GLOBAL BATTERY ALLIANCE

BATTERIES POWERING SUSTAINABLE DEVELOPMENT

GBA Battery Passport

Proof of Concept Pilots

Setup. Learning. Next steps

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1. The Global Battery Alliance Battery Passport Concept

In 2019 the Global Battery Alliance (GBA) published 'A vision for a sustainable battery value chain 2030' outlining the need to rapidly scale sustainable, responsible and circular battery value chains as a major driver to meet the Paris Agreement targets. The recently published update to this report 'Battery 2030: Resilient, sustainable and circular' in collaboration with McKinsey, highlights staggering growth forecasts, projecting that the entire lithium-ion (Li-ion) battery chain, from mining through recycling, could grow by over 30 percent annually from 2022 to 2030, when it would reach a value of more than $400 billion and a market size of 4.7 TWh. To manage the environmental, social and governance impacts of the rapidly growing industry, transparency and collective multistakeholder are vitally important. With that in mind, the GBA conceptualized the Battery Passport as a framework to increase transparency across the battery value chain. The battery passport establishes a digital twin of the physical battery that conveys information about all applicable sustainability and lifecycle requirements based on a comprehensive definition of a sustainable battery. It aims to bring new levels of transparency to the global battery value chain by collecting, exchanging, collating and reporting trusted data among all lifecycle stakeholders on the material provenance, the battery's chemical make-up and manufacturing history and its sustainability performance. The GBA's Battery Passport is unique as it is a key instrument to implement a global vision of sustainable, responsible and circular battery value chains, based on data that is standardized, comparable and auditable. Its ultimate goal is to provide end-users with a quality seal based on the battery's sustainability performance, according to reporting rules agreed by stakeholders from industry, academia, non-governmental organisations and government.

To demonstrate the practical feasibility of the battery passport, the GBA mobilized members in 2022 covering the entire value chain from mine to vehicle manufacturer to jointly establish a proof of concept. In addition to reporting the technical parameters of the battery, this included the tracking and tracing of materials flows for select value chains, integrated with consistent reporting against the GBA's Greenhouse Gas rulebook to establish the battery carbon footprint and the Child Labour and Human Rights Indices.

The GBA believes that highly globalized battery value chains, demand a truly global multi-stakeholder approach to help shape the battery passport instrument collectively. To design a fully scalable and global battery passport infrastructure requires an ecosystem approach connecting and engaging businesses, IT solution providers, regulators, auditors, public, international and non-governmental organizations. The vision for this ecosystem and the roadmap to build were captured by the GBA in 2020. The launch of the world's first battery passport proof-of-concept presents an important milestone demonstrating that our vision is feasible, but it is only the beginning of the battery passport journey. This paper outlines how the pilots were configured, learnings obtained during pilot implementation and an outlook for next steps.

2. Pilot setup, disclaimers and key observations

To implement the battery passport proof-of-concept, the GBA established several working groups, including the Greenhouse Gas and Child Labour working groups to develop the battery passport rulebooks. In addition, members collaborated in the Battery ID, and Track and Trace working groups to develop criteria of how participating track and trace partners can ensure the consistent reporting and integration with material flow data along real battery value chains for select materials including lithium and cobalt. In summary, the objectives of our pilots were to:

- Check applicability of developed content rulebooks (GHG and HR&CL) and investigate resource intensiveness of reporting process in order to decrease it in future.
- Validate the idea of automatic aggregation of ESG data with material flows data from track & trace partners, demonstrate a possibility of end-to-end (mine-OEM) reporting based on realistic data and presenting them in a meaningful format.
- Identify prerequisites for establishing a trustworthy interplay among companies representing battery value chain, T&T providers and the GBA.

2.1. Roles and expectations from participants

When configuring the GBA battery passport pilot exercise, we identified four distinct roles:

1. Regular business members (from mining company to battery producers) were invited to report against quantitative and qualitative ESG indicators namely the Greenhouse Gas rulebooks and and a subset of mandatory questions from the Human Rights and Child Labour indices and share their material flow data through various track & trace instruments.
   - For each pilot we identified an electric vehicle manufacturer (OEM) to act as leading business members. In addition to the activities outlined under 1. above, leading business members were invited to mobilize their value chains and complement the battery passport with technical data (i.e. capacity, manufacturing history etc.).
   - Regular Track & Trace (IT) providers (one or two per pilot) were asked to ensure the traceability of the selected materials (collect material flow data ensuring end-to-end reporting) and supporting business players with ESG reporting (providing templates and means for collecting data across the value chain)
   - Passport issuing Track & Trace providers, one per pilot. In addition to regular Track & Trace responsibilities, the passport issuing providers were asked to aggregate data and pack them into a battery passport container ensuring overall integrity.

Disclaimer #1: In this wave of pilots the GBA did not require or ensure verification of collected data (neither ESG data nor material flow data nor correctness of data aggregation). The GBA designed the pilot as a self-assessment exercise and fully relied on the integrity of pilot members regarding the presented ESG data points and resulting aggregated scores.

2.2. Overall proof-of-concept results

Given time and resource constrains, the GBA established three pilots with two different OEM-s, three different battery (cell) producers and three different track & trace providers, who managed to assemble three equally important battery passport proxies:

OEM and Battery producer	IT partners	Type of passport	Key achievements of the pilots
OEM #1 Battery producer 1	**Provider #1**	Individual battery	End-to-end cobalt traceability almost on physical level for a real battery item
OEM #2 Battery producer #2	Provider #1 **Provider #2**	Batch of batteries	Elements of interoperability achieved: each T&T provider tracked different materials but proper calculation of product level figures was ensured. Data aggregated for a period of time to add diversity to a value chain
OEM #2 Battery producer #3	**Provider #3**	Individual battery	Traceability of two materials including a sub-stream of recycled cobalt for a real battery item

All our pilots underwent the same journey on the path to publishing the world's first battery passport proof of concept. They:

- Formed a working group of companies, representing "cradle-to-gate" (mine – OEM) value chain, and T&T partner(s) and secured non-disclosure agreements or other appropriate legal interplay;
- Ensured correct reporting of requested ESG parameters on operational site level, collected and complemented them where necessary;
- Aggregated individual figures into a product level (battery installed into EV) passport bearing in mind actual material flows (e.g. material utilization coefficients for greenhouse gas emissions over a period of time);
- Complemented ESG product level data by materials provenance data and technical data, and assembled the data into a "battery passport container";
- Identified critical problems and collected learning to ensure future process improvements.

At the same time the GBA:

- Developed and published rulebooks and defined reasonable implementation shortcuts (i.e. reporting against a subset of mandatory questions from the child labour and human rights indices only), integrated in data collection templates and guidelines for individual company reporting;
- Ran training and Q&A sessions on content for all the pilot participants;
- Ensured overall governance, proper communication and coordination among pilots and (to the extent possible) the same standards of outputs.

The GBA proof-of-concept pilots in numbers

The timeframe for the implementation of the proof-of-concept pilots totaled two months from the distribution of the data collection templates and instructions to completing the data collection, ensuring correct aggregation and passport packaging. The GBA expects reporting time and efforts to decrease drastically after streamlining of the rulebooks.

The group of battery producers who participated in this piloting exercise represent over 53% of the global EV battery cells market share (Bloomberg, 2022). The participating OEMs represent 67% of the US Electric Vehicle market as per the recent S&P Global Mobility Report. The three cobalt producers who participated in the GBA pilots, represent the top three cobalt producers in the world in 2022 with 36% share in mine production according to CRU Reporting.

2.3. Content implementation shortcuts

Realistic data. Considering that data governance rules and frameworks for the battery passport ecosystem still need to be developed, the participating organisations had reservations about sharing any data which could be commercially sensitive. To avoid lengthy legal discussions and negotiation of dedicated agreements, the pilot participants agreed with the GBA to share realistic data instead of real data. 'Realistic' data allows for small adjustments to any individual data set which may risk unintended legal consequences (e.g. breach of confidentiality). At the same time the data presented is based on actual internal data collection according to the GBA rulebooks and data collection templates. For example, this has resulted in business members rounding figures and making certain assumptions while calculating GHG (especially if doing it for the first time), or T&T providers rounding selected figures related to the in the passport in agreement with the OEMs.

> **Disclaimer #2:** The data presented as results of individual pilots do not granularly reflect the real material flows and their parameters over time but reflect the real relationship among participating companies. Individual pilot results shall not be compared out of the context of this disclaimer

Human Rights and Child Labor. The recently published versions of the child labour and human rights indices include over a hundred questions, reflecting the complex nature of both issues. To facilitate the proof-of-concept, the GBA and the working group members therefore decided to identify a subset of mandatory questions from each index to establish the proof of concept within a reasonable timeframe and level of effort. Questions were chosen to represent different provisions and aspects of both issues but do not allow for generalization regarding the respective company's efforts in either area. All participants were presented with the option to respond only to the subset of mandatory questions or respond to all questions included in the data collection template. The final score displayed in the passports has been derived from responses to mandatory questions only:

Index	Total number of questions	Maxim possible score	Number of mandatory questions	Maximum score of mandatory questions
Human rights	55	244	15	60
Child labor	60	213	14	63

Individual scores were aggregated into a product level score by a simple mathematical operation of averaging. This type of aggregation may significantly dilute the difference between the highest and the lowest scores across the value chains and consequently will be reviewed in the next phase. Materials utilization coefficients were also ignored at this stage: a company, responsible for 2% of physical weight of battery, had the same weight in the averaged score as a company responsible for the whole battery. The GBA and its T&T partners did not request any evidence of actual performance or actions. No external documentation, audit results or certificates were included in the analysis.

> **Disclaimer #3:** Current reported results do not in any way reflect the actual performance of companies across the value chain and may not serve as evidence for their respective performance. Individual pilot results may not be directly compared due to the possibility of inapplicable questions (a company may receive a lower score due to legal or geographical conditions). For this reason, the GBA has chosen to selectively safeguard individual results. In addition, due to the aggregation process, the salience of individual issues according to different segments of the value chain is not yet appropriately reflected in the average level score.

Greenhouse Gas. The core differentiator of GHG parameters, calculated and aggregated according to the GBA Greenhouse gas rulebook principles, is the focus on product level reporting rather than corporate level reporting. The GBA facilitated agreement on common principles of process identification and common levels of granularity despite the great diversity of value chain participants and processes. In addition to the GHG Rulebook itself, pilot participants have been provided with a set of templates that a) standardized the level of granularity of expected data and b) helped companies, who ran GHG calculation for the first time, to simplify the process of LCA modeling by following the structure of the templates. The templates also helped companies to properly allocate calculated emissions in case of multi-output processes by utilizing one of the allocation principles defined by the rulebook.

An additional important element of GHG modeling was assembling end-to-end product level emissions – the battery carbon footprint. This became possible due to clearly defined boundaries of reporting (each company reported on its "inhouse" emission only) and assistance from Track & Trace providers, who complemented GHG data with "materials utilization coefficients":

> *Consider two mining companies supplying cobalt and manganese to a precursor producer. Each mine first calculated its "inhouse" emissions per unit of useful components (e.g. kg of cobalt metal). Based on the precursor producer data, the Track&Trace partner "assembled" emissions per unit of resulting precursor: multiplied cobalt emission by utilization factor (amount of cobalt metal per unit of precursor), multiplied manganese emission by utilization factor, and finally summarized it with additional emissions from a precursor producer itself. In addition to that, the Track&Trace partner took into account a mix of suppliers over time as both cobalt and manganese may have come from different mines with different emissions numbers.*

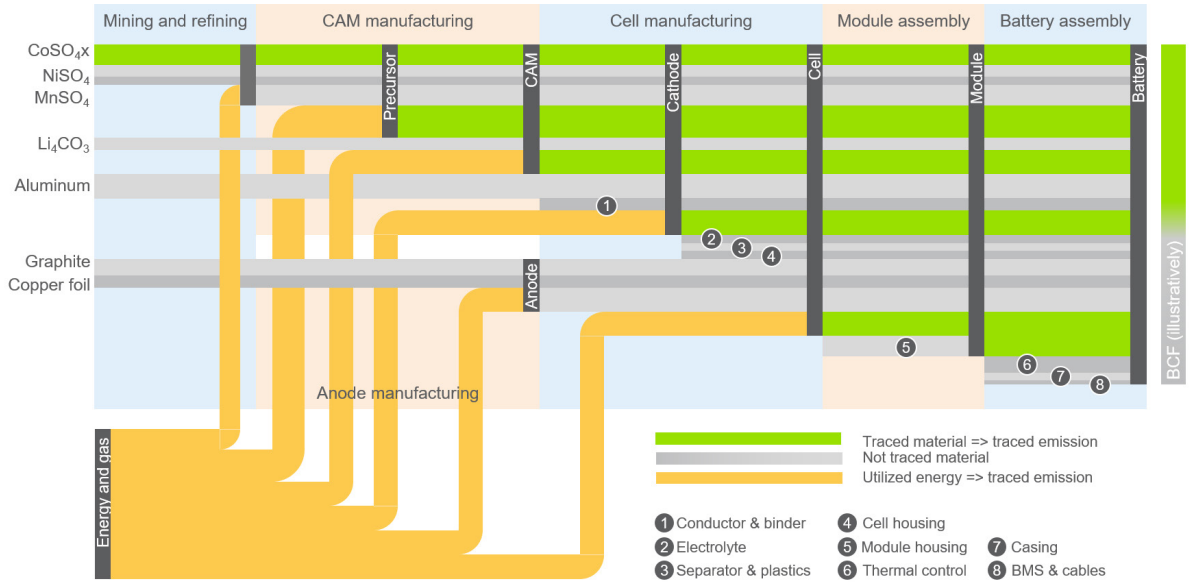
The special achievement of the piloted GHG calculation method was in the immediate assembling process. According to common approaches, each value chain process collects all inputs first and runs life cycle assessment modeling after, which significantly decreases transparency across the value chain and demands more time due to the consecutive nature of the process. In the approach pioneered during the GBA pilots, we achieved parallel reporting, clearing the path for much greater transparency and benchmarking potential in the future.

For the purpose of the pilot, the GBA did not set out to cover as many battery related metals and minerals as possible. On the contrary, the pilot participants were asked to focus on end-to-end reporting from a particular mine down to the battery installed in the electric vehicle. Any trace of a specific mineral or metal (i.e. cobalt) required the addition of inhouse contributions of all the processes down to final battery installment. For example, as a first step

of calculation of emissions associated with cobalt production, we collected emissions incurred by utilizing energy during the precursor production. We subsequently included inhouse emissions of CAM production and continued until the end of the value chain. It was immaterial which metal triggered the exercise as long as it was continued until the OEM plant. In the end this means that we may have traced only ~1-2% of the physical battery mass but collected 50-95% of the total battery carbon footprint (see Figure 1).

Pilot participants, with extensive experience calculating product level GHG emissions included emissions from other materials by complementing reported figures from the previous value chain steps with estimations of their "neighbors" (e.g. precursor manufacturer may report its own inhouse emissions and inbound emission of nickel and manganese producers if they have not been reported by another pilot member). Complementing the value chain in the manner described above allowed pilot participant to come closer to realistic GHG emission per unit of battery.

Figure 1. Illustrative process of GHG aggregation for NMC811 type of battery



Disclaimer #4: The GBA did not have access to individual GHG data points and did not control the process of aggregation beyond providing general instructions of how to avoid possible double counting specifically in case of multiple sources of reporting (multiple Track&Trace providers)

Since energy use accounts for a significant amount of product emissions and in order to differentiate and highlight the attempt of value chain members to decrease those emission by generating cleaner energy, the GHG rulebook proposes two methods of GHG calculations: HMA (Harmonized Market Approach) and PMA (Physically Modelled Approach). As we did not cover the entire value chain, the resulting difference between the two ways of calculation was not as significant as we expected, however the GBA will continue asking for both figures to be calculated and reported accurately, unless a different approach is agreed by multistakeholder consensus in future iterations of the rulebook.

In addition to the HMA and PMA figures, each individual company report (operational site) implied GHG based on primary (measured, directly obtained) and secondary (estimated, assumed) data. The GBA's Track &Trace partners were faced with both situations: when individual reports consisted mainly of primary data (a sign of either a very advanced level of measuring or misunderstanding of primary data definition by reporting entity) and a very modest share of primary data (a sign of low GHG measuring maturity).

Disclaimer #5: Given the complexity of the exercise and a set of competing factors which may have decreased or increased the final battery carbon footprint, the resulting figures do not reflect the actual battery footprint accurately and it may be higher or lower than previously reported metrics of pilot participants. Resulting figures may not be treated as accurate data, generalized to a broader set of products or misinterpreted in any other way.

Technical data. The GBA has placed a strong emphasis on enhancing the sustainability impacts of the battery value chain. At the same time, due to the technical nature of the battery, it inevitably requires a series of technical parameters to be included in the battery passport. The GBA has therefore relied on their partners, who are monitoring the regulatory developments and specifications for technical data disclosure and plans to complement and align the list of technical parameters (definitions, units, scales) building on the work of affiliated initiatives. The proposed set of technical parameters used in this first wave of pilots reflects the most critical indicators but it doesn't cover them all. Even though the indicated parameters may be much closer to real data than the reported ESG data (see Disclaimer 2), we did not aim to focus attention of our pilot participants on this information and do not consider this as the most significant achievement of the piloting exercise.

2.4. Depth of interoperability

The GBA is committed to facilitating interoperability of different IT solutions in the delivery of the battery passport infrastructure. Interoperability was expected to pose the greatest challenges to implementation but at the same time one of the most promising aspects of the pilots, including multiple IT providers. We found that in the end, the technological aspects of interoperability were easier to address than basic content readiness. We invested significantly into creating the basis for interoperability: data taxonomy, similar or translatable physical units across different geographies and processes, etc. We also elaborated several cases with overlapping reporting value chains: while one T&T instrument provided the interim BCF figure covering the "cobalt value chain" only and down to cell manufacture only, the second calculated the BCF based on end-to-end tracing of lithium. Both figures complemented each other but at the same time overlapped. The proper methods or allocation of similar double counting incidents turned out to be more important than common standards of identification of interim value chain products.

Despite these challenges, the GBA pilots achieved a breakthrough on this question and proved the technical feasibility to collect and aggregate data by multiple instruments. At the same time, significant data governance issues remain to be resolved. Simple scaling of mechanisms, which allowed two instruments to deliver consistent data sets, will highly likely undermine any mechanism ensuring transparency in a controllable way. Technical solutions to data protection questions won't be enough without adequate and conventional legal provisions, enabling companies to share more data due to rigid regulatory requirements and possible incentives.

2.5. Visual appearance

The current passport design consists of four main categories (tabs):

- **Battery:** aggregating major technical data points regarding a battery (of batches of batteries);
- **Materials:** a source of information about provenance of materials;
- **ESG:** a summary of ESG performance indicators;
- **Data:** a complementing tab on quality of collected data and data collection mechanisms.

(Individual definitions of data fields, units and terms may be found in the Addendum)

Pre-competitiveness. Since the beginning of our pilots the GBA did not expect to develop a final visual design for future of battery passports. The relative benefits of standardized design for the battery passport are limited and the GBA recognizes the ability of individual Track & Trace providers to develop more visually appealing and

user-friendly products. At the same time, we believe that the visual aspect of the battery passport is not the most important aspect of passport overall. The GBA limitations on customization of the visual presentation for the purpose of the proof-of-concept is rooted in the need to keep the focus of an external observer on the substantive achievements of the pilots rather than on visual instruments. We do expect a basic set of design requirements to apply to alle future passport issuers but we also expect for the design of the passport to become an additional field of competition among providers which end users may benefit from.

While working on delivering three proxy passports, the GBA has been consequently insisting on the precompetitive nature and principles of the Alliance. Conscious of the risk of premature attempts to compare proxy passports, the GBA has decided to safeguard selected elements of individual passports and opted for selective disclosure of parameters for each pilot despite the fact that data for all safeguarded categories was submitted to the GBA.

> **Disclaimer #6:** The GBA together with the pilot participants ensured that there were no significant discrepancies among the results of the three passports beyond those which may be explained by differences in processes or configuration of the respective value chain. Each pilot delivered expected eventual ESG parameters: Human Rights Score, Child Labor Score and Greenhouse gas emissions results. To prevent any premature comparisons between passports and products, the GBA has decided to selectively safeguard selected parameters of the results, given that these are not yet reflective of the comprehensive sustaimability performance of the individual piloting companies.

Tailoring for stakeholders. The short timeframe of the GBA proof-of-concept pilots did not allow for the GBA to assemble passports with different interfaces for different stakeholders. It was therefore decided that the current version of the passport should represent a possible set of parameters tailored to the expectations of a future end-user of the battery. We understand that some of parameters may be a) too detailed to be shared with end-users and b) to sensitive to share on a battery unit level. Therefore, the current passport view represents an “extended end-user interface”, which is unlikely to be repeated in future passports without significant amendments. The GBA expects to clarify a list of potential stakeholders of the future passport and frame necessary previews of the passport (passports) to serve the needs of specific user groups (see next steps).

ESG thresholds. The ESG tab of the resulting proxy passports has two color-coded scales (stepped scale for qualitative indicators like Human Rights Score & Child Labor Score and a quasi-continuous scale for quantitative indicators like Greenhouse gas). In the current version of the passports the GBA collected insufficient data to be able to benchmark and place a particular battery on the provided scales to reflect its ESG performance. First of all, our passport data are incomplete (see Content shortcuts), second – we need to have multiple passports (at least thousands of them) to calibrate those scales. In the future, we expect those visual elements (with probable adjustment) to become cornerstones of a battery passport, delivering the core value – quantified performance of a particular battery (batch of batteries) in a simple and understandable way.

Maturity of instruments. The GBA anticipates extensive development of battery passport instruments soon. In order to quantify this, we have developed a simplified model of interim scales to a) assess current progress and b) outline forecasted developments. We believe that battery passport data will require significantly higher levels of initial data verification, more elaborated levels of tracing (down to physical levels of traceability) and higher levels of interoperability of instruments. We also believe that the maturity of instruments will contribute to the overall credibility of the passport, e.g. end users may have greater trust in track and trace solution providers who facilitate a higher level of interoperability. The levels of data validation, traceability and interoperability may become additional competitive advantages of specific passports: for example, we may see reduced value chain coverage but higher levels of data validation. This will create additional levels of track & trace competitions which should ultimately lead to greater transparency and reliability of data.

3. Lessons learnt

The principal outcome of the pilots is the fact that they provide the proof that the concept of a battery passport is feasible and implementable in practice. The GBA and its members demonstrated that battery related sustainability data from individual companies can be collected and integrated with master (material flow) data from third-party Track & Trace instruments and more importantly that it can be achieved in an interoperable way. It was also demonstrated that the necessary levels of trust among pilot participants (business and IT partners and the GBA in general) can be achieved by a properly designed interplay even without enacted external regulations and that instruments, which have been used by the GBA, significantly sped up the process of alignment.

In addition to the general proof of concept we were able to distill a set of more specific learnings about each element of the future ecosystem: content metrics, technology readiness, data verification and data governance, readiness of industry to absorb standardized approaches, value of battery related data for internal (inside the value chain) and external stakeholders:

ESG data granularity. The current proposed approach of reporting on operational site level is huge step towards higher transparency. However, it may be not enough to run future data benchmarking and comparisons. We encountered examples where completely different processes where combined under the roof of the same operational site which made reports on the site level incomparable with peer-level pilots. Bearing in mind the desired comparability of different value chain steps we will need to define the boundaries of processes more carefully and\or aggregate them in a more standardize categories.

Product scoring. Individual company scores on human rights and child labour are not enough to incentivize companies to take actions. If we want a product owner (battery producer, OEM) to rigorously examine the whole value chain and constantly increase the level of transparency, the scoring metric (averaged, weighted average) of qualitative indicators is insufficient to unlock these issues. We either need to demand 100% of materials to be traced (e.g. by regulation) or the scoring metric itself should encourage the product owner to increase traceability level (e.g. through zero scores for missing part of the value chain).

Tracing granularity. Speaking of different battery related minerals, we faced different types of production and transportation technologies and practices. Some materials can be tracked almost on an atomic level as there are no blending procedures involved. At the same time other materials are handled and processed in piles. For these operations only materials balance methods can be applied, which are diluting tracing by its nature. When we speak about a unique battery item (and sometimes even a small batch of them) we will almost certainly face a “one supplier per one material” case, which significantly decreases transparency across the whole value chain. The unique battery passport for a battery item becomes less representative than the aggregate information about numerous batteries of the same producer over a dedicated period of time.

Content interoperability. Without achieving comparability of data points (definitions, units, scales) the technological interoperability is irrelevant. It is highly likely that product level figures won’t be the result of simple summary operations: sometimes value sub-chains overlap. In order to calculate product level metrics those overlaps should be properly allocated to avoid double counting. At the same time this issue revealed the technical possibility of individual data inputs to be reengineered (you may be bound by NDA with one IT provider but as soon you combine data from several IT providers others may recalculate your individual data inputs as well). This finding blocked several companies from participation in this first wave of pilots.

Data governance. We deliberately emphasized the need for interoperability at this early stage of the world's first battery passport to counteract potential cases of having too much data concentrated by one or a select few IT \ Track & Trace leaders from the outset. With increased interoperability come increased risks of commercial sensitivities. The more interoperable an organization becomes, the more commercially sensitive issues may arise when trying to scale the respective ecosystem, resulting in reluctance to join the system. An adequate balance must be found and the GBA believes that data governance discussions must take place in genuine multi-stakeholder settings only. We also recognize that the transition from realistic to real data will require significant regulatory action to complement general data governance discussion. Following this pioneering work of the GBA proof-of-concept battery passport pilots the GBA is uniquely placed to leverage its convening power for the data governance discussion and policy development.

New fields of competition. Being the first to volunteer information not previously disclosed comes with inevitable risks and sensitivities. However, as the rapidly growing battery industry is preparing for upcoming regulation, including requests for product level disclosures, current industry leaders recognized that risks of having early and non-verified figures misinterpreted or taken out of context could create significant reputational risks. At the same time, we have witnessed a great willingness to submit and disclose data via battery passports systems by sustainability champions within the GBA. The Battery Passport aims to unlock new ways of competition where comparable sustainability performance becomes a 'must have' rather than a 'nice to have'. Based on total end-to-end scores the battery producer may differentiate its products on the market and at the same time the end user may consciously support more sustainable business models.

Technology readiness. Track & Trace instruments in general demonstrated the desired level of material flow data transparency to evolve into the backbone of the battery passport and enable the whole ecosystem in the future. As interoperability considerations will dominate future developments, current business models of tracking instruments may significantly evolve. We expect interfaces between individual modules (e.g. intra-company data collection and external track & trace) to become very important soon to minimize companies' efforts to run reporting or translate results of existing reports into applicable formats for battery passports. We also support the idea of common identification and data exchange standards to be adopted within our ecosystem with a strong preference for non-commercial, open solutions.

Establishing trust. As expected, the value of the battery passport lies not only in measuring sustainability performance or how to implement it technologically. Establishing a trust-worthy interplay proved the most significant challenge to address to ensure a sustainable outlook for the first ever battery passport ecosystem. Neither common language (metrics, instruments, rules), standardization nor common principles of data collection, protection and exchange are sufficient by themselves to create trust in battery passports. The whole ecosystem needs to be enhanced while bearing in mind the interests of all the stakeholders to make it scalable and lasting.

4. Next steps

Based on the proven feasibility of the concept and the lessons learnt, the GBA is eager to continue working on the GBA Battery Passport ecosystem including the development of a streamlined sustainability indicator framework, deeper integration with existing and emerging IT instruments and finally making the passport a transparency framework to trigger enhancements across the value chain. The below set of next steps reflects our view of the most promising directions of development for the next couple of years which will serve as the basis of decision making by our members.

4.1. Content of the GBA Battery Passport

While working to implement the GBA's principles, including the immediate and urgent elimination of child labour in battery value chains, the members of the child labour working group concluded that existing standards did not prove sufficient to eliminate the root causes of the issues. In response, the GBA set out to develop our own proxy standard (rulebooks). We will continue working on the streamlining of the GBA's child labor and human rights indices and standard equivalency to allow reporting entities to participate without drastically increased costs. At the same time, we plan to ensure broad endorsement of our methodology for the various indices and rulebooks and are already arranging a series of external consultations will respected standard setters.

We also realized that the foundational indicators for the battery passport are overly focused on the issues specific to individual segments of the battery value chain. Simple arithmetic averaging of individual scores dilutes the input of upstream companies, where the stakeholders may expect the majority of child labour issues to be located. The next natural move would be to creatively put individual scores into aggregated metrics that highlight issues and at the same time encourages companies to be more transparent and ready to disclose more details about their value chains. We aim to make those metrics a daily tool for professionals across industry and the public sector to support decision making processes and increase circularity.

Greenhouse gas emissions and child labour and human rights issues were the foundational issues underlying the creation of the GBA and were therefore addressed as a priority. Nevertheless, we recognize that each battery material production cycle may bring individual issues. The GBA has identified almost 30 indicators across ESG topics (including waste and water management, land use, biodiversity, etc.) that are awaiting analysis, prioritization and incorporation into a family of the future GBA rulebooks.

Likewise, battery production is only the initial stage of the lifecycle. The battery is expected to be heavily used, repurposed, and at the end of the day recycled. We are investing into partnerships with affiliated initiatives specializing on lifecycle management and the GBA Battery Passport will expand to cover next steps of the battery lifecycle. For example, we rely on our partners to specify technical parameters (master data) of our passports with a focus on battery usage and recycling parameters. However, bearing in mind the unique GBA membership roster and legacy in upstream processes, expanding the battery passport to cover different types of batteries (e.g. consumer good applications), where lifecycle management is not yet that important as provenance of materials is equally feasible.

4.2. IT aspect and physical product implementation

We believe in achieving that full-scale content interoperability (underestimated so far) will be achieved in a matter of time. Therefore, technical interoperability will likely come to dominate the battery passport agenda soon. We also familiarized the GBA community with necessary standards and technologies with decentralized approaches to the identification of components, collecting, storing and protecting data, ensuring adequate data verification. The next step is making it all work together in an integrated fashion.

The achieved levels of interoperability in one of our pilots is insufficient to scale the system to more than two IT partners. In order to do that we plan to rework basic principle of IT integration and only scale it up afterwards by onboarding more value chain companies and IT providers. In that way we expect the GBA family of rulebooks to be complemented by Data Management rulebooks, an important endeavor requiring the selection of appropriate existing external standards for identification and data exchange, and detail-oriented work to ensure interoperability with other initiatives on the market.

Even though our pilot participants received support from IT partners to participate in individual pilot activities, such as responding to human rights and child labour questionnaires or running LCA modeling for GHG calculations, those blocks are still insufficiently integrated, requiring manual integration in parts. We expect to investigate opportunities for integration between Track & Trace instruments and individual data collection or calculation modules, e.g. embedded LCA modeling directly into T&T tools.

And finally, the physical implementation of passport elements, e.g. marking and identification of a battery and its components while leveraging a huge diversity of instruments like QR-codes, RFID tags and others available tools represents an area for product development. The GBA plans to explore this important aspect of the Battery Passport product soon.

4.3. The GBA Battery Passport Ecosystem

The success of the first proof-of-concept pilot demonstrates the feasibility of relying on third party data providers and the GBA is unlikely to become involved in developing IT solutions for battery passports, focusing on orchestrating the ecosystem instead. In this vein the GBA will look to more precisely define mandatory aspects of passports (like metrics and thresholds, access to data) and eventually give our partners more freedom in less strategic questions (like visual appearance of passports) and open the door for competing business models around the battery passport topic.

Partnerships are essential to our vision. Therefore, we have launched and will continue to develop a family of affiliated projects, which recognizes existing programs that we believe we may either learn from or directly combine efforts and results.

We do understand that industry members and IT providers do not cover the whole spectrum of battery passport ecosystem. We aim to elaborate the overarching architecture and introduce new roles of content verifiers, data collection and aggregation verifiers, roles of respected stakeholders like public and non-corporate members. Those roles should come with both responsibilities and privileges specifically in terms of access to battery passport data which will become a priority.

4.4. Data governance

The proof-of-concept was based on a pragmatic project implementation approach relying on shortcuts like ‘realistic’ data to help us to deliver the first results ever. At the same time this means that much work remains to be done, starting with questions of data access, disclosure rules and security. These questions are essential to resolve

before converting the passport into a fully scalable tool. Everyone wants to learn “who should see what” and we are working on answers to this question.

As the issuer of the world’s first battery passport, the GBA has acquired a unique position and valuable insights which will contribute to hosting future data governance discussions. The GBA finally went one step beyond the general understanding of the topic’s importance. We have acquired an understanding of particular issues and concerns of different stakeholders and have tried and tested multi-stakeholder consensus building processes in place.

In essence, we plan to implement future pilots with real data instead of realistic data. This will require enhanced frameworks for practical collaboration and information sharing between participants in the GBA ecosystem. At the same time as soon as we have sufficient data to issue multiple passports, we will be ready to aggregate it and sanitize (if necessary) to share with stakeholder beyond pilot members to achieve the true objective of the battery passport action partnership: Impact.

4.5. Impact

Ultimately the battery passport is a transparency tool to identify, highlight and where possible, quantify issues across the value chain to encourage and enable battery value chain members to drive improvements. We are looking forward to seeing specific improvements inspired and supported by data from the Battery Passport. Together with other partners from GIZ we have adopted a full theory of change narrative and hope to see it being implemented soon.

Join us, work with us, and change battery value chains for good.

Addendum

Individual passport data fields definitions, units, comment

Battery

1. **Battery passport ID:** a unique identificatory of a passport document (autogenerated)
2. **Battery model:** a simple description of a battery model and probably a relative EV
3. **Battery serial number:** a physical number on a particular battery (may be empty when passport is generated for a batch of batteries)
4. **Battery status:** status of physical object (a battery), which this passport refers to (original, repurposed, recycled, etc.)
5. **EV Manufacturer:** a name of OEM company, which placed a particular battery into EV
6. **Country of EV assembly:** a country of OEM facility, which has assembled an EV with particular battery (not a HQ country)
7. **Battery producer:** a name of battery pack producing company (may repeat EV manufacturer)
8. **Country of battery production:** a country of battery producer facility (not a HQ country)
9. **Battery cell producer:** a name of cell producing company
10. **County of cell production:** a country of battery cell producer facility (not a HQ country)
11. **Manufacturing date:** actual data of battery manufacturing
12. **Battery cell type:** cylindrical, prismatic, pouch, other
13. **Chemistry:** a simple text description of core chemical elements of battery
14. **Number of cells per battery:** integer, number of individual cells in a battery pack
15. **Weight:** physical weight of battery in kg
16. **Total energy:** kWh
17. **Energy density:** kWh / kg
18. **Rated capacity:** Ah
19. **Expected lifetime:** integer, number of cycles
20. **Voltage** (min-nominal-max): V
21. **Temperature range:** min temperature – maximum temperature in ˚C

Materials

22. **Recycled materials:** title of recycled materials (in future – a mass fracture of battery that has been recycled)
23. **Materials traceability (in pilot):** %, a physical mass of traced\tracked material in this particular pilot divided by weight of battery
24. **GBA member coverage:** %, same as material traceability but accounting from GBA members only
25. **First / Second traced material:** material title
26. **Physical amount per battery:** kg or “not disclosed”

27. **First / Second material provenance:**
    - % of physical weight of traced material from particular source out of total weight of material in a final battery
    - name of company (HQ, name of particular facility, country of facility)

ESG

28. **Human Rights / Child Labor Average score:** XX / YY, where XX – average of all reported score across the value chain, YY – maximum possible score for this index
29. **Questions answered:** XX / YY, where XX – number of mandatory questions answered in a questionnaire, YY – maximum number of mandatory questions
30. **Number of companies:** number of companies submitted relative reports
31. **Green House Gas BCF (HMA):** kg / kWh, GHG emission of related battery, including electricity emissions calculation based on HMA methodology
32. **Green House Gas BCF (PMA):** kg / kWh, GHG emission of related battery, including electricity emissions calculation based on PMA methodology
33. **Primary data:** a share of primary data in BCF (HMA) (#31)
34. **Secondary data:** a share of secondary data in BCF (HMA) (#31) = 100% - #33
35. **Number of companies:** number of companies submitted GHG reports
36. **Safeguarded:** scores received by the GBA but selectively withheld from publication to prevent premature comparison of products based on partial reporting

Data

37. **Value chain:** a simplified titles of battery value chain
38. **Identity:** name of company(s), performing relative value chain step operations
    - known – the name of the company is known and the company consents to share it within a pilot passport
    - hidden – the name of the company is known but the company doesn't consent to share it within a pilot passport
    - unknown – the name of the company is unknown / not identified
    - partial – a combination of any above in case with multiple companies within one value chain step (if at least one is known)
    - n/a – a process in not applicable to chosen battery model

39 **Material flow:** traceability of materials flow through a relative value chain step
    - traced – material flow (to and from a company) is being traced or tracked, material flow data is used in ESG parameters calculation
    - not traced – material flow is not traced or tracked through this value chain step or the data is not used for ESG parameters calculation
    - partial – a combination of any above in case with multiple companies within one value chain step
    - n/a – a process in not applicable to chosen battery model
40. **ESG Data:** status of ESG data provided by pilot per relative value chains step
    - reported – ESG data (both GHG and HR&CL) have been directly reported by a relative value chain step company

- estimated – at least one part of ESG data (GHG or HR&CL) have been estimated / calculated / provided NOT by a representative value chain step company
- skipped – at least one part of ESG data (GHG or HR&CL) have been neither reported nor estimated
- partial – a combination of any above in case with multiple companies within one value chain step (if at least one company reported both GHG and HR&CL)
- n/a – a process in not applicable to chosen battery model

41. **Data verification:** status of individual data points, obtained from value chain:
    - (0/3) low: no real / realistic ESG data has been collected and packed into this passport (no ESG data or estimated data only)
    - (1/3) basic: real / realistic data have been provided by value chain companies, no verification conducted
    - (2/3) med – real / realistic data has been provided, elements of data verification conducted (e.g. external certificates attached)
    - (3/3) high – real data has been provided, data verification has been conducted by independent agency according to the GBA standards
42. **Traceability:** status of maturity of traceability instrument(s):
    - (0/3) low: no material flow data from T&T provider(s) has been used to assemble this passport or material flow collected on company level only
    - (1/3) basic: material flow data have been partially provided by T&T provider(s) but no end-to-end tracking \ tracing ensured on operational site level
    - (2/3) med – material flow data from T&T provider(s) ensured end-to-end traceability (tracked and\or traced) on operational site level
    - (3/3) high – material flow data from T&T providers ensured end-to-end tracking or tracing on physical level
43. **Interoperability:** status of achieved interoperability of utilized T&T instruments:
    - (0/3) low: no interoperability demonstrated = one IT provider per pilot
    - (1/3) basic: more than one T&T provider, common system of units and definitions used, content data taxonomy ensured (e.g. no double counting)
    - (2/3) med – more than one T&T provider, unified identification, data exchange standards and protocols adopted, full content data taxonomy
    - (3/3) high – more than two IT providers, unified standards and protocols, data security protocols assured according to the GBA standards
44. **Material flow aggregation:**
    - individual battery – collected material flow data reflect real value chain of a specific existing individual battery
    - batch of batteries – collected material flow data reflect aggregation of real value chain for a defined period (an "average" battery \ batch of similar batteries)
    - virtual battery – collected material flow data reflect real value chain of a specific individual battery that is still in production
    - batch of virtual batteries – collected material flow data reflect aggregation of real value chain for a defined period for a batch of batteries still in production
45. **Start of period:** beginning of material flow data collection
46. **End of period:** end of material flow data collection
47. **Data collection assured by:** name(s) of Track & Trace providers