D2.3
Final Report
Stakeholder Analysis - Roles, Tasks and Responsibilities

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CE-PASS in a Nutshell

CE-PASS is an industrial research project addressing the issue of **sustainability-aware automotive design for the circular economy**, **in the context of highly networked, interoperable ICT systems and platforms**. Austria has a strong industrial base in the automotive sector and this sector is undergoing radical change: firstly, in terms of technology by moving away from the internal combustion engine and its reliance on fossil fuels, to competing powertrain systems such as hydrogen fuel cells and/or battery-based electric drive trains; secondly, corporate due diligence increasingly dictates a view on industrial design that bears long-term sustainability and value retention in mind. At the same time, cloud-enabled, distributed ICT has brought disruptive potential to all sectors, leading to a new wave of automation and digitally driven manufacturing processes.

The project brings together four complementary actors: AVL as one of Austria's foremost automotive design companies; iPoint as a software company with a unique offering of due diligence and compliance-related software tools and with a keen strategic interest in sustainability support for industry; the Institute of Systems Sciences, Innovation and Sustainability Research of University of Graz with its track record in life cycle assessment, circular economy and sustainable supply chain management; and Salzburg Research's "Intelligent Connectivity" group with a track record in digital technologies, having led a highly successful European project NIMBLE (https://www.nimble-project.org/) that developed an open source, B2B supply chain and logistics platform.

CE-PASS Kurzbeschreibung

CE-PASS hat zum Ziel, die Implementierung eines Produktpasses und den damit verbundenen Datenaustausch zu untersuchen und zu bewerten, um die Nachhaltigkeit und Kreislauffähigkeit von Produkten zu verbessern. Das Projekt erforscht Fahrzeug-Design für Nachhaltigkeit und Kreislaufwirtschaft im Kontext von hochgradig vernetzten und interoperierenden IKT Systemen und Plattformen. Das Projekt wird von vier Organisationen getragen, die zueinander hochkomplementär sind: AVL als österreichisches Vorzeigeunternehmen im Automobil-Sektor; i-Point als Software-Firmamdie auf Nachhaltigkeits- und Compliance-Software spezialisiert ist; das Institut für Systemwissenschaften, Innovation und Nachhaltigkeitsforschung der Universität Graz mit seiner Expertise in Lebenszyklus-Analyse, Kreislaufwirtschaft und nachhaltigem Lieferkettenmanagement; und Salzburg Research, die eine Open-Source B2B Lieferketten-Plattform ins Projekt bringt. Wir gehen davon aus, dass in Zukunft ein wachsender Anteil aller wirtschaftlichen Abläufe digital, über Netzwerke passieren wird: Firmeneigene IT-Systeme werden mit digitalen Plattformen interagieren (z.B. in Lieferketten), und es wird Datenflüsse zwischen Firmensystemen und Kontrollsystemen geben, welche Materialflüsse und die Verwendung gefährlicher Stoffe überwachen. Ebenso wird es zum Datentransfer mit öffentlichen Informationssystemen kommen, die z.B. über die Öko-Bilanz von Produkten informieren. Solche vernetzte Systeme müssen vertrauenswürdig und sicher sein und bergen hohe Investitionsrisiken, wenn sie nicht ausreichend interoperabel sind. Aufgabe des Prototyps ist, Fahrzeugentwicklern schon in der Design-Phase Entscheidungshilfen hinsichtlich ökologischer Ziele und Lebenszyklus-Kosten zu geben. Dazu wird ein Software-Prototype als plattform-basiertes Service angeboten, damit die Ingenieure Produktwerterhaltung und Kreislauf-orientierte KPIs optimieren können. Als Anwendungsfälle dienen eine Traktionsbatterie für Elektrofahrzeuge und Komponenten eines Verbrennungsmotors. Ein wesentlicher Aspekt wird die Entwicklung eines digitalen Produkt-Ausweises sein, der Industrie 4.0 Standards mit den Zielen ökologisch nachhaltiger Industrieproduktion kombiniert.

Executive Summary

This report provides a final insight into the roles, tasks and responsibilities of stakeholders for CE-PASS project, focussing on the two use cases of the project: the electric vehicle battery (EVB) and turbochargers for traditional internal combustion engines. The aim is to understand the role and responsibilities of each value chain actor in order to support the actors' decision-making concerning circular economy and sustainability.

This report follows up on the information provided in the D2.1 report ("Intermediate Report - Stakeholder Analysis - roles, tasks and responsibilities"). As the research related to this report was essentially already finished when D2.1 was written, this report mainly summarizes the results presented in D2.1 and slightly expands the information collected. The main amendment of this report is a ranking of the stakeholders involved in the EVB value chain regarding their importance during the implementation of a digital battery passport (DBP). This serves as an input for understanding the key stakeholders and their relevance for the DBP. Therefore, this report, jointly with report D2.4, provides a comprehensive into the value chain actors and their information needs, which is pivotal in developing a digital product passport as a concept.

List of abbreviations

BEV	Battery electric vehicle
BoL	Beginning of Life
CE-PASS	Circular Economy Passport
DBP	Digital Battery Passport
DPP	Digital Product Passport
EC	European Commission
EU	European Union
EoL	End of Life
GHG	Greenhous gas
ICE	Internal combustion engine
MoL	Middle of Life
OEM	Orginal Equipment Manufacturer
SCOPIS	Supply Chain-Oriented Process to Identify Stakeholders
WP	Work Package
WSC	Workshop Combustion Engine
WSEVB1	Workshop Electric Vehicle Battery No. 1
WSEVB2	Workshop Electric Vehicle Battery No. 2
WSEVB3	Workshop Electric Vehicle Battery No. 3

1 Introduction

1.1 Problem Definition

In the wake of increasing resource consumption and aggravating impacts of climate change, sustainable and circular product management becomes essential. At the same time, digital technologies enable the collection, processing and distribution of vast amounts of data, thereby allowing for improved tracking of resources and product lifecycle data (Hedberg & Šipka, 2020). In concrete terms, Digital Product Passports (DPPs) have emerged as unique product identifiers containing a product-specific dataset including both static and dynamic information (European Commission, 2023).

As Electric Vehicle Batteries (EVBs) are not only characterized by a considerable current and projected future demand growth but have also been increasingly criticized for their detrimental environmental and social impacts along their value chains (World Economic Forum, 2019), the enhancement of sustainability and circularity along EVBs' lifecycles is vital. In this regard, DPPs have increasingly gained attention as enablers of transparent and traceable battery value chains, thereby improving EVBs' sustainability and circularity performance. Nevertheless, despite some concepts and starting points for a digital battery passport (DBP) (e.g., Berger et al., 2022), the proper implementation has not yet happened and is still in its infancy. At the same time, the Circular Economy Action Plan states that "sustainable batteries and vehicles underpin the mobility of the future" (European Commission, 2020) and explicitly voices that battery value chains should be designed sustainably and circularly. For this, understanding, responding to and supporting existing and future needs of value chain actors with data and information management, e.g., for product design, supply chain management, compliance, risk management and EoL activities, is highly relevant for promoting circular economy and sustainability. For this, getting an understanding of the EVB value chain actors' tasks, roles and responsibilities is crucial.

However, the EVB value chain is characterized by a significant complexity (Bai et al., 2020), which challenges the identification of information requirements and the conceptualization of a DBP. Hence, the comparison with a potential DPP for the internal combustion engine is considered helpful in gaining insights regarding a hypothetical DPP for the already well-established ICE value chain and transferring those insights to the newer and more complex EVB use cases. For this, also the stakeholders along the ICE's value chain need to be assessed and their roles, tasks and responsibility needs to identified in order to provide an in-depth insight into this comparison use case.

1.2 Goals of CE-PASS

The overall goal of CE-PASS is to conceptualize and build a prototype system of a DPP by taking into consideration Industry 4.0 standards and stakeholders' needs related to CE practices. Stakeholders and use cases in CE-PASS are: battery solutions for the drive train of electric vehicles and turbochargers for traditional internal combustion engines. CE-PASS comprises seven work packages, ranging from the conceptualization of the DPP towards the technical implementation. Therewith, all project partners involved are responsible for certain WPs, depending on their respective expertise. The researchers of the University of Graz are assigned to WP 2 and WP 3, dealing with analyzing the value chain actors and their specific data requirements. This report presents the final results of task T2.1, which will be presented below.

1.3 Goals of Task T2.1

The overall goal of WP2 is to identify and analyze the stakeholders involved in the use cases' value chains and their requirements related to sustainability and circular product management.

Task T2.1 "Stakeholder Analysis – roles, tasks and responsibility" focuses on the analysis of the value chains of the EVB and the ICE. Specifically, it aims to map all value chain actors of the two use cases and specify their individual roles, tasks, and responsibilities. This report, just like report D2.1, presents both use cases and their related value chain actors separately and, in the end, provides a synthesis of both use cases. This serves as input for Task 2.2 and 2.3 which will be presented in Deliverables D2.2 and D2.4.

2 Use Case 1: The Traction Battery

This section provides an overview of the EVB use case. Since Lithium-ion batteries are the most commonly used electricity storage system for electric vehicles, they are in the focus of this use case.

The following section provides an insight into the methods used. An overview of the value chain actors is presented, followed by a more detailed description of each of the actors. Finally, in addition to the results of D2.1, a ranking of the EVB value chain actors is presented. All value chain actors are ranked with respect to their importance for the implementation of a DBP. This report serves as an additional input for getting an in-depth understanding of the key stakeholders and their relevance for the DBP.

2.1 Methods

In order to assess the EVB value chain actors, a multi-method approach was applied. Firstly, it was required to get a thorough insight into which stakeholders are involved in the EVB value chain. Here, an in-depth stakeholder analysis of the EVB value chain has already been conducted by Berger et al. (2021) identifying all EVB value chain actors and their data requirements by applying the method called *supply-chain-oriented process to identify stakeholders* (SCOPIS). Berger et al.'s comprehensive analysis of the EVB use case and their stakeholder map thereby served as a basis for getting a well-grounded of the EVB value chain actors and the actors involved (see Section 2.2.1).

In order to identify the roles, tasks and responsibilities of the stakeholders, the method was applied in a twofold way. Firstly, Berger et al.'s pre-work was used as their stakeholder workshop was screened for information regarding the tasks and responsibilities of EVB stakeholders while screening transcripts of the workshops they conducted with EVB stakeholders. This analysis served to identify the actors' roles, tasks and responsibilities. Secondly, as the analysis of the transcripts didn't lead to a sufficiently complete picture, the SCOPIS method was complemented by an extensive literature review, which included recent publications about EVBs and their value chains. They were found by searching for papers dealing with at least one of the stakeholders included in Berger et al.'s stakeholder map. The results shown in Section 2.2.2, comprise the results of both the analysis of Berger et al.'s transcripts and the literature findings.

Lastly, a survey was used in order to get an insight into the relevance of each value chain stakeholder for the implementation of the DBP. For this, the survey that was also used to assess the information requirements of the value chain actors (see CE-PASS reports D2.2 and D2.4), was expanded by asking the question: "In your opinion, which three stakeholders play the most important role in the successful implementation of the product passport? Please select these three stakeholders from the list, and sort them according to their importance." Here, a list of all main EVB value chain actors, as presented in Berger et al.'s stakeholder map, was provided to the survey respondents and they had to choose the "top 3" with respect to the implementation of the DBP. Thereby, the ranking was done by 50 survey respondents who were value chain actors themselves and/or experts in the field of the EVB value chain. The results of this ranking are shown in Section 2.2.3.

2.2 Results

The results presented in this report are threefold. They contain an overview of all EVB value chain actors, an insight into their individual roles, tasks and responsibilities, and the ranking of EVB actors according to their importance for successful DBP implementation. The results of Section 2.2.1 and 2.2.3 remain the same as presented in report D2.1, but they are repeated in D2.3 in order to have all final results included into this report. The primary amendment of this report is about its inclusion of a ranking of EVB actors. Thereby, this reports' results provide a more complete insight into EVB value chain actors.

2.2.1 Overview of Stakeholders Involved

The EVB value chain can be divided into four stages. The Beginning of Life (BoL) stage is the initial phase of the battery's life cycle, and it includes all steps from the battery design until the final car assembly. The subsequent stage is the Middle of Life (MoL), comprising the use phase of the product, which also includes its inspection and maintenance. After the MoL stage, the battery reaches its End of Life (EoL) and is either used for another purpose, coming to the Battery Second Use (B2U) stage, or recycled. In the case of a circular economy, there would be a closed loop between the EoL and the BoL stage as all parts are being recycled and used again. The four stages, their sub-phases as well as the respective actors are presented below. Figure 1 provides a full overview of the actors and their interconnectedness.

Beginning of Life:

- Early design
    - Battery designer/ engineer
    - Vehicle designer/ engineer
- Battery production
    - Supplier of raw materials
    - Supplier of processed materials
    - Supplier of active materials
    - Manufacturer of cell components
    - Manufacturer of battery cells
    - Manufacturer of battery module
    - Manufacturer of battery packs
    - OEM

Middle of Life:

- OEM
- (Contract) dealer for EVs
- User of EV
- Workshop/ maintenance facility

Battery Second Use:

- Repurposing company
- B2U application

End of Life:

- Waste battery collector
- Recycler

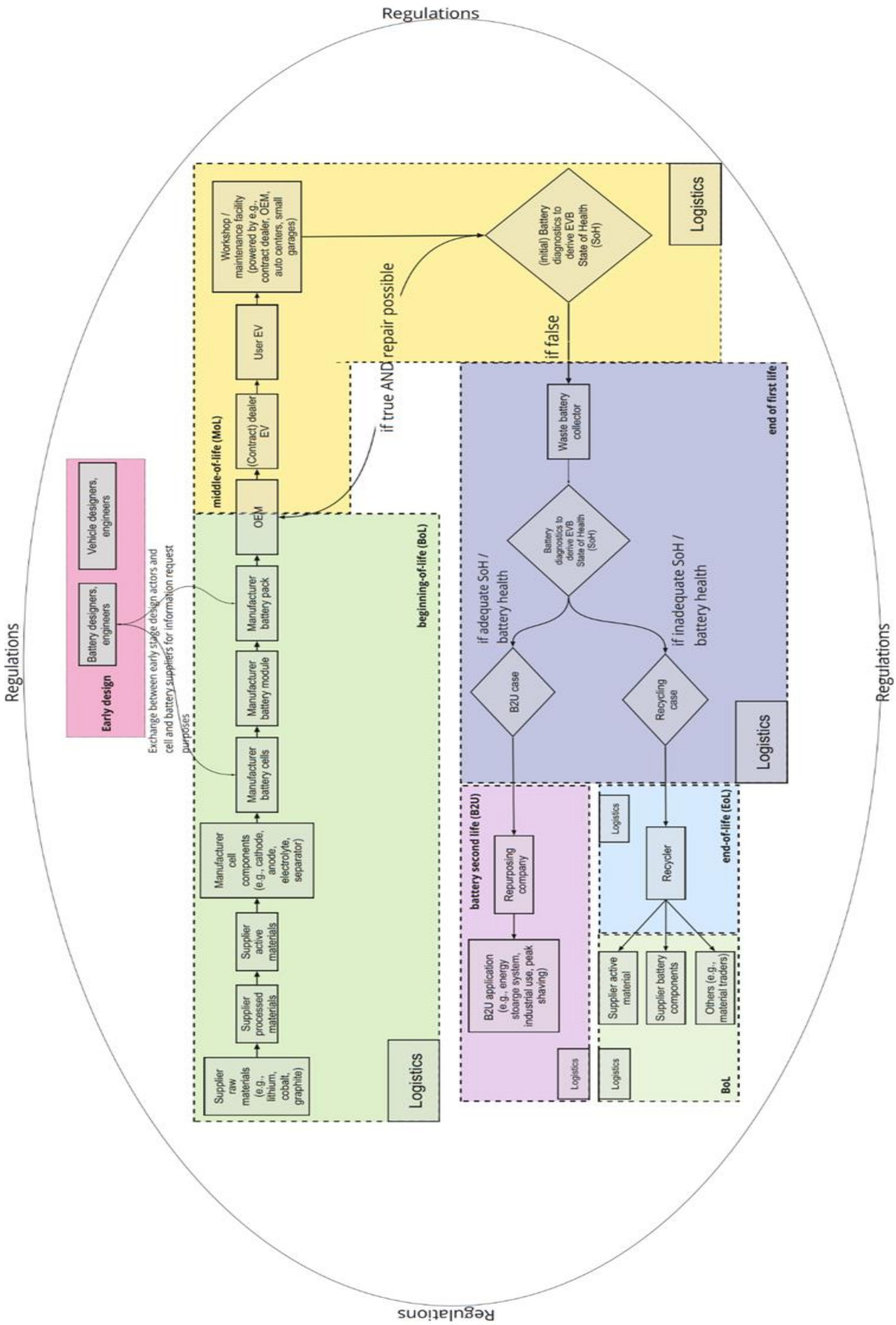

Figure 1: Value chain diagram of an electric vehicle battery (Berger et al., 2022, Appendix A)

2.2.2 Roles, Tasks and Responsibilities of the Stakeholders Involved

Following the overview of the stakeholders involved in the EVB value chain, this section provides a deeper insight into their roles, tasks and responsibilities. In order to simplify, the actors in the manufacturing stage of the EVB are summarized as (raw) materials extractors/ producers and battery (components) manufacturers. Also, the vehicle designers/ engineers are not considered in detail as they only play an indirect role in the creation of an EVB. Both the results of the literature as well as of the analysis of Berger et al.'s workshops (marked as WSEVB1 & WSEVB2) are presented.

Battery designer/engineer:

The major task of these stakeholders is to design and engineer the traction battery. Participants of Berger et al.'s workshops especially stressed the role of designers regarding design for sustainability and design for circularity, as well as the corresponding design for disassembly (WSEVB1). Furthermore, participants emphasized the need for detailed information from stages later in the lifecycle to be included at the BoL/ early design phase (WSEVB2).

(Raw) material extractor/producer:

The first and preparatory step during the production phase of an EVB is about raw material extraction. This includes tasks like mining, grinding, and treating raw materials so that they can be further processed and serve for the actual EVB production (Stampatori et al., 2020). Li-ion batteries consist of multiple raw materials, mainly lithium, cobalt, nickel and graphite. Lithium is extracted from minerals from seawater, brines, ores, and clays, mostly located in Argentina, Chile, Bolivia and China. Also, cobalt occurs in mineral form, for example, in carrollite ($CuCo_2S_4$), a sulfide of copper. The main task of this actor is the extraction of the required raw materials from minerals and their processing and refinement.

Participants of the workshops stressed the task of suppliers of materials and components to share information regarding the included substances with OEMs to facilitate and enable compliance (WSEVB1). Also, the general task of delivering fundamental substance-level information to value chain partners was mentioned by workshop participants (WSEVB2).

Battery (components) manufacturer:

This role includes multiple actors. First, the cell component manufacturer, as well as the cell manufacturer, are responsible for producing adequate battery cells. During cell manufacturing, their task is, inter alia, to prevent cells from overheating through excessive currents. Also, they need to find a compromise between ensuring the highest possible energy density and the maximum safety of the battery cells. With regards to safety, it has to be pointed out that a high number of battery cells is then connected in parallel and in series. Hence, battery manufacturers have to make sure that the cells are produced in a way that they resist potential car crashes, vibrations or varying temperature ranges. (Stampatori et al., 2020)

Whether battery cell manufacturing and battery pack manufacturing are conducted by the same actor or by multiple actors varies between organizations and countries. For example, OEMs in China and Japan are usually in control of both cell and battery pack manufacturing. In contrast, OEMs from Europe often solely control battery pack design and assembly while they import battery cells from elsewhere. In conclusion, the typical tasks of this actor depend on the respective area of responsibility and control. (Stampatori et al., 2020)

The authors in Bai et al. (2020) argue that it is the battery cell and pack manufacturers' responsibility to consider the standardization of cells and battery packs. This would serve to simplify and automate disassembly processes later on in the life cycle of the battery.

Concerning this actor, participants of workshops again voiced the task of these actors to provide the OEM with information regarding their components as early as possible, ideally already in the design phase of the battery, which is usually designed at the OEM as well as compliance reasons (WSEVB1, WSEVB3).

OEM:

In relation to the varying areas of responsibility of the previous actors, also the tasks of an OEM highly depend on their sphere of influence. While Berger et al. (2022) pointed out that an OEM is in charge of manufacturing and assembling the final EVB, Rafele et al. (2020) argued that OEMs usually purchase batteries from outside suppliers. In any case, the OEM requires detailed product-related information regarding the respective EVB in order to adequately handle the battery and proceed with the vehicle assembly. The OEM's role is to produce the finished vehicle and ensure its high performance and quality. Also, the OEM is responsible for setting the respective warranties (Ellingsen et al., 2013). With regards to supporting a circular economy, the OEM may deal with the assessment of the battery's life cycle impacts which needs to be based on inventory data (Berger et al., 2022). Through that, the OEM's role may be to contribute to decreasing the negative social and environmental impacts along the battery's life cycle as well as to promote the EVB's performance regarding sustainability and circularity. Bai et al. (2020) further mentioned that it would also be advisable that car manufacturers be given the task of recycling their own batteries as the OEMs themselves know best what materials their batteries consist of. Furthermore, some OEMs are also adopting the task of assessing their EVBs' potential second-life options for example, by designing them to be used for stationary applications e.g., for household PV storage (Gohla-Neudecker et al., 2015).

All in all, the OEM's tasks and responsibilities include a wide range of activities, from producing the final batteries through assembling the vehicle and assessing its impact to distributing the car and potentially recycling its parts.

(Contract) dealer for EVs:

This actor's tasks were not explicitly mentioned either in the workshops or in the literature. It can therefore be assumed that this player is negligible and that the tasks are similar to those of the OEM and workshops as there might be an overlap of actors here.

User of EV:

With respect to the user, it can be argued that the actor's main role is the ownership of an electric vehicle. Hence, the user can be considered to be predominantly an EV user while thereby implicitly being an EVB user. The EV user usually chooses to purchase an EV that most optimally matches his/her driving requirements (Berger et al., 2022). Hence, the user may be interested in general vehicle-related information as well as additional specific information on the EVB, such as its origin, materials, and state of health. Besides the pure use of the vehicle, the user's task is to maintain the car by bringing it to a workshop or maintenance facility. Furthermore, the user is responsible for getting rid of the end-of-life vehicle (ELV) (Nakajima & Vanderburg, 2005). They could either resell the vehicle or take it to a certified collection point for ELVs, such as a car workshop, an OEM or a recycler.

Regarding a future digital product passport, workshop participants also stressed the users' role regarding the provision on battery use data (e.g., charging frequency) (WSEVB2).

Workshop/ maintenance facility:

The main role of an automobile workshop in respect to EVB handling is carrying out the repair, maintenance and refurbishment of the vehicle, and respectively, the EVB (Berger et al., 2022). The goal of this repair or remanufacturing process is to make the battery fit for extending its use for the same application (Wrålsen, 2021). Stampatori et al. (2020) pointed out that the purpose of remanufacturing emerges from the fact that the performance of some, but not all battery cells and parts, may degrade over time. The remanufacturing and refurbishment of the battery hence serves to make all battery cells and components ready for further use. Foster et al. (2014) put it into the following words "Remanufacturing has to do with replacing cells within a battery that can no longer hold sufficient charge to meet the standards for use in a vehicle." They argue that the task of the workshop is thus to disassemble the battery, remove deficient cells and replace them with functioning cells, and finally reassemble the battery. Besides their active role within the repair, remanufacturing and refurbishment process, the workshop may provide support if the first use of an EVB has come to an end (Berger et al., 2022). Concerning the EVB, this stakeholder is responsible for maintaining the EVB's health status and related decision situations. In addition, this stakeholder is also seen in the role of a provider of information regarding the service of the battery and critical incidents of the battery (WSEVB2).

Waste battery collector:

As has been mentioned above, the ELV is brought to a collecting facility by the EV user. This could either be an automobile workshop, a car manufacturer, or a recycler. Depending on the sphere of influence and responsibility of those actors, it may be that they carry out waste battery collection themselves or deliver the batteries to a separate collection point. The task of the waste battery collector is, hence, to collect and sort the batteries and decide on whether they should be recycled or used for another purpose. (Nakajima & Vanderburg, 2005)

Workshop participants also mentioned that waste battery collectors could be the actors who carry out the battery diagnostics to assess the state of battery health (WSEVB2).

Repurposing company (B2U):

This actor is responsible for enabling a second life for an EVB, after its first life has come to an end (Berger et al., 2022). Stampatori et al. (2020) argued that the idea of repurposing an end-of-life EVB is based on the fact that if an EVB's performance is lower than 80%, it is not considered to be suitable for EV applications anymore. Nevertheless, it may be beneficial to use the battery for other applications, such as for large or small stationary storage applications. For example, battery packs can be repurposed to become a part of a smart grid by being used as energy storage systems (ESS) (Ahmadi et al., 2015).

Hence, the activity of this actor is based on a feasibility assessment of the battery with regard to remanufacturing, recycling, and repurposing (Foster et al., 2014). Thus, the main role of this actor is to identify a suitable application for the second use of the battery and to support the repurposing process and the preparation for the application of choice. The related tasks contain the following (Ahmadi et al., 2015; Foster et al., 2014): 1) sorting the end-of-life batteries, 2) assessing and selecting the batteries for a suitable second-use application, 3) disassembling the packs into modules and dismantling batteries into cells, 4) testing the cells, 5) reassembling the cells into a new configuration while installing new battery modules, packs and electronics, 6) developing the control system for the new application and activating the battery for its new application. Regarding this complex process, Foster et al. (2014) made it clear that each battery case may be related to an individually designed configuration process. This relates to the uniqueness of each repurposing process, which calls for a specifically adapted design and re-purposing process.

Overall, B2U extends the battery's total life cycle by delaying the definite end-of-life stage. The role of the repurposing company is, hence, substantial for enhancing sustainable resource management and circular economy (Reinhardt et al., 2019).

Battery second life application:

As has been explained above, the EVB could be used for another application, such as energy storage systems, after its first use has terminated. The actor who uses the end-of-first-life battery can be summarized with the term battery second-life application. The actor gets the battery from the repurposing company and then uses the re-configured battery ~~in its new configuration~~.

Workshop participants recognized these actors as information providers for BoL stakeholders, contributing to recyclability and gaining more knowledge about battery cell quality (WSEVB2).

Recycler:

As each battery and its containing cells are at some point in time unable to be used for any application and hence enter their definite end of life (Foster et al., 2014). In order to regain material for new battery production, EoL batteries can be recycled (Bai et al., 2020). One of the central tasks of a recycler is to identify adequate recycling possibilities for the respective batteries (Berger et al., 2022). Thus, this actor disassembles the battery and its cells into their components (Foster et al., 2014). The recycler must then efficiently sort components of different chemistries in order to simplify the separation processes. Afterwards, the recycler's task is to decide how to properly handle each component while keeping the process efficient. Therefore, the battery recycler assesses the battery and its components in a detailed manner, considering all materials as well as the chemical composition (Berger et al., 2022).

Workshops participants also emphasized that recyclers could also deliver information about the recyclability of batteries to the battery producers (WSEVB2).

2.2.3 Ranking of value chain actors

The survey participants were asked to rank all EVB value chain actors according to their importance for implementing the DBP. The results of the ranking are displayed in Table 10, showing the number of times a certain actor received rank 1, 2 or 3. Based on these ranks, a weighted amount was calculated by multiplying the amount of rank 1 with a factor of 3, the amount of rank 2 with a factor of 2 and the amount of rank 3 with a factor of 1. Based on this weighted number, an overall ranking could be incorporated.

Table 1: Ranking of actors

Actor	Amount rank 1	Amount rank 2	Amount rank 3	Total amount (weighted)	Overall rank
Battery designer and engineer	9	3	2	35	3
Vehicle designer and engineer	2	0	0	6	13
Raw material supplier	7	5	3	34	4
Supplier of processed materials	0	2	1	5	14

Supplier of active materials	1	3	0	9	8
Manufacturer of cell components	1	1	3	8	9
Manufacturer of battery cells	12	11	2	60	1
Manufacturer of battery modules	1	1	2	7	11
Manufacturer of the battery pack	2	5	7	23	6
Original Equipment Manufacturer (OEM)	11	6	3	48	2
Dealer for electric vehicles	0	0	0	0	18
User of the electric vehicle	1	1	2	7	11
Workshop / maintenance facility	0	0	2	2	17
Waste battery collecting facility	1	0	2	5	14
Logistics (transport and storage)	0	4	0	8	9
Repurposing company (B2U)	0	3	4	10	7
Battery second use application (e.g. energy storage system)	0	2	1	5	14
Recycler	2	3	15	27	5

The ranking results reveal that manufacturers of battery cells most often were ranked to be the most or second most important actors. When looking into the more detailed results, it received the first or second rank across all lifecycle phases groups, BoL, MoL, EoL and B2U, which underlines the manufacturers' of batteries high relevance across all lifecycle phases. Hence, they also received the overall first rank. The OEMs received the second highest overall rank as they received the highest ranking by more than 1/5 of survey respondents. Especially EoL actors gave OEMs oftentimes a high rank. The third overall rank is obtained by battery designers and engineers.

It becomes evident that these three actor groups that are ranked highest are all part of the BoL stage, which stresses the relevance of BoL for the implementation and creation of the DBP. Still, when considering those actors that appeared in the "top 3" of most participants, recyclers are also considerable actors for the DBP implementation as they were in the top 3 of 20 out of 50 survey respondents.

3 Use Case 2: The Combustion Engine

The second use case within the CE-PASS project is the combustion engine, or more specifically, the turbocharger of a combustion engine. Whereas the stakeholder map itself was drawn for the entire combustion engine, it was considered to be useful for the focus group workshops that were held for this use case, to focus on a certain component of the ICE. This allowed for being able to dive more into detail and get more concrete results within the workshops. During the focus group workshop, aimed at the validation of the stakeholder map, a team of AVL experts decided to focus on the turbocharger as part of the combustion engine. This decision was made because for this part of the combustion engine, there already exists the use case of refurbishing used turbochargers and this process could possibly be further facilitated with the help of a DPP.

The next section provides an insight into the methods used, followed by an overview of the value chain actors and a more detailed description of each of the actors. Here, both the method and the results are equal to the ones presented in the CE-PASS report D2.1. For this report, the method section is summarized to some degree in order to avoid unnecessary repetition, whereas all the results are presented again to have all results of task T2.1 united in one report.

3.1 Methods

For identifying the stakeholders of the combustion engine value chain and their corresponding roles, tasks and responsibilities, a multi-method approach was used,

For the identification of relevant stakeholders, the supply chain-oriented process to identify stakeholders (SCOPIS) developed by Fritz et al. (2018), was used. This is the same method as the one applied by Berger et al. (2022) used to develop the stakeholder map for the EVB values chain. The same method was chosen to establish maximum comparability between the EVB and the ICE use case.

The SCOPIS method comprises eight steps, as illustrated in Figure 2.

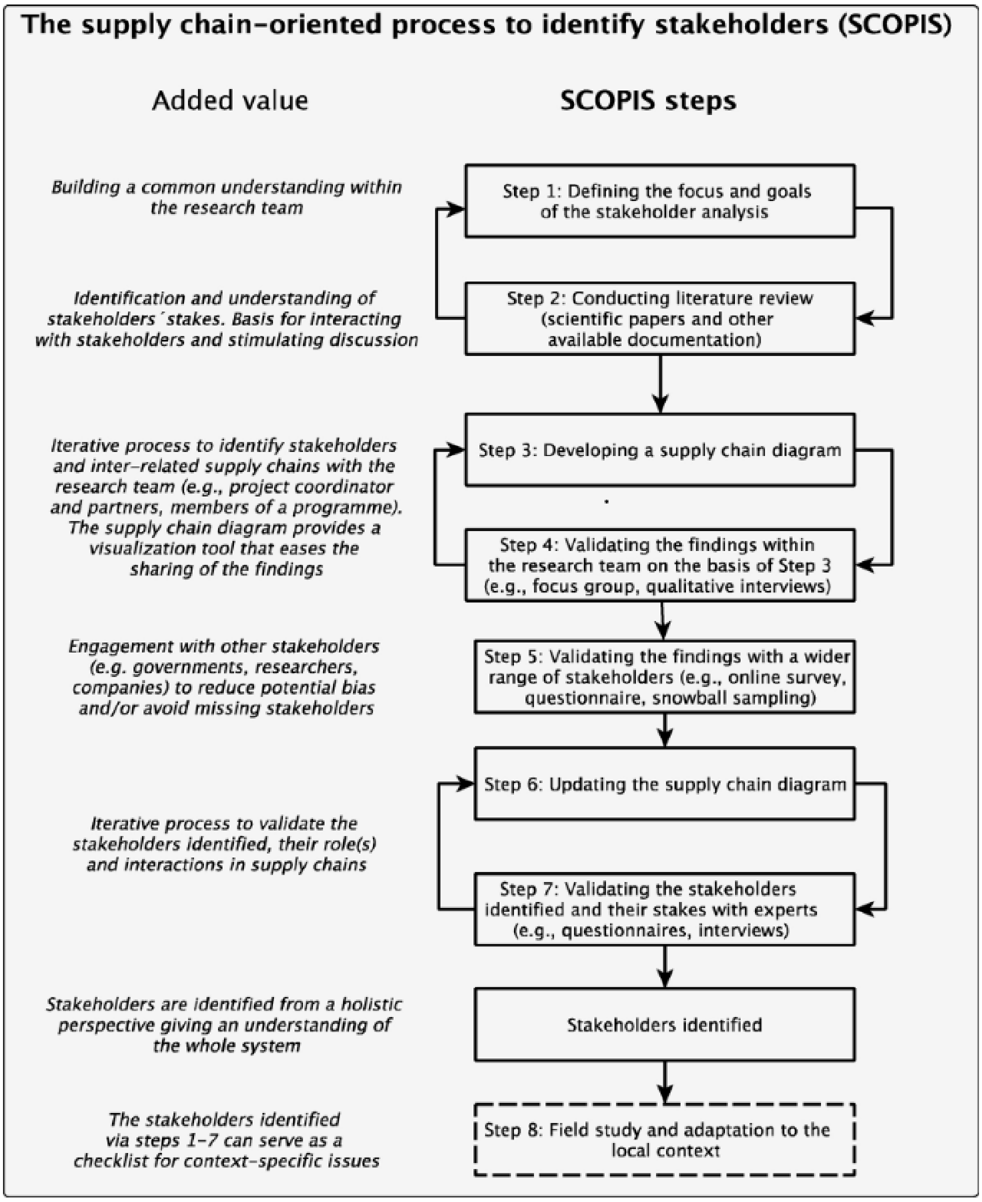

Figure 2: Overview of the SCOPIS method (Fritz et al., 2018)

After setting the goal within Step 1, e.g. to identify ICE value chain stakeholders, Step 2 comprised an extensive literature review. This included the determination of keywords, the search for papers in the search engines SCOPUS and Web of Science and the identification of initial 1104 papers. After removing duplicates and the title and abstract screening, 59 papers were analyzed in depth. During the analysis, different stakeholders were identified in the different life cycle phases, BoL, MoL and EoL, and the result of the analysis was a first draft of a stakeholder map of potentially involved stakeholders (Step 3). In Step 4, the first draft of the stakeholder map was discussed within a subgroup of the overall institute research team including experts in the field of digital battery passports, sustainability assessment and heavy-duty power-train life cycle assessment. Afterwards, in steps 5 to 7, the stakeholder map was updated and validated with external experts from the industry partner AVL, during the workshop with AVL's experts in the field of combustion engine. This process resulted in a validated and comprehensive stakeholder map of the ICE. Further details concerning the application of the SCOPIS method are available in D2.1.

In order to identify the information requirements of stakeholders along the ICE supply chain, organising a focus group workshop was considered very beneficial. This not only served to develop the DPP concept for the turbocharger as presented in D2.2 and D2.4, but also allowed for validating the stakeholder map once again and discussing the stakeholders' roles, tasks, and responsibilities.

3.2 Results

3.2.1 Overview of Stakeholders Involved

The SCOPIS process led to the identification of the following stakeholders involved in the combustion engine supply chain.

Beginning of Life:

- Raw material extraction
    - Iron ore supplier
    - Bauxit supplier
    - Oil supplier
- Material Processing and Production
    - Iron/Steel producer
    - Aluminum producer
    - Polymer producer
- Parts Producer
- Component Production
    - Component producer
    - Accredited producer replacement parts
    - Non accredit producer replacement parts
- Engine Assembly

    - OEM
    - Engine assembler

Middle of Life:

- Distribution
    - OEM
    - Distributor
- Official Maintenance
    - Official repair shop
    - Official spare parts dealer
- Unofficial Maintenance
    - Unofficial repair shop
    - Unofficial spare parts dealer
- Use of Vehicle
    - Initial user
    - Reuser for the same purpose
    - Reuser for another purpose
- Inspection Authorities

End of Life:

- Dismantler
- Shredding facility
- Recycling facility
- Waste management institutions

The different stakeholder and their corresponding interconnections are shown in Figure 3 below.

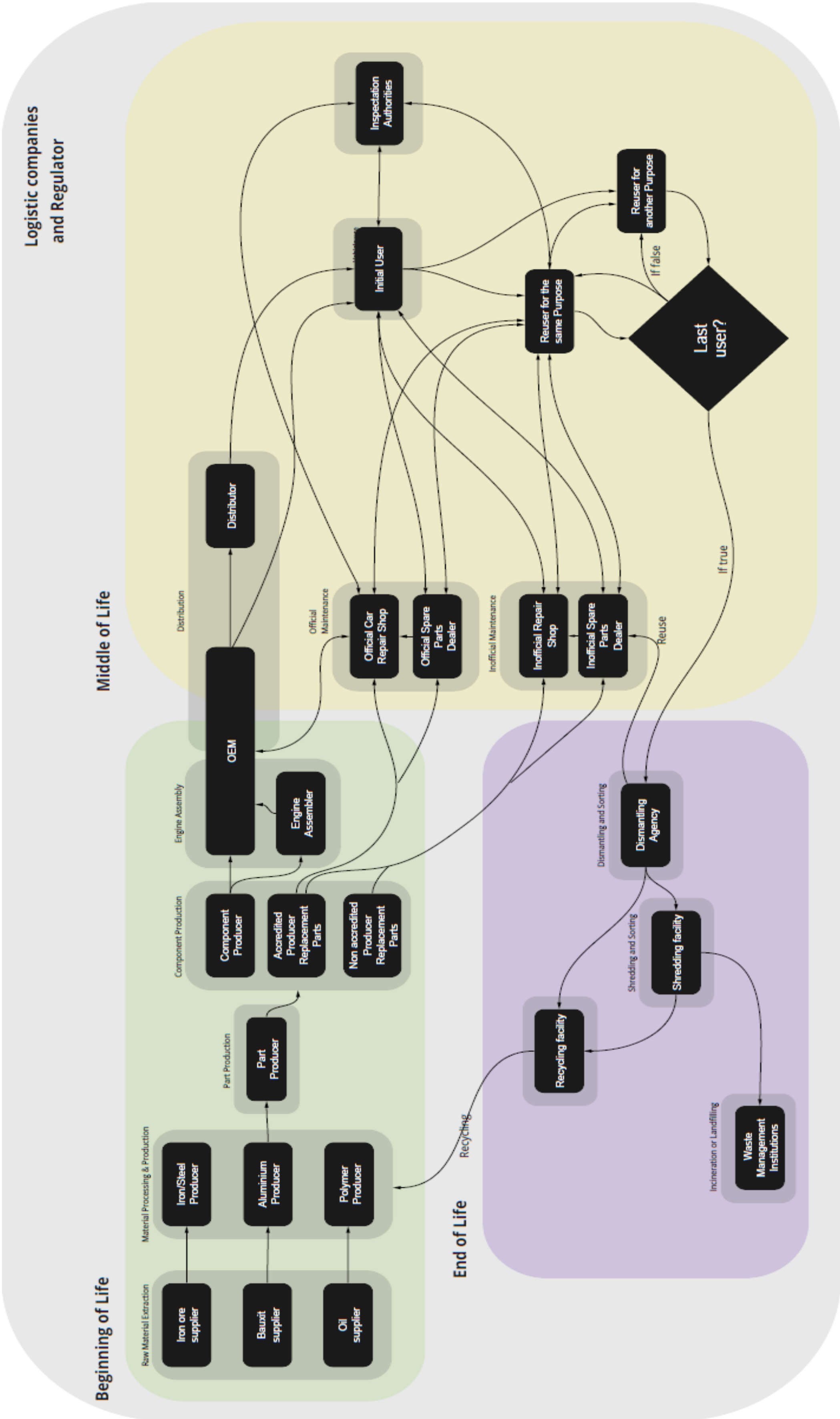

Figure 3: Value chain diagram of an internal combustion engine

3.2.2 Roles, Tasks and Responsibilities of the Stakeholders

In this section, the roles, tasks and responsibilities of the different actors, are described. For the sake of simplicity, some categories of actors are presented using higher level categories. For instance, iron ore, bauxite, and oil suppliers are summarized into raw material extractors.

Raw material extractor:

Raw material extractors are extractors of iron ore, bauxite, and raw oil. Raw material extractors are responsible for the extraction of resources from reservoirs and provide the base for producing materials, which are then used to produce the combustion engine and, respectively, the turbocharger. They are the first actors in the production phase of the life cycle and are responsible for the origin of the primary raw material. (source: Workshop Combustion Engine (WSC)) This is also supported by literature sources in which it is stated as well that this actor's main role is to extract the required raw materials (e.g., Simons & Azimow, 2021).

Material producer:

The next category of stakeholders is the material producers, who create the materials to produce the combustion engine and the turbocharger. The iron and steel producers are responsible for creating the corresponding materials, while the aluminum producer creates aluminum out of bauxite and the polymer producer creates polymer out of oil. The material producers are responsible for fulfilling the purity requirements of the created materials. (WSC)

Part producer:

This actor creates parts which are necessary for the turbocharger, out of the materials supplied by the materials producer. Based on the design and drawing information provided by the component producer, the different parts of the turbocharger are manufactured. The parts producer is responsible for ensuring that the material requirements of the parts are fulfilled. (WSC)

Component producer:

The component producer manufactures the turbocharger out of the parts which are supplied by the parts producer. The component producer manufactures the turbocharger according to the design requirements of the OEM or, respectively, of the engine assembler. Further, the component producer is responsible for compliance with the quality requirements of the turbocharger. (WSC)

Engine Assembler/ OEM:

The engine assembler or OEM integrates the turbocharger into the combustion engine. Therefore, the engine assembler or OEM is responsible for correctly incorporating the turbocharger. The end-of-line testing is also carried out by the engine assembler/ OEM, thus being responsible for the flawless working of the turbocharger. Further, the OEM can refurbish used or not flawlessly working turbochargers and resell them to maintenance and repair shops. Finally, the OEM also has the task of refurbishing turbochargers, and testing and guaranteeing the quality of the refurbished turbochargers. (WSC)

Distributor:

Following the integration of the turbocharger, the whole car, including the turbocharger, is sold by the distributor. The distributor is responsible for the fulfillment of the customer demands, also with regard to the turbocharger. (WSC)

Initial user:

The initial user buys the car from the distributor. Usually, the initial user has no specific interest regarding the turbocharger itself, and the main role of this actor is to use the car as a whole. The responsibility of the initial user is to carry out the mandatory service and maintenance requirements regarding the turbocharger and to seek a repair shop when the warning lights indicate a problem with the combustion engine. These maintenance requirements are determined by the OEM and the specific instructions are included into the maintenance directive. (WSC)

Official and unofficial repair shop:

The official and unofficial repair shops, carry out the maintenance and repair tasks associated with the turbocharger. They exchange and repair the different parts of the turbocharger in case of maintenance or damage. The official repair shop has only access to the original spare parts, while the unofficial repair shop can also use replica spare parts. (WSC)

Official and unofficial spare parts dealer:

The official and unofficial spare parts dealers supply the parts, which are required for the repair shops to carry out the required maintenance and repair tasks. The spare parts dealers are responsible for providing the repair shops with the suitable and demanded spare parts. The official spare parts dealer can access the parts provided directly by the OEM only, while the unofficial spare parts dealer can also sell replica parts. (WSC)

Inspection authorities:

Inspection authorities are responsible for the technical inspection of the overall car and for the turbocharger. They are responsible for declaring that the car is in adequate working condition. (WSC)

Reuser for the same purpose:

This actor includes the buyer of a used car and the buyer of a used turbocharger. This actor's tasks and responsibilities are identical to those of the initial user. Only regular maintenance and irregular repair activities must be initiated by the user for the same purpose. (WSC)

Reuser for a different purpose:

In this case, the turbocharger is used in a different way as intended by the OEM. A turbocharger can, for instance, be used to increase the performance of a given combustion engine, for example, through tuning. (WSC)

Dismantler:

The dismantler disassembles the end-of-life vehicle into its parts and components. This process also includes the separation of the turbocharger from the overall combustion engine and dismantling the turbocharger itself. The responsibility of the dismantler is to disaggregate the turbocharger to a level that makes it possible for the shredding company to separate the material for recycling. (WSC)

Shredder:

After the dismantler has disaggregated the vehicle and the turbocharger, the components that are not qualified to be reused or refurbished are reduced to small pieces by the shredder. The shredder is responsible for sorting and separating the resulting small pieces. (WSC)

Recycler:

The recycler delivers the pieces that qualify for recycling. The recycler, which produces the secondary raw material, is responsible for clarifying how much of the recycled material can be mixed to the primary material in order to get the same quality requirements. Further, the recycler is responsible for the purity requirements of the secondary raw material. The recycler also delivers the secondary raw materials to the material producers, who then either deliver them directly to the parts producer or use them in the creation of new materials, which are then delivered to the parts producer. (WSC)

Waste management institution:

The final stage in the value chain is represented by the waste management institution. The task of the waste management institution is to dispose of the material that is not eligible for recycling. An example here would be the thermal utilization of the remaining waste of the turbocharger. (WSC)

4 Conclusions and Outlook

This report shows the final results of the stakeholder identification process. The relevant stakeholders along both value chains, were identified and their corresponding tasks, roles and responsibilities were presented. For the identification of stakeholders, the methods were slightly different, given that for the traction battery use case, already detailed information and material was available within the research group. In contrast, the research regarding the combustion engine had to start from scratch. Despite the slightly different approach, the results were processed and presented in a way that makes the use cases comparable. The main differences and similarities between the stakeholders are shown in Table 1 below.

Table 1: Comparison of EVB and ICE use case

Life cycle phase	Difference and similarities between EVB and ICE
Beginning of life	The overall phases of the production process of the turbo charger and the traction battery can be considered similar: Extraction of raw materials, production of the components of the battery and the turbo charger and assembly of the components to finally create the battery and the turbocharger. The main differences in the BoL phase are the materials, which are used to produce components (e.g., production of battery cell vs. production of turbine housing) and the different ways of manufacturing the different parts and components.
Middle of life	Also in the MoL phase, the overall stakeholders and roles are similar. The battery as well as the turbocharger are part of a vehicle, which is sold by a distributor to a user, and workshops/maintenance facilities provide repair and maintenance services. The differences are again to be found in the details on how the different tasks are carried out. For instance, the repair process of a turbocharger differs strongly from the repair process of an electric vehicle battery. The role of the user is in both cases similar, namely the use of the car, in which the battery or turbocharger are located and the execution of regular maintenance as well as repair activities of this car. One difference in this phase is, that the turbocharger can also be used for different purposes, namely tuning of ICE, while this possibility of use does not exist for the battery.
End of life	In this life cycle phase strong differences arise. At the end of the use phase of a turbo charger there are two different

	possibilities: the turbocharger is used as spare part for another ICE or recycled, where then the materials are usually shredded and the different metals are recovered. In the case of the battery, it is assessed whether it is appropriate for a second life application. In the case of the battery being appropriate for a second life, it is usually used in a different application than before and in the case of recycling the materials, which are used in the battery are recovered as good as possible. Here, a strong difference to the combustion engine can be detected, given that the turbocharger is either used for the same purpose or recycled while the battery is used in another application or recycled.
Battery second life	This life cycle phase is only present in the case of traction battery use. The battery is used differently than before, for instance, as an energy storage system instead of in a vehicle.

The identification of the different stakeholders of both value chains will be used to identify the corresponding information needs and define requirements for the creation of a DPP prototype. Furthermore, the identified stakeholders were used as basis for the creation of user stories and personas to use within the software development process. Figure 4 below shows an example of a persona that was developed by the project partners. More detailed descriptions of the personas based on this study can be found in D4.2.

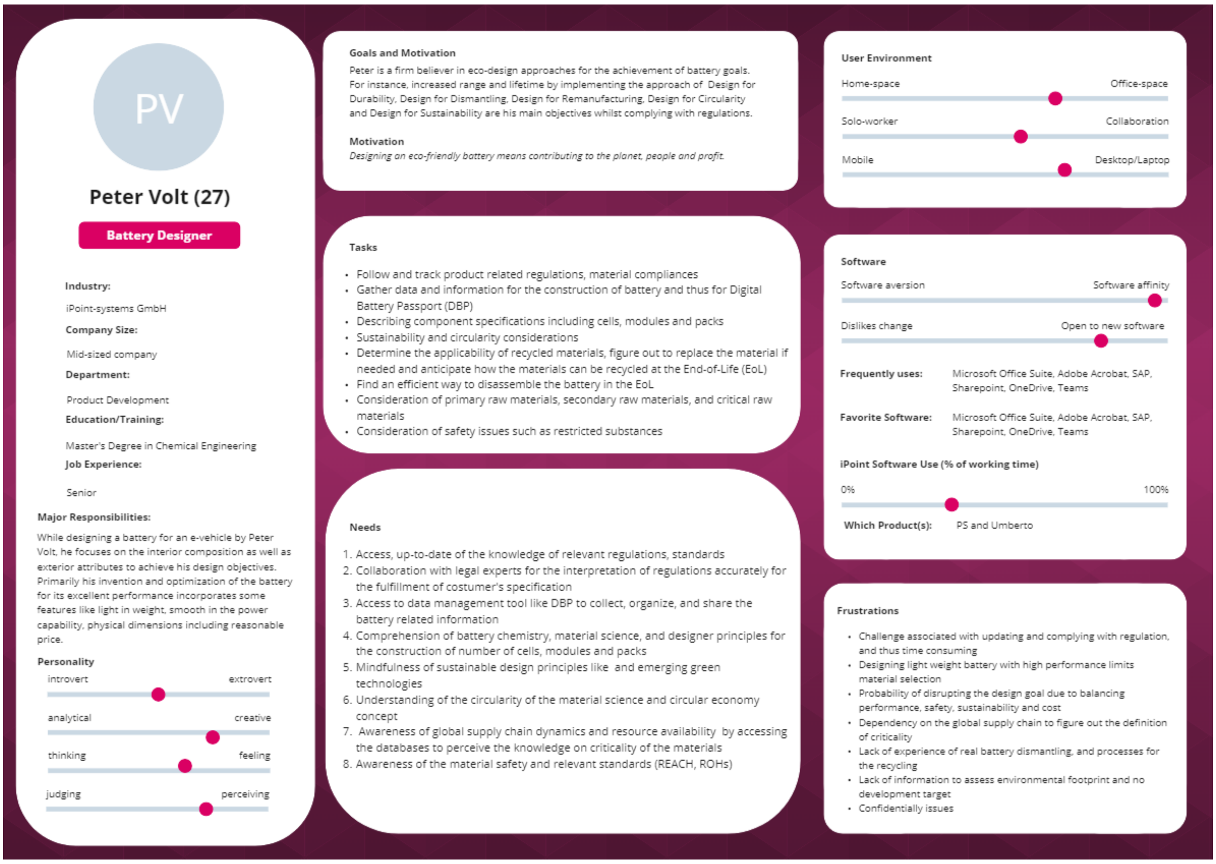

Figure 4. Example persona - Battery designer

To summarize, it can be stated that although there are similarities in the stakeholder roles in both cases, the differences in the details will influence the information to be included in the DPP. In the BoL phase especially the different materials used are important and the more complex production of the battery, which will lead to more necessity of information sharing. In the use phase, the in-use data of car users is important regarding the eligibility of the battery for a second-life application, while there is no need for *in-use data* for the turbocharger use case. The end-of-life scenarios for both use cases vary, as well their respective information requirements. While at the BoL phase information points could be more generic, e.g. “bill of materials” or “assembly and disassembly information”, there will be a need for more specific information points in the use phase, especially regarding potentially dynamic user data for the assessment of the second life option, and in the end-of-life phase, where the two use cases vary strongly.

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