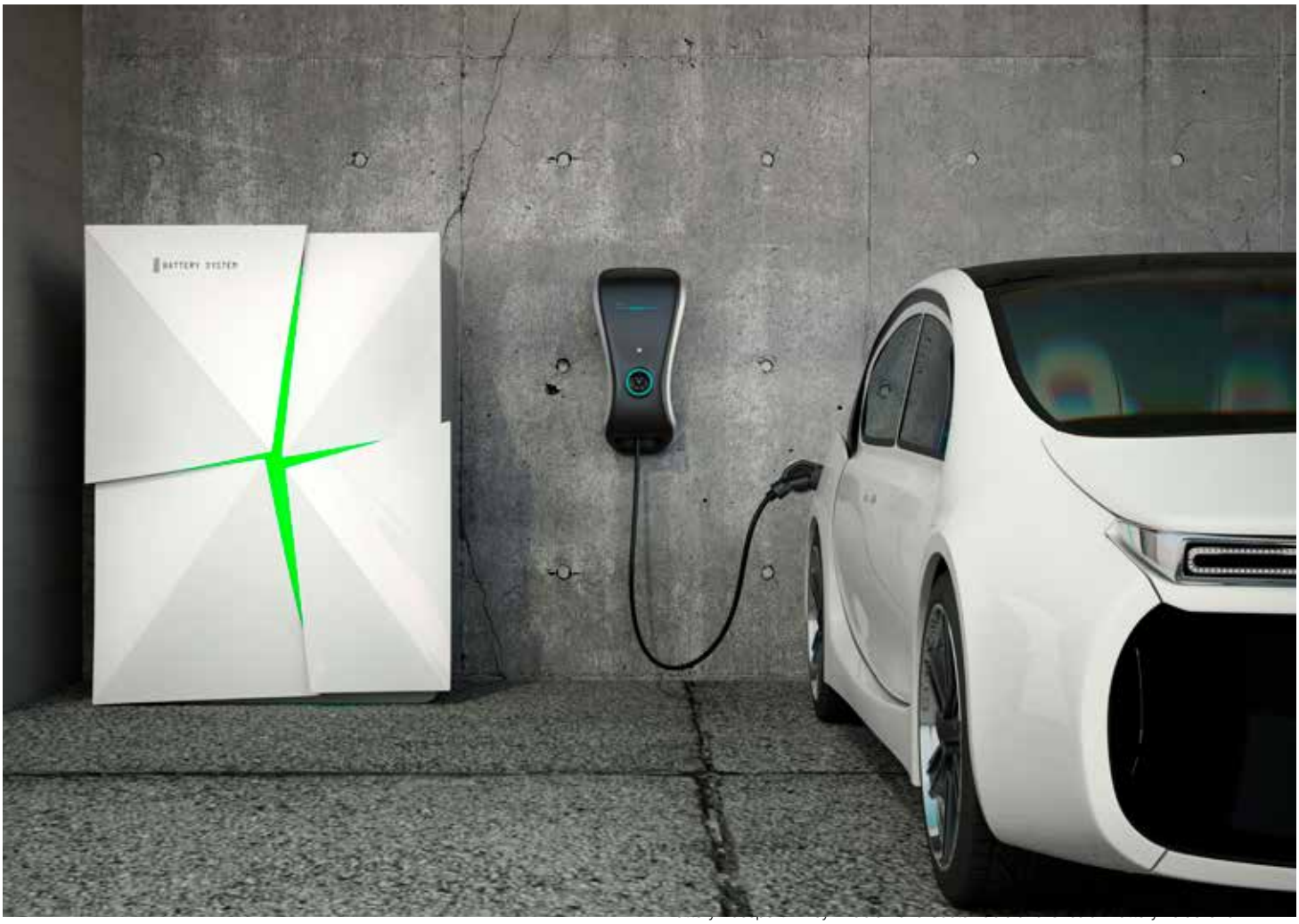
Key Enabler for a Sustainable and Circular Battery Value Chain

Discussion Paper, World Economic Forum 2020

PROPOSAL

Confidential

Davos, January 23, 2020



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Preface

The Global Battery Alliance (GBA), an initiative of the World Economic Forum (WEF), envisions a sustainable and circular battery value chain in 2030. A GBA report published in September 2019 identifies electric vehicle (EV) and stationary batteries as major drivers for meeting the Paris Agreement targets, with potential value creation along three dimensions: economic, social, and environmental. To achieve these targets and value, the report highlights the need for a global solution to provide transparency, accountability, and circularity in the battery value chain: the Battery Passport.

This discussion paper shows that there is an urgent need to act now. In 2020, the GBA and its members plan to begin the implementation of the Battery Passport in three phases.

The objective is to demonstrate responsibility and sustainability along the battery value chain in line with the United Nations' Sustainable Development Goals – signaling to the market and regulators whether a given battery supports sustainability criteria or not. In the future, a global "quality seal" (a label similar to the energy efficiency ratings of white appliances or certification by the Responsible Jewellery Council) will be explored to foster a market mechanism that embeds sustainability and responsibility into the battery value chain. For example, it can be used to certify compliance with CO2 emission laws or the protection of human rights. The goal of this label is to transform the market for batteries towards sustainable outcomes by 2030.

At the 2020 WEF Annual Meeting in Davos, the GBA asks interested participants to support the initiative and sign up their organizations to contribute to further realizing the Battery Passport concept.

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Introduction

The GBA supports the creation of a global solution for transparency, accountability, and circularity of EV batteries.

A sustainable and circular battery value chain is a major driver for meeting the targets outlined in the Paris Agreement. The GBA 2030 Vision report describes such a battery value chain. The report highlights that a transition to a sustainable state across the value chain could unlock significant battery value via total lifecycle cost reductions (by 23%) and CO2 abatement of 30% in the transport and power sectors and of 50% in the battery value chain, respectively. Moreover, $150 billion in economic value can be unlocked in 2030 by these significant battery cost reductions, resulting in increased battery demand. 10 million additional jobs could be created, and access to electricity to 600 million additional people could be provided (70% of the current electricity access gap), as illustrated in Figure 1.

Overall, the report identifies that annual revenue could rise to $450 billion within the battery value chain. Critically, these opportunities must be realized in a manner that safeguards human rights and fosters economic development in line with the United Nations' Sustainable Development Goals.

The 2030 Vision report forecasts that a 35% increase in battery demand will result from the aforementioned battery cost reduction. This potential will be realized by key levers for a circular economy, sustainable business and technology, and a responsible and just value chain. Circular economy levers require battery information in order to increase utilization – e.g., electric shared mobility, smart charging (V1G), and vehicle-to-grid (V2G) – and enable life extension or material recovery – e.g., design for repair, refurbishment and disassembly, repurposing of EV batteries after first use, and recycling. Advancing sustainable business and technology is achieved via electricity-based clean battery production leveraging renewables, for example. A responsible and just value chain will be accomplished by ensuring consistent transparency along the value chain, for instance, based on verified provenance of materials and sustainability norms and principles.[1]

Figure 1: A circular battery value chain is a major driver for meeting the Paris Agreement targets

Global Battery Alliance (GBA) report recap: A vision for a sustainable battery value chain in 2030

Establishing a circular battery value chain is a major driver for achieving the Paris Agreement

30% emission reduction in the transport and power sector

50% emission reduction in the battery value chain

Transforming the economy in the value chain creates new jobs and economic value

10 m additional jobs

150 bn in economic value generated in a responsible and just value chain

35% increase in battery demand

Safeguarding human rights and economic development is in line with the UN SDGs[1]

600 m additional people with access to electricity, reducing the gap of people without electricity by 70%

Ensuring safe working conditions, fostering anti-corruption practice and eliminating child/forced labor

Additional impact of a sustainable value chain in 2030 compared to business as usual – unattainable with business as usual!

1 Sustainable Development Goals
SOURCE: World Economic Forum, Global Battery Alliance, McKinsey analysis

1 For further details on levers, refer to Appendix 1.

Creating this significant socioenvironmental and economic potential requires businesses, governments, and civil society organizations across the value chain to make distinct decisions driven by reliable, accessible, and trusted data. An initiative called the Battery Passport can help accomplish this. The Battery Passport relies on a data set documenting battery-related information and transactions along the value chain from raw material mining until end of life to recycling and re-entering the value chain. With the legitimation of the Battery Passport, batteries and their materials can be traced back to their provenance, their greenhouse gas emission footprint can be made transparent, and their degree of sustainability and circularity can be measured. Thus, the Battery Passport provides value to players at every step in the battery value chain by addressing their specific needs.

Importantly, while the required data already exists – at least partly – it is siloed in each value chain stakeholder's individual IT systems. If this practice continues, it will be impossible to embark on the process of transitioning the value chain to a sustainable and circular state and realizing the full business potential that comes with this transformation. When this data is shared – ensuring both the privacy of stakeholders' competitive advantages and transparency for value chain collaboration – true sustainability of the value chain can be achieved.

> Battery Passport: A digital platform to exchange data among all authorized lifecycle stakeholders to support a sustainable value chain for EV and stationary batteries.

The Battery Passport is a GBA initiative to create a digital platform for sharing value chain data on batteries and their components by the respective stakeholders. This enables the participating stakeholders, including businesses, governments, and civil society entities, to collaborate better and benefit from shared data, thereby optimizing the entire value chain.

The Battery Passport's goal is to serve the specific needs of all value chain players, including battery and vehicle manufacturers, their suppliers, repurposers, and recyclers. This is achieved by:

- Exchange of data (e.g., on materials chemistry, origin, the state of health, chain of custody, carbon footprint, social impact) among all lifecycle stakeholders to support sustainable business and technology for EV batteries, including a circular economy and responsible and just value chains.
- Optimization of lifecycle management as well as support of battery life extension and end-of-life treatment. Thus, all transactions and interactions along the value chain are transparent, traceable, and verifiable.

Drawing upon our research and analysis (see Text Box 1), we address three key questions in the following:

1) Why is the Battery Passport valuable?

2) What will be the foundation of the Battery Passport?

3) How will the Battery Passport be implemented?

The focus of this discussion paper is on the Battery Passport concept as a global approach. Conditions related to organizations, politics, and geographical boundaries are not discussed here, but they will have important implications for the implementation of the Battery Passport concept and need to be addressed in the further process.

Text Box 1: Methodology

We used a quantitative and qualitative mixed-methods approach in the development of this report.

- The recommendations and insights of this document are based on the GBA 2030 Vision report titled "A Vision for a Sustainable Battery Value Chain in 2030: Unlocking the Full Potential to Power Sustainable Development and Climate Change Mitigation," published by the WEF and the GBA in September 2019.
- The analyses of the report are underpinned by an analytical fact base and a model of the battery value chain. While the analyses focus on lithium-ion batteries and their application in road transport, energy storage, and consumer electronics, the model – focusing on a 2030 time horizon – not only simulates material flows along the value chain, associated energy use, and greenhouse gas emissions, but also models value flows and associated investments. For the model assumptions, proprietary databases and models from McKinsey & Company (e.g., the Energy Insights Global Energy Perspective) and SYSTEMIQ were used, as well as stakeholder perspectives, research papers, and expert interviews.
- Economic benefits are assessed based on value creation within the value chain. Other economic benefits or costs, e.g., societal benefits on the health system from reductions in local air pollution, were not part of the quantitative analysis.
- The risk assessment along social dimensions (e.g., working conditions, child labor) as well as along other environmental dimensions (e.g., water and air pollution) were not quantitatively analyzed, but their impacts are characterized based on interviews and literature research.

For further details on the GBA's vision and principles, refer to the "GBA 2030 Vision Principles" section in Appendix 1.

Why?
Value Proposition of the Battery Passport

1

The battery value chain is still evolving and needs clear guidance in order to avoid unfair business practices, corruption, and the exploitation of resources and people. A successfully implemented Battery Passport initiative will serve as an instrument to steer the evolution of the value chain.

Overarching Value Proposition

Most of today's established systems are completely centralized and only available to the parties that own them. A decentralized digital platform can connect the centralized systems to let value chain participants benefit from the Battery Passport's value proposition. By connecting a battery to a decentralized computing system and capturing data throughout the value chain, it becomes possible to understand what the battery has experienced throughout its lifetime.

The Battery Passport is specifically designed to fulfill these needs (see Figure 2). Its aim is to enable secure data exchange among stakeholders in the value chain while establishing the necessary transparency for public and private entities: providing data transparency, traceability, verifiability for key transactions, and interaction along the value chain. Equipped with the Battery Passport as a digital platform, players along the battery value chain will have confidence in their investments, the security of their transactions and interactions can be ensured, and accountability data can be measured on economic, social, and environmental levels. Hence, the Battery Passport is a crucial enabler for releasing the full potential within the battery value chain.

The Battery Passport provides distinct value to stakeholders in the value chain. In addition to its positive environmental impact, it can drive transparency and accountability regarding the provenance of materials and encourage market forces to address violations of human rights and corruption in the sourcing of materials. Also, it facilitates the disclose of emission footprints and environmental impact across the entire battery value chain, allowing relevant stakeholders to market sustainably produced or used batteries to customers. With all battery life data available, a battery can be (re-)used more efficiently, extending its lifetime and increasing its residual value. This can also enable battery cost reduction, as making essential information available can facilitate

Figure 2: : Overview of the Battery Passport's key characteristics and overarching value proposition

Overarching value proposition of the Battery Passport

The Battery Passport combines 3 main characteristics and provides an overarching value proposition

Characteristics

Data transparency
Providing next-level data transparency and business confidence for all interactions along the value chain

Data verifiability
Verifying authenticity of information and securing transactions along the battery value chain

Data traceability
Measuring and tracking data concerning economic, social, and environmental dimensions

Value proposition

Provenance of materials
Verification of material provenance

Social impact
Proof of compliance with human rights and anti-corruption policies

Emission footprint disclosure
Disclosure of GHG footprint and general environmental impact

Measurable sustainability
Proof of general compliance with sustainability requirements

Circularity
Extension of battery life together with an increase in residual value and reduction in cost

Basis for a global battery label ("quality seal") – demonstrating sustainability and responsibility norms and principles along the value chain

improvements in processes related to fast charging, V2G solutions, secondary use, and increased value of materials from recycling. Furthermore, risk for manufacturers is reduced as data transparency decreases the risk of original owner liability after repurposing. Transboundary flows of EV batteries, which are subject to varying regulations from country to country, can also be streamlined by data available via the Battery Passport.

Specific Benefits Along the Value Chain

To achieve its positive impact as described above, the Battery Passport will be intentionally designed in a way that offers a distinct benefit to each stakeholder along the value chain via the data transparency provided. All downstream stakeholders, including battery and automotive original equipment manufacturers (OEMs), receive verified information on the provenance of raw materials and proof of compliance with human rights and anti-corruption policies and environmental impact to enable sound procurement decisions. Additionally, the Battery Passport allows governments and the public to independently scrutinize such information. Manufacturers can realize higher residual values via increased utilization of batteries and extend the life of batteries for EV purposes with reliable Battery Passport data. Furthermore, enhanced second-life opportunities enable improved recycling business cases.

However, making data available to everyone in the value chain at all times can be perceived by some players as unnecessarily sharing intellectual property. Accordingly, it is critical to define which limited data must always be available, which data can be made available to some players at specific times in a secure way, which data can be made available only if needed, and which data will not be made available at all.

The key economic benefits to specific value chain stakeholders from mining to OEMs, recovery to recycling providers, as well as external stakeholders beyond the value chain are outlined in Figure 3 on page 14. In interviews, recycling providers with information such as battery chemistry and disassembly at hand have forecast a 25% cost reduction in recycling, and battery second-use repurposers have used battery health data to forecast a 75% reduction in the cost of repurposing.

In addition to these economic benefits, the Battery Passport as a key enabler of a sustainable and circular battery value chain also provides social benefits (e.g., creation of additional jobs, safeguarding of human rights through traceability) and environmental benefits (e.g., certification of sustainable battery production, reduction of carbon emissions through more effective battery usage) for the involved stakeholders.

With the first generation of EVs coming to its end of life in 2019 and the explosive growth in EV production and sales, policy makers across the globe (e.g., in China and the EU) are developing rules and regulations that will govern the management and ultimate disposal of EV batteries. In New Zealand, a group of automotive manufacturers has formed the Battery Industry Group to support a regulated producer-responsibility program in the future.

Similarly, there are private efforts in segments of the battery value chain that can be leveraged. The objective of the Responsible Minerals Initiative (RMI) is to advance consensus on data, interoperability, and governance regarding the application of blockchain-enabled solutions in mineral supply chains. Moreover, individual companies have or are developing internal traceability systems.

The Battery Passport as a Blueprint

The Battery Passport can be a blueprint for clear rules for data handling (e.g., access, protection), balancing transparency with data confidentiality. The GBA has the opportunity to lead the design of a globally harmonized set of rules and mechanisms that are interoperable with public and private systems. Failure to act now risks the reality of disparate systems that fail to enable the necessary data exchange or mandated but unprotected systems that impede business investments.

Ultimately, establishing the Battery Passport as an effective, secure, and trusted mechanism for sharing data not only provides the necessary information for shifting to a more sustainable battery value chain but may also help create accountability and certification procedures . This could ensure adherence to applicable principles and standards for responsibility and sustainability along the battery value chain and provide the basis for a global “quality seal,” signaling to the market and regulators which batteries support sustainability criteria and which do not. The Battery Passport can thus be used to certify compliance with CO2 emission laws or the protection of human rights. Most importantly, the data in the Passport will clearly position a sustainable battery as a different and more valuable product in the market. Lastly, it will enable the market to assign different values to batteries based on their sourcing impact and performance.[2]

2 For further details, refer to Appendix 2.

Figure 3: Overview of the Battery Passport's specific benefits for stakeholders

Examples of benefits for stakeholders along the battery value chain

External stakeholders

All value chain stakeholders

- Facilitation of design for disassembly, refurbishment, and repair
- Verification of compliance with human rights and anti-corruption policies

Cell/pack production

- Acceleration of technology innovations
- Justification of adherence to sustainability requirements – e.g., GHG footprint

Mining, refining, processing

- Verification of material provenance
- Adherence to social and sustainability requirements – human rights and anti-corruption policies, environmental impact

Electric vehicle (EV) OEMs

- Increased residual value to monetize used batteries
- Risk reduction regarding liability and extended producer responsibilities
- Facilitation of extended functionalities – e.g., smart charging (V1G) and vehicle-to-grid (V2G)
- Expansion into new business areas – e.g., mobility services

Refurbishing, repurposing, recycling

- Scalability of business with proven static and dynamic data
  - 2nd use (refurbishing, repurposing) – safe and optimized
  - Increase in value of recycling due to improving quality of secondary materials and reduced cost of recycling

Key value chain stakeholders

Consumers

- Transparency on provenance, GHG emission footprint, and battery usage profiles
- Lower retail cost of batteries

Investors

- Provision of a basis for investments into business models along a circular and sustainable value chain

Governmental institutions

- Provision of information for law, regulation, and tax-related decisions
- Streamlining of transboundary transactions for facilitating a circular economy

What?
Key Factors to Be Considered in the Design of the Battery Passport 2

This section discusses key factors that are foundational to the design of the Battery Passport as well as other factors that could be considered but are not essential. An overview of the key foundational factors is provided in Figure 4.

Digital Platform with Proper Infrastructure

Key to an effective Battery Passport is the development and architecture of the supporting information system. A joint, decentralized platform is required that ensures data security, quality, and transparency without interfering with proprietary data; it also needs convenient interfaces to various applications and phases (e.g., partner enterprise resource planning [ERP] systems) in the value chain.

The Battery Passport, as a digital identity, could offer dynamic storage, processing, and provision of data via adaptable user interfaces. The interface to the system can be as simple as a mobile phone or an application programming interface (API), making it readily accessible.

The infrastructure of the Battery Passport consists of several entities, databases, and data processing units. In the back end, a blockchain or other technically feasible infrastructure could be implemented to serve as a distributed ledger, facilitating and validating all transactions or data exchanges that occur between stakeholders. This distributed ledger would contain the relevant data. Data analyses and use would be possible through AI or linked data and semantics.[3]

Figure 4: Consideration of key factors in the Battery Passport's design

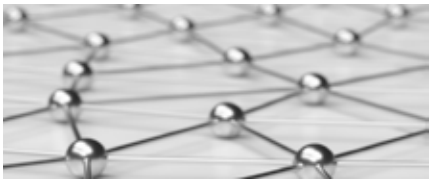
Key foundations of the Battery Passport

Digital platform with proper infrastructure specifications

- Decentralized platform with easy data access
- Interfaces with various applications (e.g., partner ERP systems)
- Dynamic storage, processing, and provision of data via adaptable user interfaces

Governance for maximum data security

- Requirement of a governing entity ensuring transparency, security, and quality while protecting proprietary data
- Data anonymization and decisions on recorded data points
- Data access according to permission rules
- Data protection through encryption, hardening of systems, decentralization, and blockchain



Interoperability and common standards for integration

- Cross-platform data sharing for enhanced collaboration
- Common standards for seamless integration into system landscape
- Consideration of compatibility of existing initiatives, e.g., the Mining and Metals Blockchain Initiative, Responsible Minerals Initiative

3 For further details, refer to the "Platform and Infrastructure" section in Appendix 3.

Governance for Maximum Data Security

Data security is a crucial aspect, as data sets may be sensitive and not appropriate for sharing with entities outside a defined frame within the Battery Passport ecosystem. Thus, a governing entity is needed to ensure transparency, security, and quality without compromising proprietary data. For example, this could be done through:

- Data anonymization and impact-based decisions on recorded data points to limit recorded data
- Data access according to established permission rules regarding who can access which data sets
- Protection of data through encryption techniques, hardening (securing by streamlining) of systems, and decentralization (e.g., blockchain)
- Greater consistency in data structures and in the application of standards
- Certification of involved parties with a "quality seal"

Data privacy guidelines can be adopted from the European Union's General Data Protection Regulation (GDPR) and relevant international privacy standards. GDPR closely monitors the controller, owner, and processor of the data. Herewith, it can be determined which data should be available and shareable on the platform and which data needs to be hidden and stored on private servers.

Regarding sensitive dynamic data, alternative data points need to be defined to provide highly relevant information while protecting intellectual property. For example, battery lifetime data collected by an OEM could be provided to the system only in aggregated form (e.g., total number of charges performed) or as extremal values (e.g., battery use in extreme weather conditions).

Details on standards to ensure interoperability are explained in the following section.[4]

Interoperability and Common Standards for Integration

Ease of deployment and system interoperability through a standardized API and data protocol are essential when scaling technological solutions and, for example, establishing a blockchain for Battery Passport stakeholders. They enable smooth cross-platform data sharing as well as automation (e.g., through easier execution of [smart] contracts) and, thus, enhance collaboration.

To ensure the above, common standards for seamless integration of the Battery Passport into the value chain participants' systems are required. The GBA could follow a data standard for a common ontology across data systems (e.g., World Wide Web Consortium Web Ontology Language), use guidelines for blockchain or other solutions (e.g., as developed by GS1), and generalize the data collection process (e.g., using product information management, which is an extension of the GS1 standard).

Apart from value chain participants' systems that could be integrated into the Battery Passport platform to enhance interoperability, existing complementary initiatives, e.g., the Mining and Metals Blockchain Initiative, are also to be considered to ensure compatibility.[5]

4 For further details, refer to the "Governance" section in Appendix 3.
5 For further details, refer to the "Interoperability and Standards" section in Appendix 3.

How?
Commitment and Road Map for the Battery Passport

3

The GBA – as an alliance of public and private members working with all stakeholders – has the opportunity to take the lead and shape the regulatory landscape, but the time to act is now. The GBA plans to establish a work group of companies, governments, and NGOs across the value chain and geographies to determine the scope and scale of the Battery Passport. Critical for the success of the Battery Passport will be the sufficient support and engagement of leading battery and automotive manufacturers in this work group from the very beginning. Initially and immediately, the work group would define the set of data for the proof-of-concept phase (Battery Passport 1.0) – this will primarily focus on "static data" such as provenance of battery materials, battery chemistry, and identity, but may also include a limited set of battery health data (charge, damage). Subsequently, the work group would determine the scope of "dynamic" data for the full implementation of the Battery Passport (Battery Passport 2.0) – battery performance data that can enable the full realization of battery life extension while protecting confidential and business information. **CEO commitment from key players is needed for the GBA to take the lead in shaping the battery value chain towards sustainability and circularity.**

See figure 5a/5b.

Figure 5a: The Battery Passport's potential can be unlocked by moving along three phases

Implementation phases

Phased buildout of the Battery Passport in consultation with stakeholders across the value chain ensures full protection and realization of benefits

Battery Passport concept
Groundwork

- Evaluation: static[1] and dynamic[2] data sets, data implementation in Battery Passport 1.0 and 2.0
- Establishment: Battery Passport platform to show compliance with GBA principles and implementing commitments (standards)

Battery Passport 1.0
MVP

- Focus on static data[1,2] e.g.
- Provenance of materials
- Static battery information
- GHG disclosure
- Potential inclusion of limited dynamic data[1,3]

Battery Passport 2.0
Broader ecosystem roll out

- Extension of participant group
- Extension of technical and organizational solutions across the battery value chain
- Focus on limited relevant dynamic data[1,3]
- Battery aging
- Life-cycle emissions
- Etc.

1 No confidential business information
2 Data that is constant after being recorded
3 Data that changes after being recorded

Figure 5b: The Battery Passport's potential can be unlocked by moving along three phases

Proposed timeline

2020
- Battery Passport concept established
- Principles and standards established across the battery value chain
- Critical data set for Battery Passport 1.0 defined

2021
- Battery Passport 1.0 established

2022
- Battery Passport 2.0 established for relevant data
- Battery "quality seal" established

A three-phase approach, as illustrated in Figure 5, is suitable for gaining experience and achieving tangible results quickly. Crucial questions are answered within a core team to accomplish a proof-of-concept with limited investment.

Key milestones include:

Phase 1 – 2020

- **Battery Passport 0.0 stakeholder group is formed**
- **Battery Passport 0.0 is established** as a mechanism for disclosing adherence to GBA principles and implementing standards across the battery value chain
- **Battery "quality seal" work group is established** to explore a certification framework
- **Battery Passport 1.0 stakeholder group is convened** to establish a proof-of-concept model focusing on static data (chemistry, chain of custody)

Phase 2 – 2021

- **Battery Passport 1.0 is established** with a focus on static data
- **Battery Passport 2.0 stakeholder group** establishes rules focusing on dynamic lifecycle data (e.g., battery performance data)

Phase 3 – 2022

- **Battery Passport 2.0 is established** with a focus on dynamic data
- **Battery "quality seal" is launched**

This approach will enable the Battery Passport to be brought to life within a short period of time. With the commitment of GBA members and further participants, and if first steps are taken immediately, the rollout can start as early as 2021.

Outlook

A more complete Battery Passport concept will be further detailed after the work group begins to shape the first phases in 2020. The Battery Passport is a global approach and its actual design will be subject to conditions in several areas, including political, geographical, organizational, and even regulatory – all of which need to be considered to implement the Battery Passport successfully.

Initial steps towards establishing a global Battery Passport solution have already been taken. Involving their organizations now allows value chain members of all types – from raw material mining to OEMs to recyclers – to contribute to the overall value proposition and generate their specific value from the Battery Passport.

Appendix 1: Deep Dive into the Background and Impact of the Battery Passport

This appendix provides further insight into the GBA 2030 Vision principles, the levers and impact of the Battery Passport, and the role of the Battery Passport in realizing the battery value chain target state.

GBA 2030 Vision Principles

1. **Establish a circular battery value chain as a major driver for achieving the Paris Agreement by:**
   - Maximizing the productivity of batteries in their first life
   - Enabling a productive and safe second life
   - Ensuring the circular recovery of battery materials
2. **Establish a low-carbon economy in the value chain and create new jobs and additional economic value by:**
   - Disclosing and progressively decreasing greenhouse gas emissions
   - Prioritizing energy efficiency measures and substantially increasing the use of renewable energy as a source of power and heat when available
   - Fostering battery-enabled renewable energy integration and access with a focus on developing countries
   - Supporting high-quality job creation and skills development
3. **Safeguard human rights and economic development consistent with the United Nations' Sustainable Development Goals by:**
   - Immediately and urgently eliminating child and forced labor, strengthening communities, and respecting the human rights of those employed along the value chain
   - Fostering protection of public health and the environment, minimizing and remediating the impact of pollution in the value chain
   - Supporting responsible trade and anti-corruption practices, local value creation, and economic diversification

See figure 6 on page 20.

Role of the Battery Passport in Realizing the Battery Value Chain Target State

The role of the Battery Passport in realizing this vision is at least fourfold:

1. The Battery Passport could help build the necessary market confidence to attract the $550 billion in investments across the value chain that are needed for the value chain to expand 19-fold and unlock the benefits outlined in Figure 1.
2. It would contribute significantly to the United Nations' Sustainable Development Goals by supporting the responsible sourcing of raw materials from low- and middle-income countries, increasing access to electricity, and providing transparency on how local communities have been affected by and benefitted from the value chain.
3. It would enable additional battery cost reductions of approximately 23% (compared to not having the Battery Passport in 2030) via circular economy levers (e.g., battery life extension, more productive battery use), thereby boosting battery demand and enabling the required value chain expansion for the 2030 Vision.
4. These cost reductions would create annual economic value of ~$150 billion in 2030.

Figure 6: A variety of levers address challenges and support achievement of the target state

To scale up the battery value chain sustainably, actions need to be taken now: 10 concrete recommendations have been derived

	Key recommendations	Description
Circular value chain and connected business cases	1 **Life extension and end-of-life treatment**	Regulators, battery manufacturers, and automotive OEMs to commit to common standards and targets, enabling scalable systems and improved product design for end-of-life treatment
	2 **Smart charging and V2G**	Regulators, utilities, battery manufacturers, and vehicle manufacturers to foster smart charging and V2G solutions by ensuring technical readiness of the grid and vehicles and incentivizing deployment
	3 **Electric shared and pooled mobility**	Automotive OEMs to foster the development of purpose-built vehicles to improve cost competitiveness of xEVs; regulators to provide regulatory framework for electric autonomous driving
Sustainable economy and technology	4 **Renewable energies in the value chain**	Companies in the value chain to focus on deployment of renewable energy and switching from fossil fuel – based to electricity-based processes
	5 **Charging infrastructure**	Regulators and network operators to increase efforts to enable deployment of large-scale charging infrastructure, allowing for smart charging and vehicle-to-grid services
	6 **Batteries in the grid**	Regulators to revise the regulatory framework for battery-enabled renewables in conjunction with smart charging and other strategies to address intermittency
	7 **Financing and local value creation**	Investors (private, semi-public, and public) to establish instruments like “green bonds” and “blended financing” models; comprehensive local development strategies should be advanced
Responsible and just value chain	8 **Established sustainability criteria**	All players to commit to established international expectations/KPIs on social and environmental practices, ensuring objective impact measurement (e.g., Battery Passport)
	9 **GHG disclosure and emission regulations**	Regulators to consider the environmental impact along the full value chain, including applications (Scope 3); private-sector companies to agree on GHG disclosure based on life-cycle considerations
	10 **Access to electricity**	All players to support deployment of battery applications in mini-grid and off-grid solutions in areas so far lacking access to electricity

Appendix 2: Deep Dive into the Economic, Social, and Environmental Values Introduced in Chapter 1

This section provides further details on the overarching value proposition of the Battery Passport by the categories introduced in Figure 2.

Provenance of Materials and the Sustainable Development Impact of Batteries

Currently, the EV battery market has inadequate and unreliable information for confirming that critical metals and minerals have been sourced for battery production without violating human rights or subverting anti-corruption laws. The Battery Passport can enable the transmission of information and data to downstream stakeholders to facilitate higher-confidence selection of sourcing.

A reliable record of provenance is necessary to understand any risks in a battery's supply chain and to take action to address these issues according to key guidelines, such as the OECD Due Diligence for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas and the United Nations Guiding Principles on Business and Human Rights . Even large international investors, such as PMI Investment Group , and key metal exchanges, such as the London Metal Exchange, are establishing standards and goals for their investments and members according to these guidelines. These guidelines clearly outline that a company should understand its supply chain and avoid "cut and run" behavior from risks in its supply chain that it may have contributed to indirectly or directly.

Currently, the technologies that are being applied to establish the tracking of minerals use a combination of tools and functionalities. Depending on the sophistication of the supply chain, technologies may be using offline platforms to establish tracking at the source where internet connectivity is not available, or could be pulling official certificates and invoices from more established mining and trading bodies. Pilots are being conducted to also use cross-sections of data from mobile money technologies to establish the first digital representations of transactions from artisanal miners, and key encryption to protect the trading relationships that are considered intellectual property in the mineral commodity sector.

Once a company has gone through the process of understanding its supply chain and addressing potential risks, then it can begin the process of regularly reviewing the supply chain to confirm that the critical metals and minerals used in battery production have been sourced with clear risk mitigation of human rights violations or environmental damage. The key is to be able to demonstrate a clear understanding of the supply chain and clear follow-up and systems to consistently address the challenges of the supply chain.

The Battery Passport can enable the transmission of information and data to downstream stakeholders to facilitate higher-confidence selection of sourcing, as well as actually support the mitigation of risks in the supply chain. There are several technologies that support and enable tracking of different types of mined mineral supply chains. Technologies also use the information in the Battery Passport, including tracking, to drive impact for workers and the environment.

As these companies develop their services, many are exploring common reporting terminology and coding to ensure interoperability in the future. They are meeting with organizations within the WEF, OECD, and RMI.

There are existing efforts to establish digital systems for provenance information. Key immediate steps could include:

- Harmonization of existing provenance traceability efforts
- Verification of provenance information for the Battery Passport 1.0 and 2.0

Emission Footprint Disclosure

The Battery Passport would serve as a mechanism for disclosing verified greenhouse gas emissions based on widely accepted accountability mechanisms. Initially, this would enable disclosure of the direct emissions of stakeholders in the value chain. Ultimately, this would provide full access to information related to greenhouse gas emissions throughout the lifecycle of batteries. A parallel effort would include improving the reliability and accuracy of accounting for greenhouse gas emissions and accounting's role in greenhouse gas credit systems.

Cost and Risk Reduction

Cost Reduction

Reducing the cost of batteries via circular levers is the key to sustainably realizing economic value of ~$150 billion per year in 2030. Major drivers for achieving this cost reduction are:

- Optimizing first use in vehicles with refurbishment, electric shared mobility, V1G, and V2G (returning excess electricity to the grid)
- Extending battery value to secondary use for energy storage through repurposing
- Recycling responsibly, including end-of-life recycling

Liability Risk Reduction for Manufacturers

Some EV producers have fully recognized and embraced the value of secondary use of their batteries by developing in-house repurposing activities or outsourcing to a trusted partner. Others have concerns that if one of their batteries is transformed for a use other than initially intended, and that battery is involved in an incident such as a thermal runaway, they could be held liable as the original owner.

By enabling data exchange among stakeholders in the value chain, the repurposers can take formal ownership of the battery they receive for repurposing and associate a new digital identity for the battery in its second life. This formalizes the repurposer as the manufacturer of the "new" energy storage battery and, as such, as responsible for the second lifecycle.

Compliance with Sustainability Requirements and Extended Producer Responsibility Laws

Compliance with Sustainability Requirements

Currently, transboundary transactions of batteries for reuse, repurposing, and recycling are caught up in significant uncertainty due to transboundary regulatory treatment of such transactions. The challenge for trade officers and the transboundary regulations is distinguishing such circular activities from waste management. A digital system that enables access to information and data to demonstrate the legitimacy of transactions can significantly reduce these uncertainties/barriers, in conjunction with regulatory harmonization.

An initial function of the Battery Passport would be as an accountability/certification mechanism, showing adherence to applicable principles and standards of responsibility and sustainability for all participants in the battery value chain.

This will build on the principles adopted by the GBA and its members (see Appendix 1), developing and advancing them into implementation commitments based on existing standards across the battery value chain. The vision for the Battery Passport is a structure for establishing initial accountability for GBA principles and commitments:

1. Each member/endorsing organization would publicly disclose their pledge and implementation plan.
2. Each member would annually disclose how their pledge has been implemented – specific to each principle and pertinent commitment.
3. The Battery Passport would be the basis of a GBA report titled "State of Compliance with GBA Principles and Commitments" that compiles implementation information on all members, lists all suppliers identified as best-practice performers, and summarizes trends. In later years, this would be enhanced to potentially include: 1) standardized reporting, 2) independent verification, and 3) a publicly recognized label that recognizes all members that establish full compliance with the GBA principles and commitments.

Producer Responsibility Conformance

As governments grapple with the growing challenges of managing waste and creating sustainable communities, extended producer responsibility (EPR) laws, requiring manufacturers to take responsibility for recycling their products, are on the rise and have taken several forms across the globe.

All EPR systems involve transactions between parties, whether it is the manufacturer transacting directly with a consumer or with contracted collectors and recyclers. Some of these systems have become riddled with fraud, with instances such as "paper weight," or falsified recycling records created to garner payment when no recycling has occurred. Perhaps an even bigger challenge and risk for manufacturers is having their well-intentioned recycling efforts go awry when a primary recycler ships material to a downstream processor that doesn't meet the requirements of the EPR system (e.g., shipments of hazardous scrap/components from OECD to non-OECD countries in violation of the Basel Convention).

The Battery Passport can support validation of both financial and material transactions by ensuring that only authorized parties are engaging the battery and that all contract requirements are being met.

Regulatory Pressure

Global EV battery regulation is increasing. In China, manufacturers are already subject to regulations requiring tracking and full disclosure of EV battery data from production to final recovery. The EU is currently revising its Battery Directive to support lifecycle management and plans to announce a package of laws on sustainable batteries that is expected to include requirements for batteries placed on the EU market to provide an "electronic product passport" on their provenance, circularity, and CO2 footprint. The Battery Industry Group in New Zealand is designing a system to support what will become a regulated producer responsibility program. Beyond regulations, pressure is fast mounting from the general public to ensure batteries comply with international human rights and environmental standards – the Battery Passport will demonstrate effective and transparent adherence to those principles.

Similarly, there are private efforts in segments of the battery value chain that could be leveraged. The RMI aims to advance consensus on data, interoperability, and governance regarding the application of blockchain-enabled solutions in mineral supply chains to gain transparency on the provenance of minerals or metals transactions. The WEF's Mining and Metals Blockchain Initiative is intended to be a neutral enabler for the industry to address the fractured development of blockchain that lacks standardization transparency and efficiency, and subsequently improve the reporting of carbon emissions. Moreover, individual companies have or are developing internal traceability systems.

Appendix 3: Deep Dive into the Foundational Elements Introduced in Chapter 2

In the following, we discuss the most important foundational elements for the Battery Passport's implementation along four dimensions: platform and infrastructure, governance, data protection, and interoperability and standards.

Platform and Infrastructure

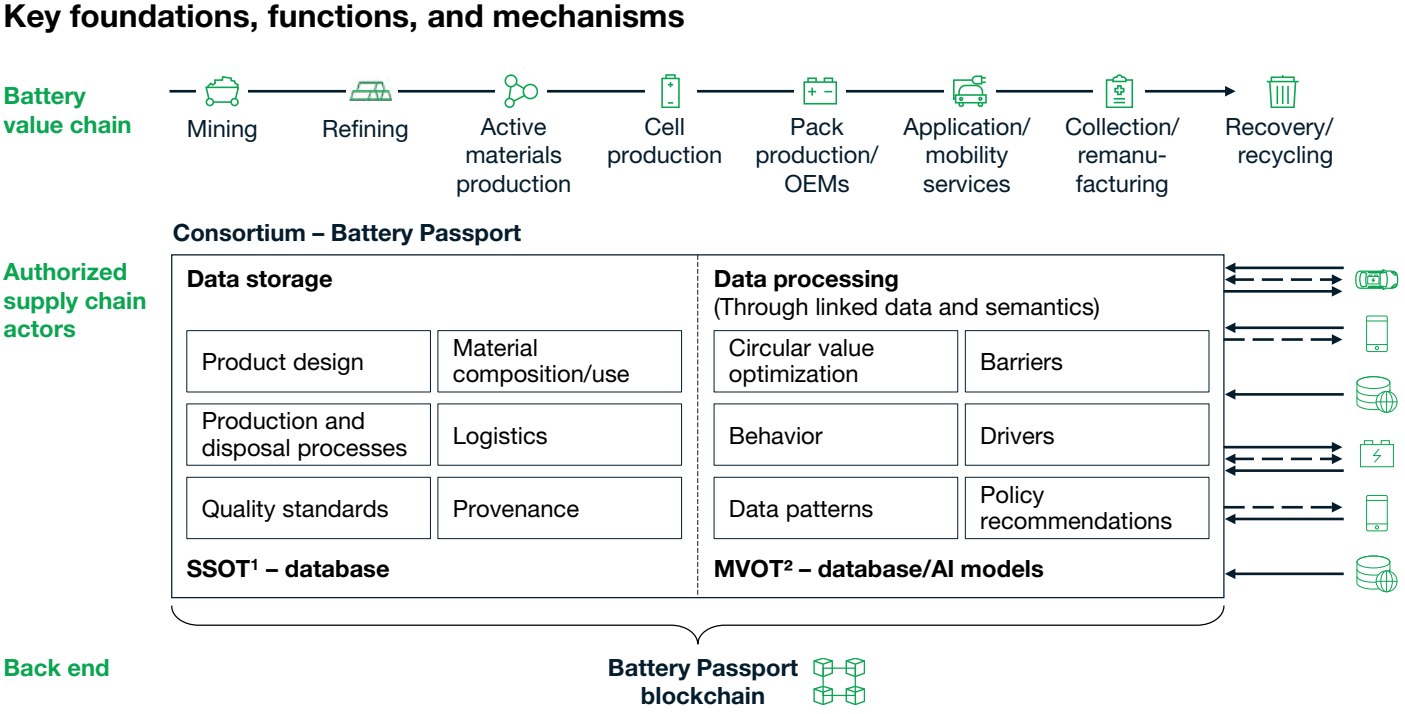
Decentralized Platform Infrastructure

Key to an effective Battery Passport is the development and architecture of a supporting information system. The infrastructure of the Battery Passport, which contains the relevant data itself, could consist of several entities, databases, and data processing units, as shown in Figure 7. On the back end, a decentralized infrastructure could be implemented, facilitating all transactions or data exchanges that occur between stakeholders. For example, a blockchain might be able to digitally represent the Battery Passport, and all data or metadata could be provided or consumed via one of the nodes distributed throughout the network. Nodes would be established for authorized value chain actors, so that all data provided to or consumed from the ecosystem would be fundamentally authorized. Data analyses and use would be possible through AI or linked data and semantics.

Interfaces to Various Applications

The design should also consider ease of integration into the current IT blueprints of companies and other private and public institutions and allow for coverage of other reporting requirements. The platform infrastructure needs to have APIs with all major partner systems. Integration of the information into commodity markets is equally important to clarify, as technical questions regarding the assessment of changing material quality and the role of recyclates in the batteries will certainly arise.

Figure 7: Overview of possible Battery Passport infrastructure (not exhaustive)



1 Single source of truth
2 Multiple versions of truth

Dynamic Storage, Processing, and Provision of Data

The Battery Passport, as a digital identity, can dynamically "store" all the above data and make select data available to authorized stakeholders who have password access to the system. The user interface can be as simple as a mobile phone or an API with the system, making it readily accessible. An ideal system would be flexible and allow for the flow of large volumes of data along the value chain from raw materials, to manufacturers, OEMs, customers, and recyclers/refurbishers.

Potential Implementation Technology: Blockchain

The provenance of materials and products becomes increasingly unclear with the vast and growing number of actors in the supply chain. Therefore, a potential implementation scenario for the Battery Passport could include innovative technologies – like RFID, QR codes, and blockchain – that enable transparency and traceability over the supply chain. For example, blockchain functions as a shared and trusted ledger to immutably log the provenance of materials, the whereabouts of products, and all transactions over the supply chain. The blockchain provides a means to allow every actor in the supply chain network to maintain and review immutable records, source raw materials and components, manufacture means of telemetry for transportation, keep track of events that impact the battery such as repairs and accidents, and support end-of-life recovery.

The Battery Passport will reveal data points previously lost or hidden from the different actors in the supply chain. An abundance of rich data will lead to the creation of sound business cases. Actors at various stages in the supply chain can evaluate the best circular strategy to apply based on data, creating economic and environmental benefits.

Governance

Governing Entity

Our purpose is to enable greater trust and transparency in the exchange of material in the battery supply chain, and we expect that our focus on data quality will drive value for the industry – especially for those parties seeking to provide a higher standard for extending the life of batteries, leading towards a circular battery value chain. Foundational governance and control structures must:

- Ensure greater consistency in data structures and in the application of standards to enable faster, more seamless, and more trustworthy exchanges between parties.
- Enable parties who have invested in the quality and integrity of their supply chains to produce evidence of those efforts (for example, making sustainable sourcing claims).
- Reduce the need for later amendments to data (as original data should not be erased).
- Support the delivery of specific data structures to demonstrate end-to-end provenance for multiple parties and customers across the value chain.
- Meet or exceed the expectations of end consumers, who may not understand all the nuances of data in the industry but who are expecting levels of data credibility from the Battery Passport solution.

Data Anonymization and Impact: Decision on Recorded Data Points

The GBA interviewed multiple repurposers and recyclers during the second and third quarters of 2019 to better understand the challenges and opportunities within these sectors. That information, coupled with a December 2019 survey of repurposers and recyclers active in NAATBatt International (originally the National Alliance for Advanced Transportation Batteries), identified the following data points (including potential alternative representation to protect intellectual property):

- Vehicle identification number (or an alternate association of a vehicle with its battery)
- Material safety data sheet
- Battery bill of materials
- Battery configuration
- Manufacture dates (battery, modules, cells)
- Chemistry
- New battery (initial) voltage
- State of health
- State of charge
- Key disassembly (and safety) instructions and tools
- Identification of parts for return to vehicle OEM or designated parties
- Transportation requirements (regulatory, e.g., packing, placarding)
- Any designated repurposers and/or recyclers

Data Access

Making data available to everyone in the value chain at all times can be perceived by some players as unnecessarily sharing intellectual property. As such, defining which data must always be available, which data can be unlocked for certain players at specific times, and which data can be made available only if certain conditions are met, is crucial.

Also essential is a platform that ensures data security, quality, and transparency without interfering with proprietary data. Digital rights management ensures that access to information is granted only for the specific information needed by a specific party. For example, a provider of second-life storage applications would need to know about age, remaining capacity, and number of cycles. A recycler would instead need information on a battery's raw materials, cathode and electrolyte chemistry, and cell design. Having this information can unlock cost advantages in transport (e.g., for hazard-level transportation) or for recycling (improved efficiency). The data is especially useful for streamlining increases in battery lifetime and facilitating recertification for second life as well as ownership changes. Furthermore, this system gives players along the value chain the opportunity to future-proof their businesses and signal to customers that their product is sustainable.

Protection of Data

As the data protection is a large topic, we provide only a high-level breakdown of some different ways to protect data, separated by topic:

- Data classification and treatment (in line with GDPR policies)
  - Sensitive versus non-sensitive data
  - Storage approaches, backup policies, isolation techniques, and deletion frequency
  - Access controls based on risk assessment (personnel, scope, role)
  - Anonymization/pseudonymization of data using zero-knowledge proof protocols
- Technology
  - Use of decentralized systems: the control is not with one individual person but across the members in the consortium
  - Blockchain architecture: with linked lists of records and blocks in the blockchain, data is immutable and traceable
- Encryption techniques
  - Data at rest
  - Data in transit
- Hardening of systems (servers and data lakes)
  - Using anti-malware
  - Anti-spoofing techniques

Interoperability and Standards

Cross-Platform Data Sharing

To realize and sustain the Battery Passport at scale, complex business-process data needs to be harmonized and made easily and securely accessible. ERP components like complex manufacturing, inventory and material requirements management, environment, health, and safety, etc. integrate seamlessly with digital supply chain solutions like SAP's Logistics Business Network, Asset Management, and Integrated Business Planning to manage the end-to-end value chain of batteries. They also ensure keep the necessary data, like material and component traceability data, static and dynamic battery data, emission data, or health and safety data, ready for the Battery Passport.

Several companies in the battery value chain are already implementing a significant number of these solutions. This makes it easier for them to extract and reference or share data. However, it should be noted that it is still possible to provide data for the passport without having these solutions installed at the beginning for the pilot.

Common Standards

The growth of digital platforms has resulted in a disparity in how data is gathered, stored, and exchanged across systems, especially in the supply chain and finance sectors. We observe similar challenges with the introduction of multiple blockchain solutions, each having their own way of gathering, storing, and exchanging data. This does not help with interoperability and scalability. Hence, the solutions are often suboptimal. Therefore, we are in need of a common ontology for the Battery Passport to be able to manage two challenges of the digital world: interoperability and scalability. System interoperability is essential when scaling technological solutions, as it enables smooth information sharing across platforms and blockchains and automation through easier execution of smart contracts, thereby increasing the opportunity for collaboration. In order to be able to develop such an ontology, we would follow the guidelines provided by GS1 for developing blockchain solutions. Some of the

companies, like Microsoft and IBM, adapted the GS1 standard guidelines for enterprise blockchain solutions. The Battery Passport will use the same outline, along with several others.

Some of the GS1 standards that we envision implementing in the Battery Passport in order to achieve standardization, easy sharing, and interoperability could be:

- Unique identification of batteries that are registered on the platform
- EPCIS as the standard for data format, data models, and exchange format
- Established policies regarding how the network participants will operate and share data
- Clear list of what is written on the ledger (database) and how
- Policy on access rights to the transactions (read/write/delete and public/private access)
- Information on how this data is gathered and how it can be generalized and monitored using product information management

Some of the other standards that we will develop as a part of our solution will involve the following:

- Semantics around data and relationships
- Increased adoption and interoperability by encouraging companies to adopt an "API first" approach regarding the data they gather and share with our platform
- Linked data: a data structure that interlinks data based on the parameters of a material or product
- Connected data: we will follow global standards such as using the Resource Description Framework developed by the World Wide Web Consortium to store the data and its links in a triple format (subject–predicate–object)
- A common ontology: we will be using Web Ontology Language, a semantic web standard, to:
  - Develop/identify relationships within the data of a particular battery and its properties
  - Generate/identify relationships across batteries (car battery versus a bike battery versus a laptop battery)
- Semantics: based on the linked data and ontology, we will develop a common language for the platform so that every company on the platform can communicate seamlessly. A good example of this is Core Business Vocabulary, the GS1 standard for data exchange, which is already used by businesses in the supply chain to enable standardized exchange of data and item-level tracking for products:
  - Our common vocabulary will define what the "Battery Passport" is and how all parties should refer to it, and include other nomenclature and terminology that will be developed for and used within the Battery Passport ecosystem

Once we gather data from the Battery Passport and within the platform, we will develop smart data from the linked data and ontology to achieve interoperability:

- This smart data will be used to generate recommendations using data tools and provide valuable insights into the supply chain, quality, circular options, predictive analytics, regression and correlation, forecasting, and historical insights. This will lay the foundation for achieving and accelerating the GBA's circular economy goal.

Based on the gathered data, we will develop the following:

1. Lessons learned/best practices database
2. Knowledge database (of circular solutions, value, actors, etc. across the supply chain)

- This database will eventually be updated with relationships, and the ontology design will be ready for use within the platform based on recognized data formats (we will use graph-architecture technology to achieve this in an optimal manner).
- Graph architecture helps in the following ways over traditional systems:
  - Speed of execution
  - Data traversal
  - Flexibility
  - Extension of data points and scalability

The above two solutions will help us develop what we will call "knowledge architecture" for the Battery Passport platform. Knowledge architecture is a framework that will allow us to transform raw data into actionable, meaningful knowledge (smart data). With it, we can connect all the bits and pieces of data gathered on the Battery Passport platform and through external systems and transform them into a powerful mechanism that can help make smart and effective decisions.

Institutionalizing the knowledge architecture approach for the platform will give us the possibility to look at what kind of data is being generated, captured, and exchanged on the platform, as well as how and by whom. Gathering data in this way is a huge leap towards achieving more organized interoperability within the platform. A similar approach is currently being used by some of the biggest platforms of our time, such as by Google, which uses Knowledge Graph, and by Facebook, which uses Open Graph.

Using the above approach towards creating the digital Battery Passport platform, we will achieve the following benefits:

1. Informational value (for manufacturers, customers, policy makers, etc.)
2. Analytics and historical insights (for informed, data-driven decisions)
3. Predictive analytics (for forecasting)
4. Historical data (for identifying circular solutions)
5. Battery design improvements (based on the gaps observed from the data gathered over the platform)
6. An ontology and common semantics for the Battery Passport platform

Existing Initiatives

So far, operating a supply chain at high efficiency levels has been considered a success. However, changes in market dynamics driven by sustainability demands introduce other success criteria for supply chain managers. These demands are accelerated by circular economy expectations that not only extend the supply chain, but also change traditional business models.

Existing efforts focus on merely tracking batteries. For example, China adopted a rule in 2018 requiring that EV batteries be given a unique ID to help track them during their entire lifecycle, from production and sales to use and secondary use, all the way through to recycling. EV battery manufacturers there are required to code the batteries according to the Coding Regulation for Automotive Traction Batteries, and stakeholders along the value chain will need to update and upload their battery information onto the traceability management platform. This effort has a specific focus on tracking end-of-life management and extended producer responsibility – it does not focus on the exchange of dynamic data (battery performance data) to extend the life of batteries or enable safe secondary use.

The Battery Passport handles complexity by mapping products at various levels like product group, components, and materials. Once mapped, it can aggregate as well as disaggregate products to link materials to their components or their associated assets. For example, a lithium-ion battery is an energy material built of various components, like a cathode, which in turn contains lithium. By mapping the material content of such products, economic value can be determined. However, circular value is often not merely related to the material composition, but also to the functionalities of the materials and components. Therefore, the Battery Passport addresses parameters like chemical and physical characteristics or properties. By mapping products in such detail, actors along the supply chain can create sound business cases based on economic and circular value.

Simply registering product parameters, however, will not suffice. Data needs to be updated continuously as product value fluctuates across the supply chain. Moreover, in order to reuse/refurbish/remanufacture/recycle products, those products need to be located and retrieved first.

To meet the new market reality, several digital supply chain solutions already exist that support end-to-end processes enhanced by automation and predictive capabilities. These solutions lay the processes, systems, and data foundation for a sustainable Battery Passport.

An example of an existing initiative that will be leveraged is the Mining and Metals Blockchain Initiative. This initiative will pool resources and cost, increase speed-to-market, and improve industry-wide trust that cannot be achieved by acting individually. It aims to be a neutral enabler for the industry, addressing the lack of standardization and improving efficiency. The intention is to send out a signal of inclusivity and collaboration across the industry. The initiative will look to develop joint proofs-of-concept for an inclusive blockchain platform. Over time, this could help the industry collectively increase transparency and efficiency or improve reporting of carbon emissions.

In many cases, blockchain projects to support responsible sourcing have been bilateral. The result has been a fractured system that lacks interoperability and leaves behind parts of the ecosystem. But the Mining and Metals Blockchain initiative is owned and driven by the industry, for the industry. Members will examine issues related to governance, develop case studies, and establish a work group.

Key areas of collaboration and development could include carbon emissions tracking and supply chain transparency. Members will use blockchain technology to increase trust between upstream and downstream partners, address the

lack of industry standardization, and track provenance, chain of custody, and production methods.

The role of logistics in the battery value chain is critical as it enables the actual fulfillment of stakeholder demands and the inbound and outbound flows of goods. Software such as SAP's Logistics Business Network connects business partners (shippers, consignees, carriers, freight forwarders, etc.) for intercompany logistics collaboration and real-time visibility across the complete value chain. Logistical data, including material traceability and component/subcomponent tracking and tracing required on the Battery Passport, can be shared or referenced directly from the networking software.

Batteries are considered assets, and the battery value chain is expected to generate massive amounts of data about these assets. This requires a seamless, digital representation of physical assets – a digital twin, so to speak – that allows digitization of key processes. Several asset management solutions like SAP's Asset Intelligence Network, Asset Central, and Asset Strategy and Performance Management can help asset managers connect to their assets, predict and simulate asset system behavior, share asset information, and collaborate. The necessary static and dynamic information about batteries for the Battery Passport could be shared or referenced from these asset management solutions.

Environment, health, and safety solutions help companies manage and report on compliance with environmental, health, and worker safety requirements. Applied to the battery value chain, all the necessary sustainability information required for the Battery Passport, like emissions, water, and resource consumption, could be shared or referenced using such solutions.