CONCEPT

Digital Product Passport

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The report has been commissioned by:
Technology Industries of Finland
Finnish textile & Fashion

The report has been funded by:
Teollisuuden ja Työnantajain Keskusliiton (TT) -säätiö sr

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Gaia Consulting

1 Executive summary

The Digital Product Passport (DPP) is a technology concept for a digital policy instrument that collects information about the value chain, sustainability, raw materials and safety of products across different sectors. The DPP could also collect information about how products are used, maintained, recycled and repurposed. This transparency is intended to encourage sustainable production, enable transition to circular economy, provide new business opportunities for economic actors, help authorities to verify compliance, and help consumers and end-users to make sustainable choices.

The DPP as a concept is under extensive study by numerous actors, there is a lack of concrete and tangible action plans regarding the topic. The goal of this study was to identify what the DPP concept would look like if designed from the ground up to be practical and feasible, taking into account economic actors' viewpoints, technical feasibility, emerging regulation, trade secret protection, and stakeholder groups' needs. The aim was to create a generally applicable concept that also meets specific industry needs. To facilitate this, the concept was developed in a participatory process involving textile industry and battery value chain actors. Textile industry value chains have been found to be the most complex across industries (Accenture, 2019) while battery value chains are under increasing scrutiny due to the environmental impacts of mining, the global energy crisis, electrification, and safety issues. The participatory design process was complemented with benchmarking of existing technologies and ongoing initiatives, regulatory desktop study, and stakeholder interviews.

According to the findings, the DPP can lead to better and longer-lasting products, responsible actors and collaboration, more sustainable production and consumption, and new circular business models and innovations. Creating business value for economic actors is the key to positive impact. The recommendations of this study go into detail on how to create incentive for economic actors to support and adopt the system. The DPP can balance effort and value for all actors in the value chain by leveraging existing data sources and enterprise systems rather than trying to supplant them.

2 Introduction

2.1 Background and context

Circular economy and policies promoting sustainable products are central to the EU's Green Deal initiative, which aims to develop the EU's competitiveness in digitalization and the green transition. The sustainability of products and their value chains are under increasing scrutiny, as evidenced by the EU's Circular Economy Action Plan (CEAP) 2020, new framework for battery regulation, the EU strategy for sustainable and circular textiles, and the Sustainable Products Initiative (SPI). EU has also proposed this year a legislation Ecodesign for

Sustainable Products (ESPR) that includes the implementation of digital product passport.

A circular economy means rejecting the current linear economy model and adopting a new, regenerative circular economy model. The new model is based on using resources efficiently, wasting as little as possible and re-using waste. Adopting the circular economy model requires new materials and products with new design, new technologies and new production processes. All this requires that value chains and material flows become not only circular but also traceable and more transparent. To support the green transition in the EU, there is a need for innovation in new business and for digital solutions that support the circular economy in practice.

Gathering product data is the subject of wider discussion in the EU: consumers increasingly demand more information about products and their origin. Information about products' chemical composition is needed at the end of the product's lifecycle to identify safe recycling and repurposing options. Traceability and data that follows each individual product is a key question that, if solved, would create a giant leap forward in product industry sustainability.

International, cross-border industries such as the textiles industry and various technology sectors have already implemented voluntary sustainability actions and developed methods for tracing products and their origin as well as for promoting safe circular economy. Companies and industries are continuously looking for new digital solutions to these needs.

As a new concept, the European Commission has proposed developing a Digital Product Passport (DPP). The goal of the Commission is to not only help end-users to make sustainable choices about their consumption, but also to accelerate business-to-business circular solutions. In addition, market regulation and oversight could benefit from developing a Digital Product Passport, which would strengthen the EU's single market.

Companies have seen the Digital Product Passport as an example of how the European Twin Transition can be implemented on a market-driven and voluntary basis. The Digital Product Passport also meets industries' needs to accelerate the circularity of hard-to-recycle materials and components as well as the need to find ways to comply with the Ecodesign for Sustainable Products.

Because the needs for applying the Digital Product Passport are wide-ranging and diverse, its basic specifications need to be as technology-neutral as possible.

The goal of the Digital Product Passport would be to gather information about products throughout the products' lifecycles, and thus enable the traceability of products within the single market. The Digital Product Passport could include comprehensive data about each product, its raw materials, components, sourcing, dangerous chemicals, recyclability, repairability, reusability and disassembly.

The European Commission has stated that the EU needs standards for data sharing and functionality related to the Digital Product Passport in order to

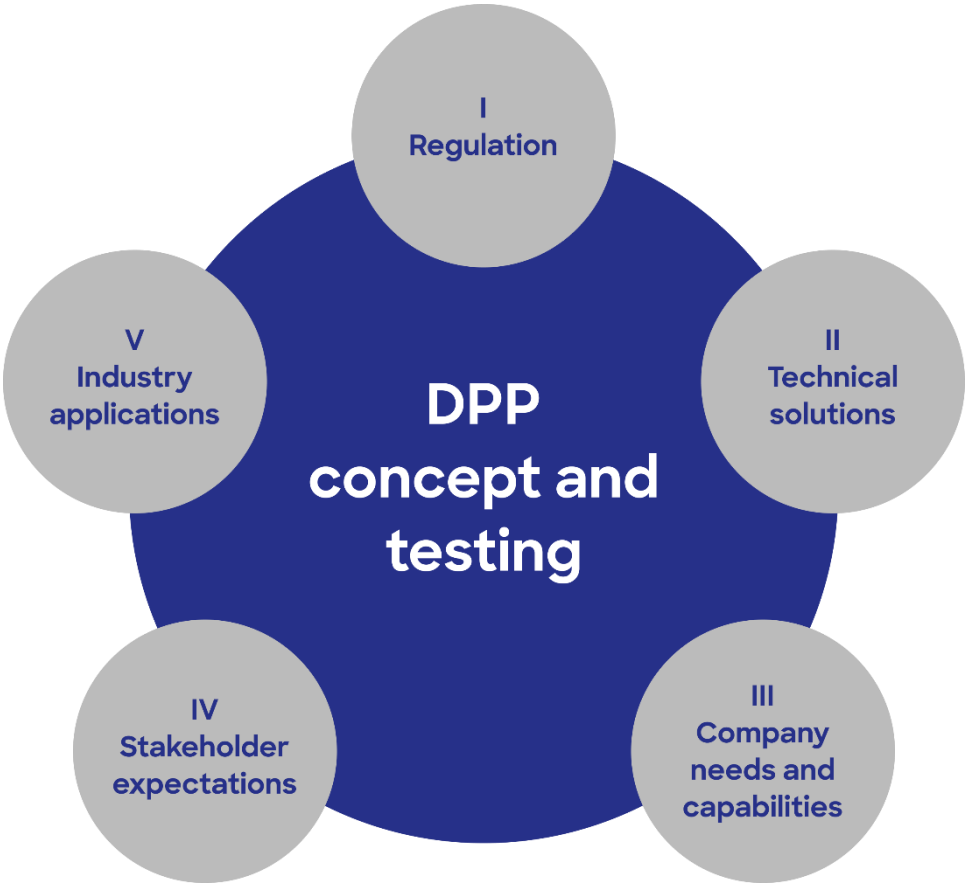
guarantee the operability and security of the system. The European strategy for data aims for the development of common European data spaces. As part of this development, the Commission has requested solution proposals from industries and member states for the Digital Product Passport.

2.2 Objectives

The aim of this study is to define a Digital Product Passport concept that can serve different industries and value chains. The concept will be tested in the context of textile industries and battery value chains. The selected value chains will act as pilots for gathering input and feedback, based on which the concept can be developed further so that it can be applied to other industries and can be offered as a solution across the EU.

The study defines a concept, data architecture and technical approach that meets the needs of companies, developing regulation, and stakeholder expectations. Technical solutions are designed to be generally applicable, so that the Digital Product Passport can be used for different categories of products and is able to support information of different kinds, including, but not limited to material content, material safety, raw material origin, recyclability and repairability. Further, technical solutions are designed to support the enrichment of product information with e.g. data gathered from product use during its lifecycle, without compromising on the trustworthiness and verifiability of the data. The goal is to define a data model that is compatible with the EU regulation on trade secrets.

2.3 Research Questions



I Regulation

From the regulatory perspective, this study aims to identify current and upcoming regulation and voluntary governance systems related to e.g. information management, environmental sustainability, chemical safety, product sustainability, circular economy and waste regulation that should affect development of the Digital Product Passport.

Key results include a description of current and future regulation and recommendations regarding how mandatory legislation and voluntary systems should complement each other in the context of the Digital Product Passport, and an impact analysis of voluntary, market-driven approaches.

II Technical solutions

The study investigates and benchmarks existing technical solutions related to product value chain transparency and product trust, and the applicability of those existing solutions or their technical approaches to the implementation of the Digital Product Passport.

Key results include a description of benchmarks and their approaches, as well as key takeaways and a high-level vision for the technical architecture of the DPP.

III Companies' needs and capabilities

From companies' point of view, the study aims to highlight what product and value chain information is useful for companies, who should be responsible for maintaining it, who has the right to read information, and how information is enriched and verified. Methods include participatory workshops and interviews of company representatives.

Key results include a description of the data model and data management practices related to the DPP concept as well as companies' concerns and viewpoints for the development of the DPP.

IV Stakeholder expectations

From the perspectives of consumers, NGOs, legislators, authorities and other stakeholders, through participatory methods the study aims to shed a light on the requirements and expectations related to product information, traceability and proof of sustainability.

Key results include an evaluation of the role of a voluntary Digital Product Passport in adhering to the duty of care.

V Industry applications

The study aims to evaluate how the Digital Product Passport described and discussed in the results of this study can apply to textile industries and value chain and lifecycle management for battery minerals.

Key results include a description and evaluation of the applicability of the DPP concept in these industries alongside any relevant concerns and development needs.

3 Regulation basis related to the DPP

3.1 Ecodesign for Sustainable Products Regulation (ESPR)

One major legislative undertaking currently under process is the proposal a for a new Ecodesign for Sustainable Products Regulation (ESPR)[1] which is set to create a universal basis for product design, labeling, and reporting requirements that would help reduce the negative lifecycle environmental impacts of products

[1] Proposal for Ecodesign for Sustainable Products Regulation (europa.eu)

and improve the functioning of the internal market. The proposal builds on the current Ecodesign Directive, which only covers energy-related products.

The ESPR focuses on two requirement categories: performance and information. The requirements related to performance dictate how products should be designed in terms of energy efficiency, durability, recyclability, waste generation, and environmental footprint. The information requirements focus on details related to product performance and cover how the information should be supplied with the product in manuals, labeling and/or product passports. With regards to the latter, the ESPR will designate general and product-specific rules on the information that should be included in the digital product passport. The general criteria include rules on inter-operability, accessibility, data points, and roles and responsibilities to maintain the data in the digital product passport.

A product covered by the ESPR is obliged to have a product passport, to enter the internal market.

3.2 Common legislation affecting the general requirements of the DPP

In addition to the ESPR, there are, in general, four different categories to which common legislation can be argued to belong. The categories are:

- Chemical regulation
- Circular economy, sustainability, and waste related regulation
- Safety and product responsibility related laws
- Regulation related to reporting

There are also product group specific rules that apply only for certain products, e.g. Waste from Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (RoHS).

The legislation is summarized in the figure below. Further details on the legislation can be found in the appendix.

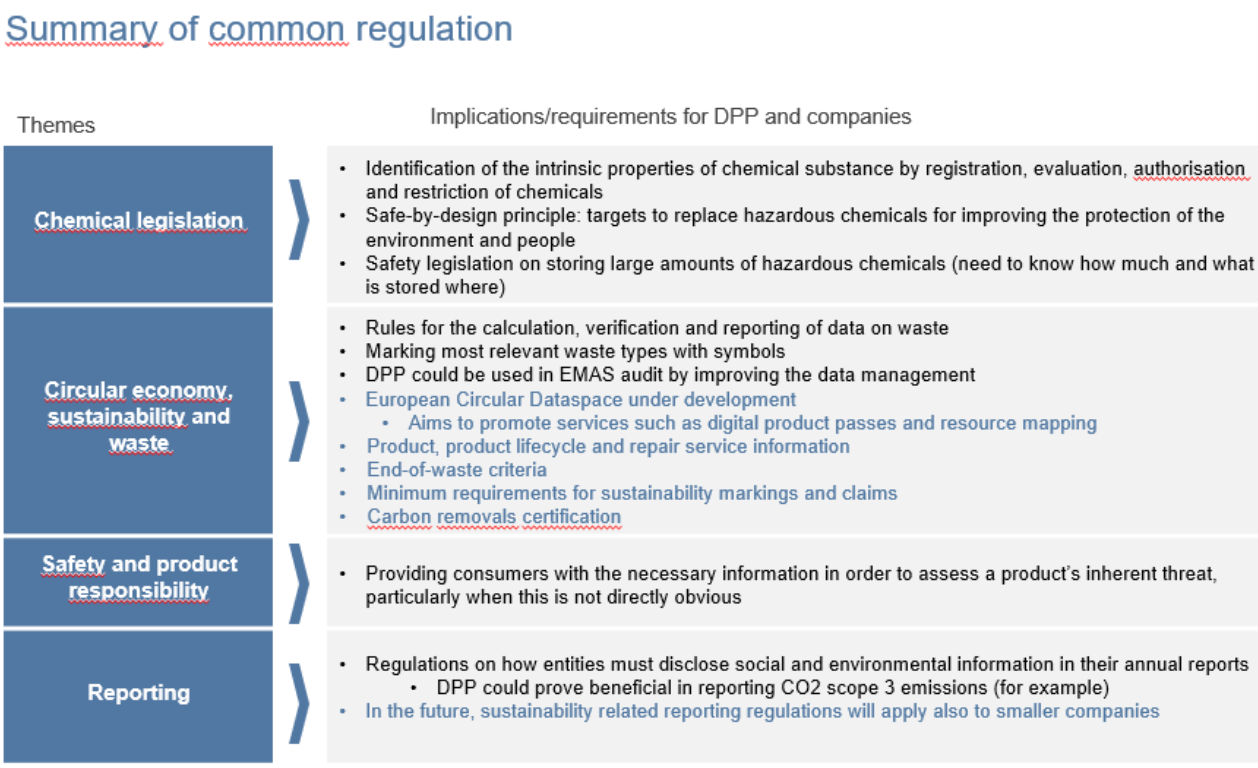


Figure 1 Summary of common legislation

3.3 Legislation for batteries

In general, the battery related legislation can be divided into three different categories:

- Data management and accessibility
- Waste management, recycling, reuse, and sustainable product policies
- Transport regulations and Safety

These categories are summarized in the figure below. Further details on the legislation can be found in the appendix.

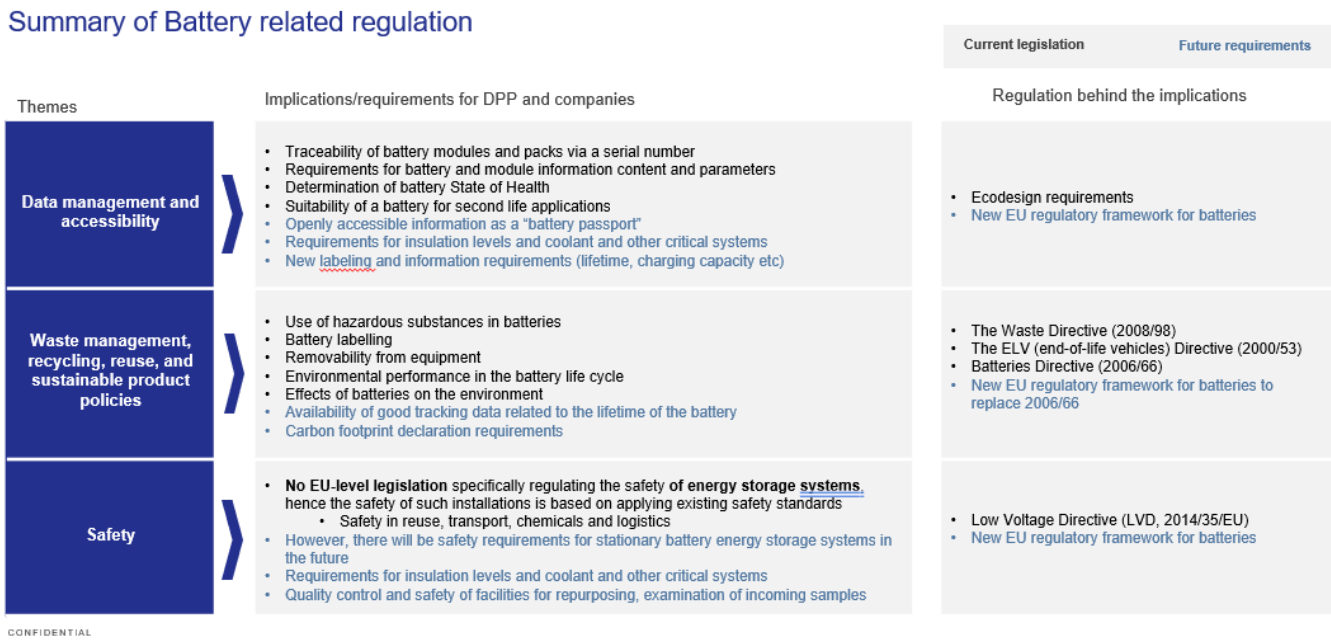


Figure 2 - Summary of battery legislation

3.4 Legislation, initiatives, and strategies for textiles

There are several regulations, initiatives, and strategies affecting textiles.

The EU has aligned laws in all EU countries with Textile Regulation (EU) No 1007/2011. This regulation addresses fibre names and related labelling and marking of the fibre composition of textile products.[2]

While the common EU legislation affects all products in the EU market[3], the following common legislation is the most relevant to textiles: General Product Safety Directive (GPSD); Market Surveillance; Unfair Commercial Practices; Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH); Personal Protective Equipment (PPE) Directive; Toy Safety Directive; Industrial Emissions Directive; the establishment of the criteria for the award of the EU Ecolabel for textile products; and Green Public Procurement (GPP) on textiles[4].

2 For Textile Regulation (EU) No 1007/2011, see Legislation (europa.eu)
3 For general regulation affecting all products in the EU market, see Chapter 3.2.
4 Other legislation related to textiles and clothing (europa.eu)

In addition to the EU legislation, various standards also affect textiles in the EU market[5]. Furthermore, as part of the EU goal to advance circular economy, the Commission is aiming at increasing the sustainability, circularity, industrial competitiveness and innovation of the textile sector.

From the DPP perspective particularly relevant are the following EU level initiatives and strategies: the new European Circular Economy Action Plan (CEAP)[6], the EU strategy for sustainable and circular textiles[7], and the new Ecodesign for Sustainable Products Regulation (ESPR)[8]. Also, the revision of the Waste Framework Directive (WFD) will have relevance to textiles in the future[9].

In general, the EU textile legislation, strategies and initiatives can be argued to belong to four different categories. The categories are:

- Data management
- Circularity
- Waste management
- Sustainable product policies and ecological planning.

The effects of the legislation are summarised in the figure below. Further details on the legislation can be found in the appendix.

5 In addition to the EU legislation, different standards affect textiles that are sold and used in the EU market such as standards related to the safety of clothing. See e.g. New EU Standards on Safety of Children's Clothing | SGS.
6 Circular economy action plan (europa.eu)
7 The strategy implements the commitments of the European Green Deal, the new circular economy action plan (CEAP) and the industrial strategy. See Textiles strategy (europa.eu).
8 Proposal for Ecodesign for Sustainable Products Regulation (europa.eu). See also Chapter 2.3.
9 Waste Framework Directive revision (europa.eu)

Figure 3 - Summary of textile regulation

4 Materials and methods

4.1 Desktop study

Regulatory review was studied through existing and future regulations, policies and EU plans that are driving the digital product passport forward. They set the scene and framework for the principles of the DPP. The fundamental regulations and especially ESPR are playing an important role when bringing the DPP forward in practice. The key regulatory frameworks, policies and plans are described in detail in the appendix.

4.2 Benchmarking

The idea of the DPP, existing systems and ongoing projects were studied by looking at both public and private DPP initiatives as well as other publications and projects. Key principles and assumptions were gathered and tested at the interviews and workshops, and after validation described as design drivers for the concept. All benchmarks are listed at the appendix of this report.

4.3 Workshops

The business needs and values described in the study are an outcome of a participatory design workshop for businesses. Technology Industries of Finland was represented by four participants and six member company representatives. Finnish Textile & Fashion organisation had three participants, seventeen member companies and in total eighteen representatives. There were different

types of businesses working in different phases of the product value chain. The participatory design workshop focused to enlighten following topics:

- Short-term and long-term business value of the DPP for companies
- Challenges and concerns of companies
- Use cases and needs; identification of needed user interfaces and functionalities of the DPP
- Data needs of different actors
- Opportunities vs.effort balance

Later the battery and textile industry perspectives were analyzed based on the participatory workshops arranged for these two industries in April and May. In total, 14 textile industry companies and 3 technology companies together with key persons from Finnish Textile & Fashion and Technology Industries of Finland participated in the textile workshop and 3 battery industry companies together with key persons from Technology Industries of Finland participated in the battery workshop to discuss the following topics:

- The most relevant data elements in different phases of value chain supporting traceability, sustainability, circular economy, and safety
- Data sharing
- Benefits of digital product pass
- Challenges related to data collection

4.4 Interviews

The generic concept of the DPP was discussed in the context of textiles and batteries by conducting interviews with individual representatives (private companies and the public sector) of the textile and battery value chain, and by addressing the findings of the interviews and the concept in workshops where different value chain stakeholders shared their thoughts of the matter together. These interviews were conducted prior to the industry workshops held in April and May.

In general, the findings of the interviews and workshops can be characterized by these categories:

- The value and usefulness of the DPP to the value chain
- Specific data points
- Principles of how to collect and store data
- Possible challenges of implementing the concept

5 Results

5.1 Digital product passport concept

5.1.1 Phased implementation

Based on the findings of this study, the Digital Product Passport should be built in phases. Because the needs and requirements of different economic actors and stakeholders for Digital Product Passport are so diverse depending on the value chain stage, industry, product category and other factors, it is impossible to build a system meeting all the needs without building shorter feedback loops into the implementation process. This means that new capabilities and functionalities should be introduced gradually while exposing the system to new industries and gathering feedback to identify further development needs.

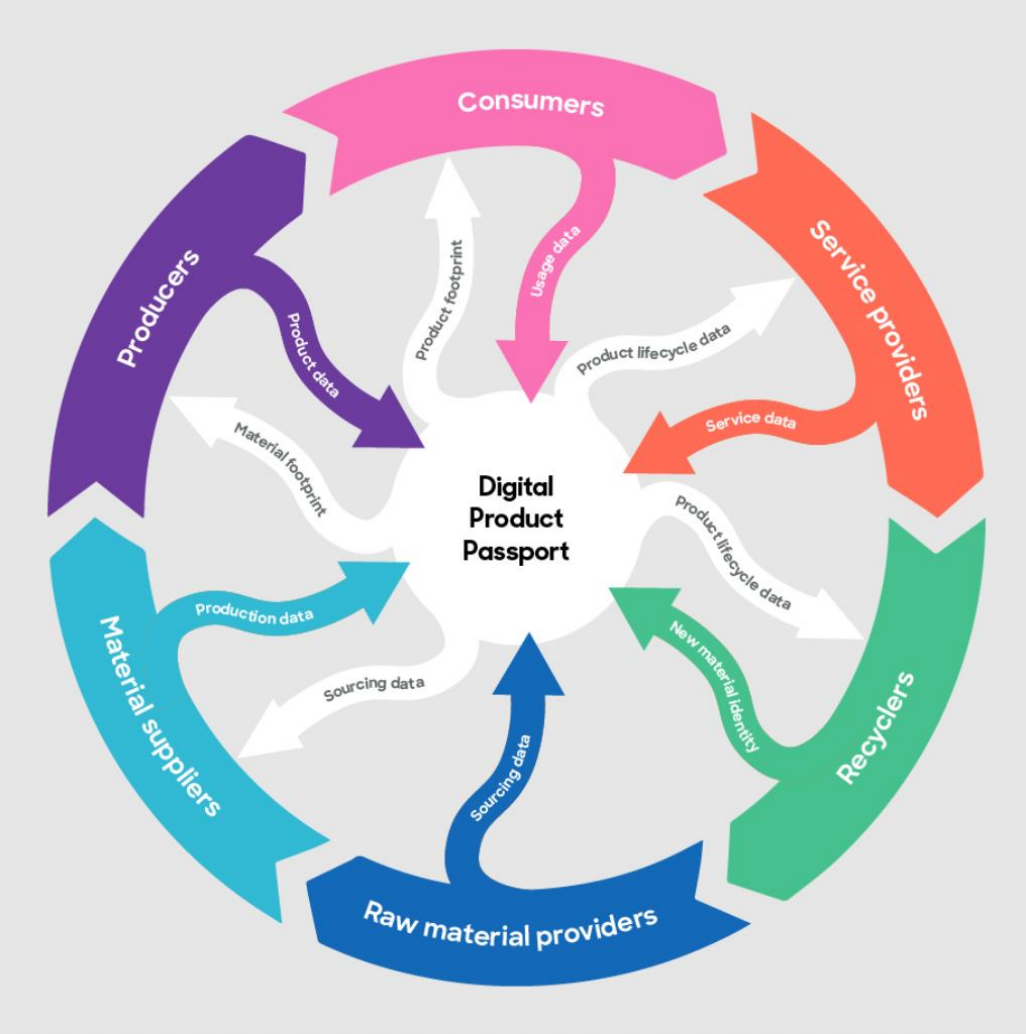
Additionally, a phased implementation is necessary to ensure actors are capable to manage the changes to their business and production processes.

5.1.2 Long-term vision of the DPP

The Digital Product Passport will increase transparency of the full life cycle of a product. The passport will tell how sustainably materials are sourced, what are the social and environmental impacts of used materials, production, use and end of life.

The DPP will support companies in their product sustainability reporting and emission calculation for all three scopes: reporting company (scope 1), upstream activities (scope 2) and downstream activities (scope 3). Information on product safety and substances of concern will become more accessible.

The DPP will support consumers and service providers to lengthen the product life cycle with instructions. Durability of products will become transparent when there will be data collected during testing, use, maintenance, repair and finally recycling. This will enable companies to develop their products further.



5.1.3 Actors

The concept will focus on actors who all have an important role in both giving and receiving product data:

- raw material providers, including recyclers and virgin raw materials providers
- material suppliers, including materials and components
- producers of end products
- consumers and end users of a product, including b2b and b2c product use and maintenance
- service providers such as product renting, resale, maintenance and repair services

- recyclers, including collection, deconstruction and sorting of waste

Raw material providers, material suppliers and producers are all in important role of giving data about the production value chain. Consumers, service providers and recyclers need data about the product, but will also enhance the data with products use life information.

In addition to people, actors can also be devices, software or organisations. Examples of such:

- Devices that update information in digital product passport, for example electric vehicles updating number of battery discharges
- Organisations that do auditing, validating reporting or giving credentials, for example third party who calculates the product CO2 footprint and updates this information to the product passport

5.1.4 Design drivers

Effort-value balance for businesses

That businesses stand to gain from the DPP is key for rapid adoption and scaling across industries. Value of the DPP for businesses can drive rapid digital transformation and increased transparency especially in low-maturity industries.

Leveraging existing data

The DPP integrates to existing enterprise systems and minimizes the need for manual data management for actors.

Reliable data via standardized, verifiable credentials

Actors produce data about their own production or services as verifiable credentials on a decentralized data system in standardized international data formats.

Passport of realized products

The DPP represents realized production batches and value chains of actual, existing products.

Generic and widely adaptable

The DPP is generic enough to serve a wide variety of industries across the EU. It's fair and adaptable across all business sizes and poses minimal bureaucracy.

Open ecosystem

The DPP is a foundation for an open ecosystem of public and private actors to build their own digital applications, integrations, and innovations both globally and locally.

Modular and scalable

The Digital Product Passport concept is designed to create value already in the first-phase implementation, but the concept scales to new needs, use cases and industries over time.

5.2 User interfaces

Data will be provided to Digital Product Passport via many different interfaces. A large amount of data is provided when actors integrate their enterprise systems to the DPP service using APIs (integration interfaces between different systems that provide automatic data transfer). That way the information that is created and edited using actors' internal tools, such as PIMs or ERPs, can be automatically synchronized to the DPP.

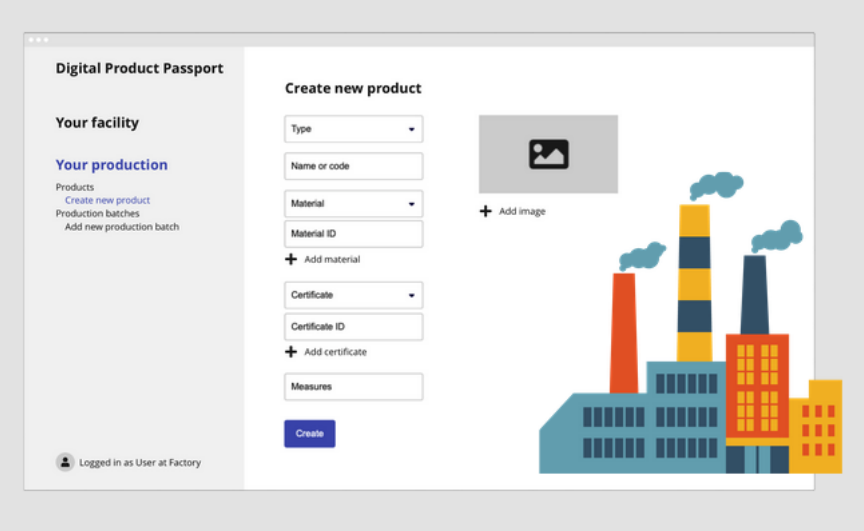
However, all actors don't necessarily have the resources to immediately integrate their own systems with the DPP. Some actors, particularly SMEs do not even have such systems available. In the building phase of the DPP, all integration options may not even be available.

For these situations, user interfaces are offered so actors and other stakeholders can read data from and write data to product passport.

Visual user interfaces will make data in the DPP accessible for different groups throughout the product's life cycle. We have recognized a need for two different user interfaces to make the first-phase implementation of the DPP deployment in larger scale possible. They are data input interface for production and digital product passport interface to access the product data.

5.2.1 Data input interface for production

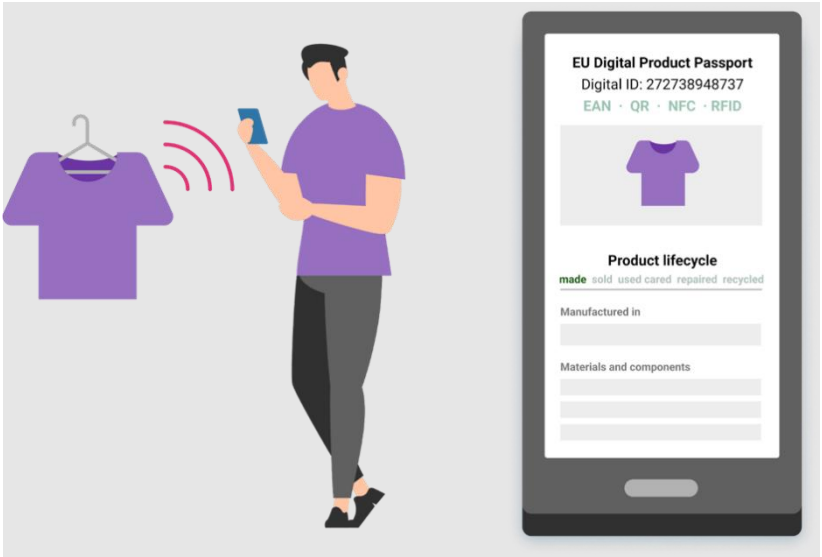
The data input interface should be offered for raw material providers, material suppliers and producers. The first phase implementation of the DPP data input interface will, for the most part, be intended for storing data that companies already have in some form.



5.2.2 Digital product passport interface

Digital product passport interface is offered for reading data about the product. The main interest groups are consumers and end-users, service providers and recyclers, but it offers visibility to value chain also for material suppliers and producers.

Later the same interface could offer possibilities for data input about the product during the use phase.

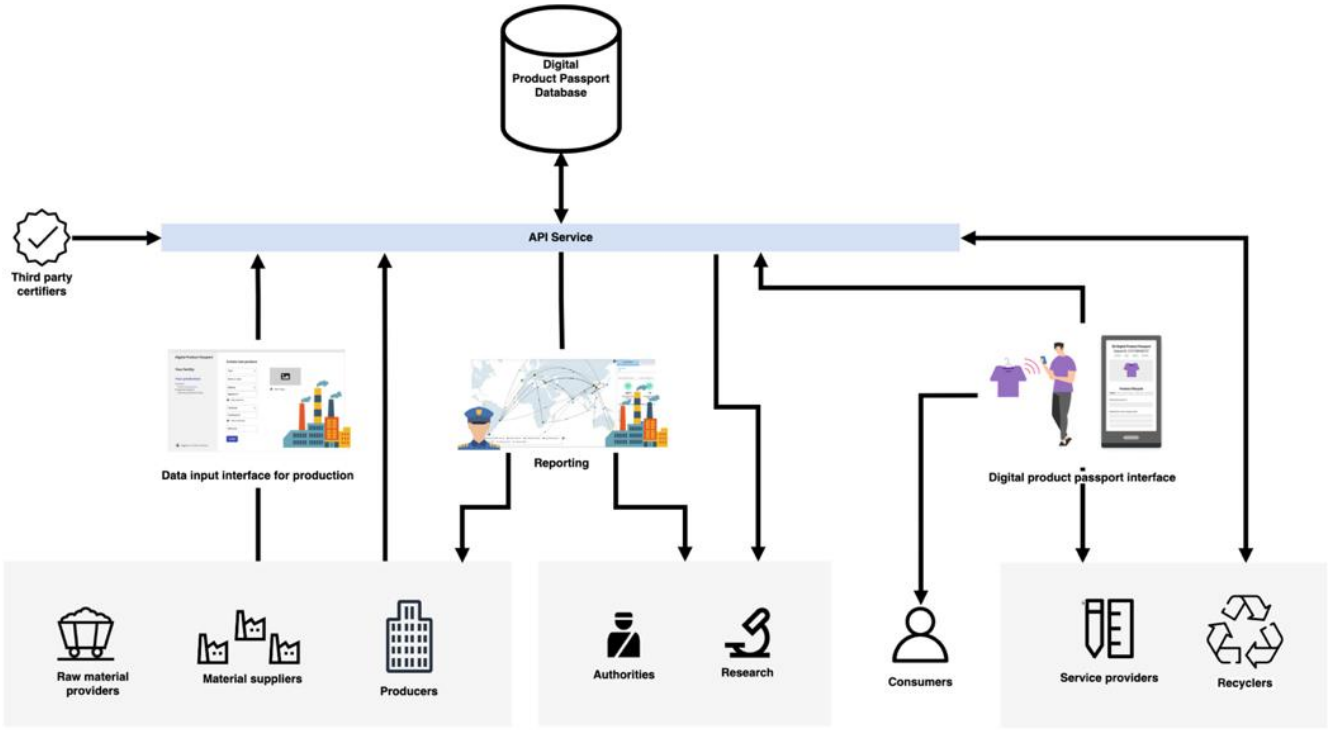


5.2.3 User interface ownership

User interfaces should be build for the main use cases and the most important target groups. There are also other opportunities and access through public or partly restricted APIs gives opportunity for national operators and businesses to innovate and build their own user interfaces. There could be many benefits on national applications like language versions and instructions following the national laws and regulations. Open data would give space for innovation and business models.

5.3 Vision of high-level architecture for the DPP

These chapters describe the concept vision of the DPP high-level architecture. It is not an implementation description (although some implementation-related concepts are also discussed). The high-level architecture describes the connections between the main functionalities of the DPP.



It should be noted that The Digital Product Passport Database shown above is a high-level concept for data storage which can be a single database or decentralized data storage. The actual implementation of data storage is not described in this document.

Another notable thing is that the Digital Product Passport data will be produced at many different sources using various methods of input – the Digital Product Passport is a collection of many different pieces of information.

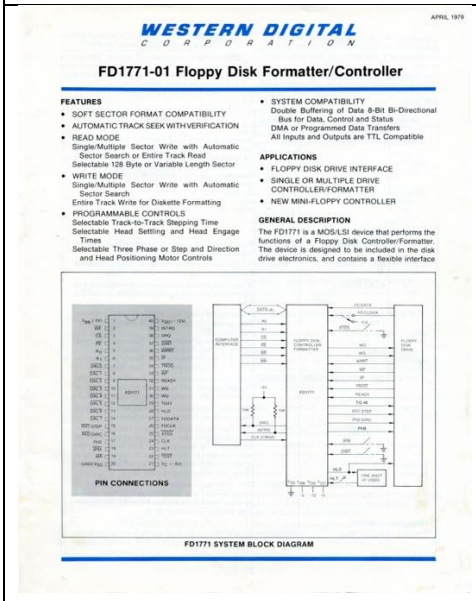
In this document we propose a first phase implementation that will provide a prototype of the Digital Product Passport. It will contain simplified version of the actual product. The differences are described below:

Version	Data input	Data storage
First phase	Single graphical user interface	Single database
Final phase	Many different interfaces: APIs, UIs, integrations	Decentralized data storage

5.3.1 Digital product passport as a tree of information

The digital product passport can be thought as a container for information from multiple sources.

The simplest form of the DPP is a collection of data entries that contain information about a product, in a same way as *data sheets* were physical documents describing characteristics of products, machines or components.

Front page of a floppy disk controller data sheet (1979)[10]	Digital data sheet containing key-value pairs
	

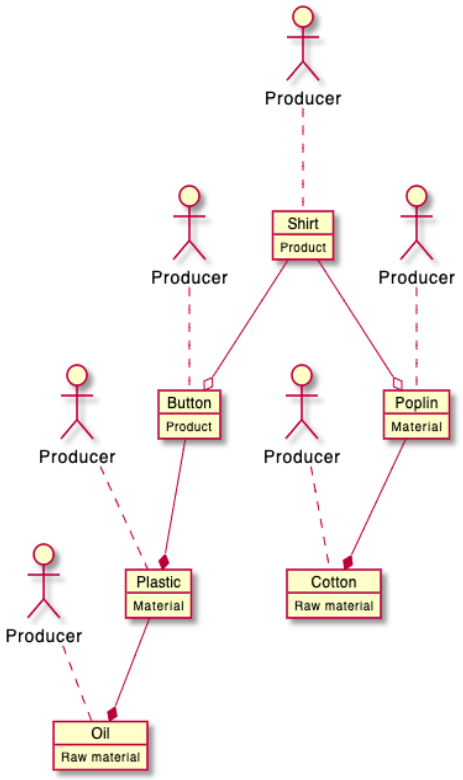
ID	00012345678905
Width	22 cm
Production date	2022-01-02

[10] Data sheet (Wikipedia). Image copyright: Public domain

The digital product passport will extend the amount of information with additional data sheets that contain other product-related information, such as material information, certificates, instructions and so on.

As the product consist of parts and materials, these have their own data sheets that can be linked to as well.

In the end, the digital product passport becomes a linked tree of data sheets for the product:



Each data sheet is managed by the actor who is producing that particular information. Data sheets are linked together by unique identification keys.

There is no single item called Digital Product Passport – instead the product passport is a collection of information about a product where pieces of information can be created and modified by relevant actors and linked to the whole.

There is no central storage location for saved information - instead, each data provider determines the location and accessibility of information.

Decentralized storage of data brings following benefits:

- Data is produced at its birthplace - it is always up-to-date and correct

- More data can be created and connected to the product passport as it is created
- Data entries can be removed or modified
- Information providers can be identified
- Producers can control the access to data by choosing the amount and visibility of sharing
- The digital product passport system is not owned or controlled by any single entity
- The tools and systems for controlling data are not limited to any vendors or systems - the actors can freely choose the tools as long as the tools follow open standards

5.3.2 Using the information in the DPP

As the information is decentralized, information can be used in various ways. In addition to viewing the data entries for the product, the viewer can follow the link chain to find information about subparts and materials.

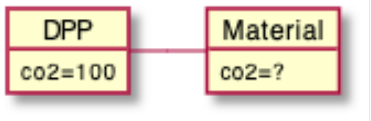
New inferred data can be created from existing data: for example, the carbon footprint of the product can be calculated by traversing the linked material and subproduct information and adding up the amount of CO2 emissions for the parts and materials of the product.

This calculated information can be saved as a new data sheet and linked to the product.

Access control

Each actor can control and limit the accessibility of the information they provide. In the carbon footprint calculator example above, the access to CO2 emissions of materials can be limited only to e.g. official agencies.

That way the general public is not able to see CO2 data of material but has access a calculated data of total amount of CO2 emissions in the product passport.



Even though limiting information access is possible on concept level, we encourage the actors to be open with information visibility. Information transparency can be ensured on policy level.

5.3.3 Technical details of the DPP architecture

We propose implementing the digital product passport with The World Wide Web Consortium (W3C) standards-based solution. These standards are widely supported and offer numerous benefits for the DPP architecture.

The implementation will be based on

- Decentralized identifiers
- Verifiable credentials
- Verifiable presentations

Decentralized identifiers

Decentralized identifier (DID) is a unique identifier that is used to identify wide variety of objects and things. Each product that has a digital product passport has a DID. The companies and other actors providing information for the product passport have DIDs as well.

A decentralized identifier contains cryptographic information that can be used to ensure the identity of the DID owner. DIDs also contain service endpoints that can be used to interact with the DID. These endpoints also provide access to verifiable credentials.

DIDs exist as documents that can be saved in many types of locations: blockchains, web servers, etc. Each DID has a URI address that can be used to locate and read the DID document.

DIDs vs. organisation-managed identifiers

As the name implies, decentralized identifiers are not created by centralized organisations but are instead created by the entities themselves. DIDs can be used alongside centralized identifiers such as GS1 GTINs[11].

Verifiable credentials

Verifiable credential (VC) is a set of information which is a claim made by one entity (identified by DID) about another entity (identified by DID).

With digital product passport a verified credential is created when an actor (identified by DID) creates a claim about the product (identified by DID) and signs it. The claim can, for example, be one or more value-attribute pairs. After signing it becomes a verified credential that is attached to the product via DID.

[11] Accessing Digital Product Passports with Decentralized Identifiers (DIDs) (medium.com)

A third party can verify the correctness of claim by checking the digital signatures of the party who has made the claim and the product that the claim has been made about using keys available from DIDs.

Verifiable presentations

Verifiable presentations are combinations of information that are created from collections of verifiable credentials.

That way a number of separate data sheets, claims and other information can be combined into one verifiable presentation that contains metadata, the information and proofs of authenticity as digital signatures.

Benefits of W3C standards-based solution

The solution which is based on decentralized identifiers and verifiable credentials offers many benefits:

- End-to-end verifiability: product data correctness and completeness can be ensured
- Data quality: correctness of data is ensured by digital signing by known actors
- Revocation: if data is found to be incorrect or information provider found to be untrustworthy, the digital signatures can be revoked and false information can be invalidated
- Access control: actors can limit the data visibility to known parties recognized by a digital signature
- Inclusivity: being based on standardized solution means that the actors can use a wide variety of software from open-source solutions to commercial solutions
- Flexibility: the system which is based on trust chains is not dependent on any single controlling entity but can grow and extend independently

5.3.4 Implementing the DPP architecture

Standards of decentralized identifiers and verified credentials are still evolving. Other requirements are still high-level as well, so this concept does not describe detailed technical implementation of the DPP architecture. Instead, there are some guidelines that are described below.

Physical identification and data carriers

The physical form and structure of products and materials vary a lot. Therefore, there is no single solution for presenting product identification.

An example of physical form of a digital product passport is a QR code which contains DID URI address pointing to web-based DID resolver, which provides context-related response to the user. Response could provide a way to view the DPP or provide an endpoint to modify or add information to the DPP by creating new VCs.

Some information could also be coded directly into the data carrier - this should be limited only to information that is considered permanent.

Storage

DIDs and VCs are stored in decentralized storage which means that each actor is responsible for storing their information. Storage options vary from blockchains to web pages or various tools - this concept does not delve further into that subject.

5.4 First phase implementation of the DPP

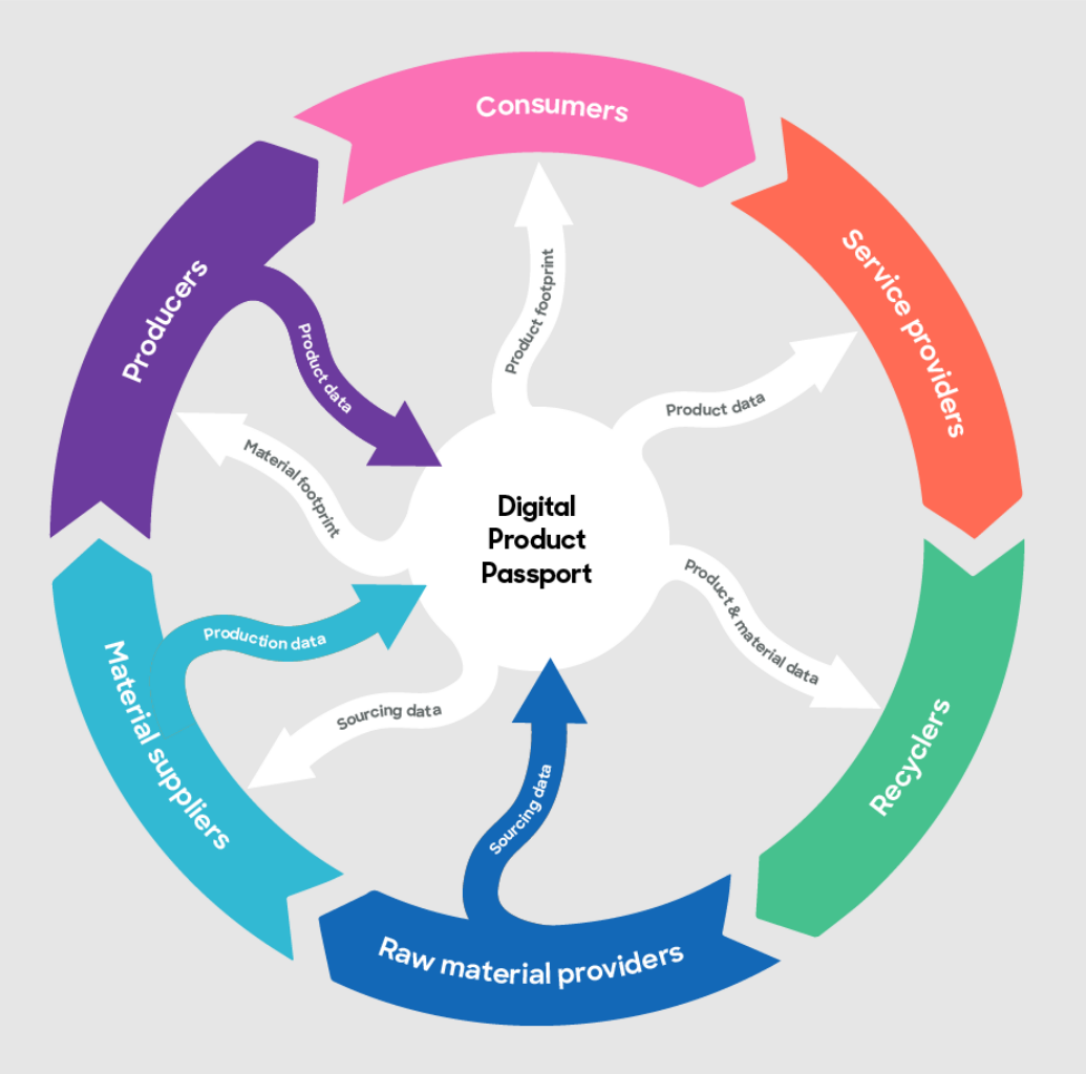
The Digital Product Passport concept is so complex and actors' needs are so diverse across industries that trying to implement the long-term vision in one broad stroke is not feasible. Therefore, the DPP should be implemented in phases, introducing new functionalities gradually as the DPP is introduced to new industry contexts.

The first phase implementation of the DPP described here is intended to serve as a starting point for implementing the Digital Product Passport concept in practice. It is intended to represent a version of the concept that can be built today, and that can provide value for economic actors and the European CEAP.

The first phase implementation of the Digital Product Passport is primarily intended to primarily collect existing data from product value chains. That way adoption is made easier for the companies. The first phase implementation is designed to be general enough to serve industries with heterogenous needs.

The main objective of the first phase implementation is to gather data from long production value chains and make it visible to increase transparency. The data will be available for different stakeholders throughout the whole product life cycle.

The main difference between the first-phase implementation and the long-term vision of the DPP is that in the first-phase implementation data is only collected from sourcing and manufacturing. This is due to practical reasons. A digital product passport is built in an ecosystem where there are several actors and needs. It seems appropriate to start with the actors upstream in the value chain, as they will have a reason and an opportunity to be part of the DPP. The system will evolve in a modular way over the years, step by step, towards a visionary solution covering the whole value chain.


Consumers
Service providers
Recyclers
Raw material providers
Material suppliers
Producers
Digital Product Passport
Product footprint
Product data
Product & material data
Sourcing data
Production data
Material footprint
Product data

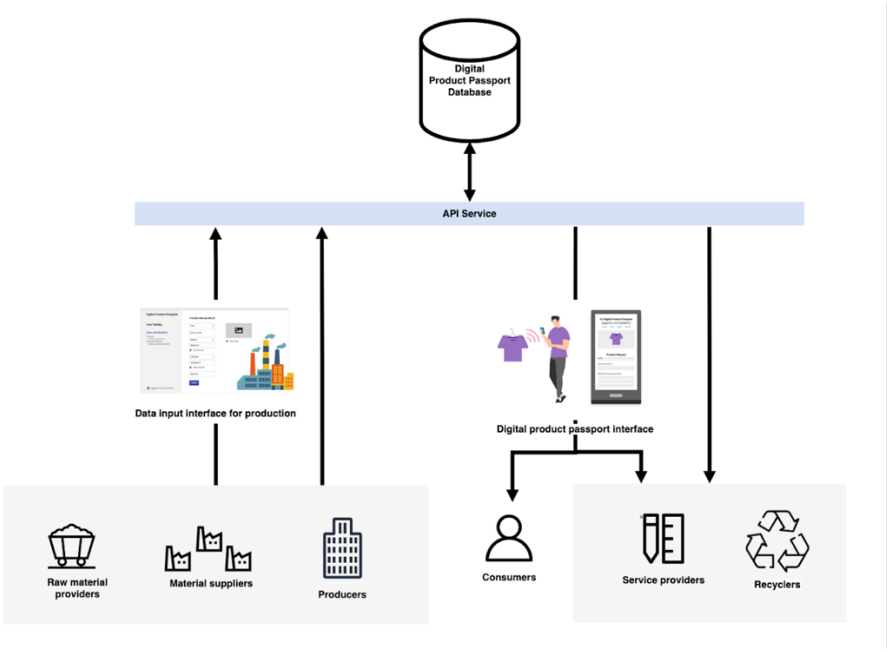
5.4.1 First phase implementation data

First-phase Digital Product Passport data	Availability in existing registers and systems	Regulation
Actor • Trade ID • Trade name • Function • Location	European Business Register, national business registers	
Product data • Raw material/material/product • Product ID • Measures	GS1 Enterprise systems	• Sustainable Products Initiative
Production • Batch • Date	Enterprise systems	• Extended Producer Responsibility
Composition • Composition • Recycled/virgin materials	Enterprise systems	• Ecodesign Directive • Circular Economy Action Plan (Part of Green Deal) • Extended Producer Responsibility • Textiles and clothing legislation 1007/2011
Chemicals • Hazardous and non-hazardous	SCIP	• REACH directive • The Dangerous Substances Directive 67/548/ETY
Safety • CE markings	Enterprise systems	• General Product Safety Directive 2001/95/EC • Seveso III directive (2012/18/EU)
Recycling • Type of waste		• The Waste Directive 2008/98 • Waste Framework Directive • Waste Statistics Regulation (2150/2002) • The Basel convention

	Generated data	Data needs
Raw material providers	• Actor data: ID, name, location • Product data: type, ID, measures • Production: batch, date • Composition: material, virgin/recycled • Chemicals	—
Material suppliers	• Actor data: ID, name, location • Product data: type, ID, measures • Production: batch, date • Composition: material, virgin/recycled • Chemicals • Safety • Recycling	• Raw material composition: material, virgin/recycled • Chemicals used in raw materials
Producers	• Actor data: ID, name, location • Product data: type, ID, measures • Production: batch, date • Composition: material, virgin/recycled • Chemicals • Safety • Recycling	• Material composition: material, virgin/recycled • Chemicals used in materials • Safety of materials
Consumers	—	• Producer data: ID, name, location • Product data: type, ID, measures • Production: batch, date • Product composition: materials, virgin/recycled • Chemicals • Safety • Recycling
Service providers	—	• Producer data: ID, name, location • Product data: type, ID, measures • Production: batch, date

		• Product composition: materials, virgin/recycled • Chemicals • Safety • Recycling
Recyclers	—	• Product composition: materials, virgin/recycled • Chemicals • Safety • Recycling

5.4.2 First phase high-level architecture

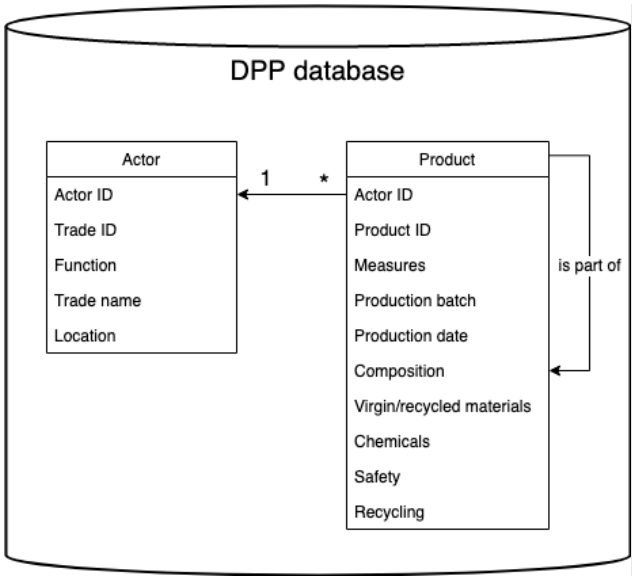


5.4.3 First phase data model

Actors that will input data to the DPP in this phase are raw material providers, material suppliers and producers. The data can be sent to digital product passport system via API or manual data input interface. All actors will provide same information about their business trade ID, trade name, function, and location. Due to international competition laws some of the actor related data could be held private and this should be considered in the APIs' design. Actor data of producers should be public due to extended producer responsibility.

Raw materials, materials and product could all be saved in similar format. There should be some differences in what type of data is mandatory for each of the actors. The broadest mandatory data set is requested from the producers.

The first phase implementation will not use linked verifiable credential (VC) structure for data, but uses more straightforward database instead.



5.5 First phase vs. long-term vision effort and data opportunities

	First phase implementation		Long-term vision	
	Effort	**DPP data opportunities**	**Effort**	**DPP data opportunities**
Raw material providers	Provide existing data from enterprise systems to DPP via API or manual entry.	Become visible in later stages of product value chain (risk or opportunity?)	Provide new data from new or existing data sources to DPP via API or manual entry, e.g., environmental, and social impact.	Improved market understanding and evaluation of own production against it. External validation of actor and production sustainability and quality, resulting in fair pricing.
Material suppliers	Provide existing data from enterprise systems to DPP via API or manual entry.	Improved transparency into raw material composition, sourcing, chemicals used.	Provide new data from new or existing data sources to DPP via API or manual entry, e.g., environmental, and social impact.	Improved market understanding and evaluation of own production against it. External validation of actor and production sustainability and quality, resulting in fair pricing.

Producers	Provide existing data from enterprise systems to DPP via API or manual entry.	Improved transparency of value chain, product safety, and production chemicals. Brand and reputation benefits.	Provide new data from new or existing data sources to DPP via API or manual entry, e.g., environmental, and social impact.	Supports sustainability reporting and creates product lifecycle data to support R&D. Improves ability to evaluate value chain and suppliers.
Consumers	—	Improved ability to evaluate value chain, composition, and product safety.	Automatic, privacy-preserving data entry via IoT and connected devices.	Enables better buying decisions by improving ability to evaluate product quality, sustainability factors and ethical questions.
Service providers	Read data from DPP via API or manually.	Visibility into product value chain, age, and composition.	Provide data about renting, resale, maintenance, and repair to DPP via API, manual entry, IoT or connected devices.	Visibility into product lifecycle and product maintenance instructions, enabling new business models.
Recyclers	Read data from DPP via API or manually.	Visibility into product composition, age, and chemicals used.	Provide data about product lifecycle length and recyclability to DPP via API or manual entry.	Visibility into production side streams.

5.6 Key takeaways from stakeholder interviews and workshops

5.6.1 General attributes of Digital Product Passport

During the participatory process, economic actors representing various stages of industrial processing and commercial distribution identified numerous ways in which the DPP could create value over different timeframes:

Immediate benefits

- Incentive for digitalization of product information in all parts of the value chain.
- Associating individual product information with each individual product.
- Availability of up-to-date individual product information to all parties that need it.
- Transparency and standardization.

Near-term benefits

- Building a comprehensive picture of product safety and sustainability using value chain data.

- Easier product quality and sustainability communication.
- Brand and reputation benefits.

Long-term benefits

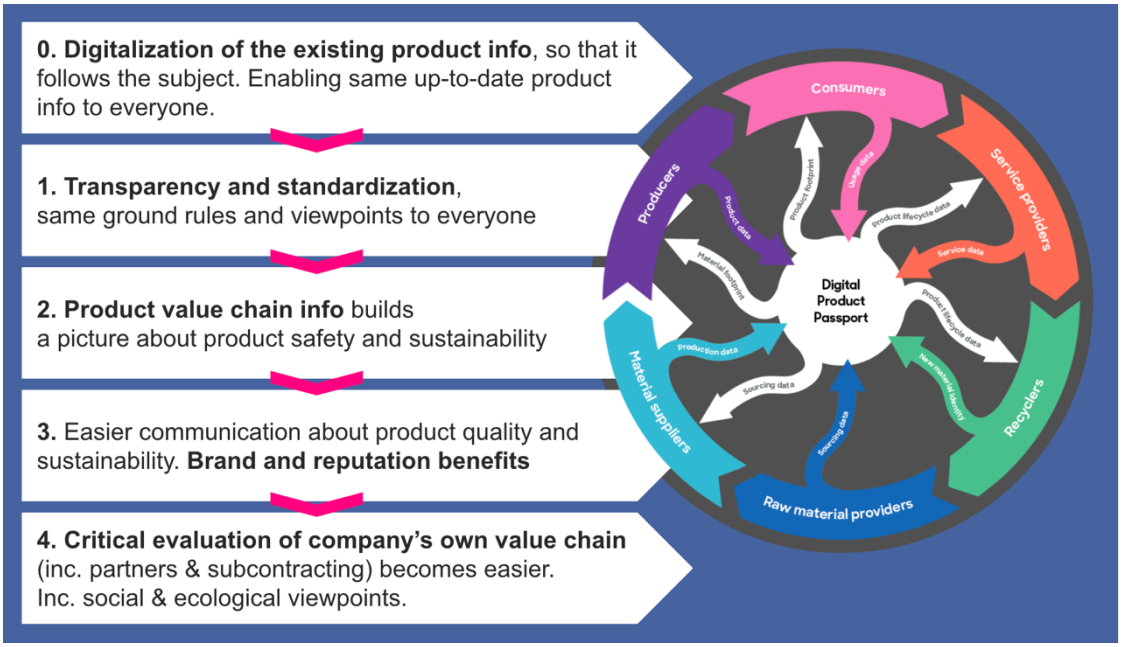
- Critical evaluation of company's own value chain (incl. partners & subcontracting) becomes easier. Incl. social & ecological viewpoints.

Business value drives improvements in quality, environmental factors and social responsibility. Value for economic actors is a prerequisite for circular economy.

Product-level traceability and detailed raw material, sourcing and component information enables better quality products. Defects, low-quality material batches and other factors are identified more easily by companies at different stages of the value chain. This leads to more durable products with a longer lifecycle due to increased repairability, but also enables new business models and innovation around circular economy.

New jobs could be created around product lifecycle services and materials reclamation and reuse. Higher quality product-level material and component data enables more efficient recycling and saves natural resources, improving the business viability and sustainability of various product industries.

Increased value chain transparency encourages responsible collaboration and selecting responsible partners. This creates healthy competition around the topic of value chain sustainability and creates pressure to avoid irresponsible actors, creating opportunities for increased pricing.



5.6.2 Identifying special characteristics of the DPP for textile and battery industries

The results of the desktop analysis, first stakeholder workshop and stakeholder interviews were later discussed in two participatory workshops arranged for the textile and battery industries in April and May. The workshops focused on discussing the most relevant data elements in different phases of value chain, data sharing, benefits of the DPP, and challenges related to data collection. As a result of these phases, the special characteristics of the DPP for both industries were identified.

5.6.3 Special characteristics of the DPP for textile industries

As the textile sector is known for the complexity and global nature of its value chains, it offers an interesting empirical context for testing the DPP concept that can also shed light on the applicability of the concept in other goods.

The value chains of textiles include a great number of process stages, carried out by different industrial actors. The basic value chain of textiles includes the stages of fibre production, spinning, weaving/knitting, finishing, cutting, and sewing, merchandising, wholesale/retail, consumption, and disposal/recycling. The production of a finished textile product often includes the production of different components and intermediate products before the finished product can be assembled. Hence, to understand to which of these “products” in the textile sector the DPP will be applied, a clear definition is needed for what is meant by a “product” in the context of the DPP.

Finished textile products include many different product sub-categories such as apparel, home textiles, technical textiles, and textile fibre. In addition, a textile product can be a service when a textile good is for example leased to customers. Textile products can thus include for example pullovers, underwear, workwear, carpets, tablecloths, car seat covers, furniture covers, medical textiles, healthcare products, hygiene products, agro-textiles for crop protection, protective clothing, sounding boards, threads, yarns, and textile fibre. These different textile products have different value chains. They also differ in terms of product life cycles and material sustainability issues. Textile products cannot therefore be addressed as one product category. This implies that clear definitions for a textile product and its sub-categories are needed to better understand how the DPP will be applied in the different textile product sub-categories.

Furthermore, to ensure data comparisons and objectivity, and to avoid the risks of misleading sustainability claims, there is a need for consistent data formats, calculation principles and definitions. Without these, the data collected into the DPP cannot be compared and the DPP will not provide its users with objective information on the product’s sustainability performance. In the textile sector, the need for consistent data formats, calculation principles and definitions applies in particular to chemicals, fibre types, emission data and water use.

In addition to the need for consistent data formats, calculation principles and definitions, adequate resources in the value chain are an important pre-requisite for implementing the DPP in the textile sector. The textile value chain actors are likely to need additional or new types of resources such as time, IT skills and sustainability data knowledge. In addition to work done within a textile sector company, textile sector companies may also need to invest in advancing sustainability knowledge and data standard understanding among their value chain partners. All these efforts related to the DPP implementation in the sector require additional financial resources and investments both from large and small textile sector companies.

Challenges and development areas

The digital product passport should not become an excessive collection of data. Rather, it should include only the data necessary for creating sustainability impacts in the textile sector. The importance of information required at different stages of the value chain should therefore be assessed carefully to define what kind of information should be included in the DPP. For complex products such as textile products, it can be challenging to create a comprehensive list of materials and chemicals. Therefore, the information required to be inserted in the DPP should reflect the EU circular economy and textile strategy goals.

In addition, due to several production stages and varying production partners, the DPP implementation at product level may become challenging. The implementation might be more feasible at a product batch level.

Overall, the adoption of the DPP is likely to increase workload in all textile sector companies. The DPP should not, however, increase administrative burden for companies. The textile sector SMEs that are already operating with low profit margins and have limited resources, are likely to face financial challenges in using the DPP. On the other, new textile sector innovation companies, e.g. producers for new man-made textile fibre, are likely more prepared to adopt the DPP as sustainability data disclosure is already needed for commercial purposes and supported by IT solutions.

In addition, the actions that brands and retailers are already making product information digitalization should be considered to avoid double efforts in product and sustainability information disclosing. For example, the relationship between the DPP and the concept of a digital twin[12] needs to be considered. Furthermore, existing standardization and certification schemes should also be considered in developing the DPP instead making them redundant with the use of the DPP. Overall, the DPP should not create new overlapping reporting practices. Existing schemes should therefore be integrated into the DPP.

[12] A digital twin is a virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity (https://www.digitaltwinconsortium.org/initiatives/the-definition-of-a-digital-twin). In the context of clothing, this could mean giving to each garment in the world a digital identity, or a “digital twin”. This would mean giving each item its own unique digital fingerprint. (https://www.innovationintextiles.com/a-digital-twin-for-every-garment-in-the-world/)

Additionally, while external verification is generally welcomed as a means for ensuring data quality and consistency, its implementation possesses several challenges in the textile sector. A third-party assessment may increase lead times. Third party assessments can also increase costs for textile companies and negatively affect the competitiveness of the companies, especially SMEs.

Furthermore, the DPP should not create new barriers to international trade. The DPP is an EU-driven initiative that needs to consider the textile sector's global value chains. Therefore, it is essential to understand the impact of the DPP information requirements on the third to fourth and fifth+ tier suppliers that are often located in developing countries. Incentives, financing, and other forms of support (e.g. IT access and trade cooperatives) are probably needed to engage and enable various value chain actors to participate outside the EU region.

Overall, the value of the DPP needs to be evident to ensure engagement also outside the EU region. Legislation relevant to textile products differs between countries also in the EU region, but even more in the textile products' global value chains. On the other hand, the DPP may have potential for engaging and involving value chain actors outside the EU region in improving the sector's sustainability in a global scale. The sustainability performance of the value chain is also essential for investor decision making and will impact future financing decisions.

Furthermore, among the topics that need further attention in the DPP, are also data confidentiality and intellectual property rights (IPRs). Although the textile sector companies support the idea that information should generally be open to all, this principle includes several notable risks in terms of business data confidentiality and intellectual property rights. Exceptions in data provision are needed for example when producing new man-made textile fibre as disclosing all substances may harm IPRs.

In addition, it remains unclear who owns the DPP's information and who would be responsible for the management and ownership of the data base for the DPP.

Furthermore, the environmental footprint of the DPP should also be assessed to ensure that that the well-intended benefits of the DPP will not be compromised by the environmental footprint of the DPP itself.

Finally, the DPP should be a user-friendly application that meets the needs of all its user groups. Information presentation formats need to be tailored for different users. Especially when disclosing product sustainability information to consumers detailed technical information should be avoided. Information intended for consumers should be made easy to assess, understand and compare even without any sustainability knowledge.

Recommendations to tackle the challenges and move forward in practice in textile industries

Based on the textile sector specialist interviews, it is strongly recommended that various types of economic impact assessment and feasibility studies will be carried out to understand how the DPP would affect the textile sector companies and what are the current practical limitations to the DPP implementation in the sector.

Prior to conducting any type of economic impact assessment and feasibility studies, clear sector and product specific definitions and criteria are needed. These need to be tested for concrete textile products in the different textile product sub-categories.

5.6.4 Special characteristics of DPP for battery value chain

The specific concept of DPP for batteries follows the principles of the generic DPP with some minor exceptions on data fields in various steps of the value chain.

The categories of value chain members are, however, the same as in the generic concept.

The generic concept of DPP was discussed in the context of batteries by conducting interviews with individual representatives (private companies and the public sector) of the battery value chain, and by validating the findings of the interviews and the concept in a workshop where relevant stakeholders shared their thoughts of the matter together.

In general, the findings of the interviews and workshop can be characterized by these categories:

- The value and usefulness of DPP to the value chain of batteries
- Specific data points in the context of batteries
- Principles of how to collect and store data
- Possible challenges of implementing the concept

The value and usefulness of DPP to the value chain of batteries and observations on specific data points

In general, the concept is considered to carry potential benefits for different players along the value chain. Many of these benefits tangle around the fact that DPP can enhance traceability of materials and processes along the value chain. For example, knowing the origin (name of the recycler or coordinates of the quarry of virgin raw materials) and composition of materials could boost trust among stakeholders, or having a view on the social conditions of the manufacturing processes can be valuable by either facilitating the ESG

reporting of organisations or enhancing the social brand value of the final product. Traceability is important from a compliance point-of-view. Having access to reliable information on, for example, what substances of concern product contains or knowing that the battery is free from raw materials originating from conflict zones, could help companies fulfil the needs of various sets of legislation. One aspect of traceability emphasized in both interviews and the workshop was that, if possible, the DPP should contain a holistic view on the ESG impacts of each stage of the value chain. In other words, it would be considered useful if one could see what the impacts of different processes on each step of the value chain are in terms of CO2, biodiversity, social issues, job safety and incidents. Traceability is valuable also when moving up the value chain: recyclers need to know what materials and components batteries contain and the DPP could facilitate their work by providing access to a reliable source of information. Recyclers could also provide input to material suppliers by stating the source of recycled materials, which in turn would improve the traceability of the whole value chain.

Another aspect of value discussed in the interviews and workshop was whether battery usage data should be included in the DPP. Knowing in what ways and conditions and for how long a battery is used could help battery producers further develop their solutions – especially if actual up-to-date performance and fault data is also included in the DPP. Actual usage and fault data could also add value by enhancing visibility on whether a specific battery is safe for reuse. In other words, if one can clearly see that a battery is free of faults and damage, it would be easier to enable safe reuse. This could, however, be troublesome from the point of view of the final user due to the fact that many consumers might feel hesitant to share this information.

One dimension on data points in the context of batteries is that since batteries are technically complex products, sharing too much information could be harmful for business. For example, specific data on chemicals such as the exact composition of electrolyte additives could be business critical and should, therefore, not be shared among all value chain members. One possible principle for the level of detail in material data is that it should contain only what main metals, solvents and plastics have been used. Other business critical information such as pricing and contract data between suppliers and producers should not be shared either. Also, when considering whether the DPP should contain data on reparability and maintenance instructions, one should take into account how it would affect the safety and warranty of the final product. In other words, although sharing this information would enable third parties to do maintenance and repairs on the product, battery producers often have specific requirements on who should perform these tasks. To tackle the issue of sharing too much information between different parties, one could utilize certificates created by external actors. These certificates could guarantee that materials come from vetted and compliant sources without sharing too detailed and business critical information between parties.

Although the EU requirements for the level of detail and dimensions of the data required are not clear yet, in general, the aspect of enhanced information sharing is considered to be a value driver for the DPP. This is highlighted to be

the case for situations where there is interaction between smaller and larger players in the value chain since these parties do not always necessarily share the same level of knowledge in terms of systems and processes. Thus, the DPP could be a partnership facilitator in this sense between these parties.

Principles on how to collect and store data

One topic discussed in the interviews and the workshop was the principles of data collection and sharing. Who should be responsible for collecting and feeding the data into the DPP? According to some interviewees, the data input should be done by each member of the value chain whereas others see it as the responsibility of the final battery producer. In the latter option, supplier and raw material data are attained through due diligence processes by the producer.

Based on the interviews and the workshop, incentives are needed for the value chain actors to participate in the DPP implementation. This means that it should be clear what the value of the DPP is for each party. The concept of subjective value also relates to the point of how to share the cost of the DPP implementation fairly among different members of the value chain. One possible approach is that it could be done proportionally to the value gained from the DPP by each value chain member. After data is collected, one should also define who owns each datapoint and who owns the actual DPP – are these parties the same or should each datapoint be owned by the party from which it originates? Also, how should one address data that originates from outside the EU: is the party that “imports” it, responsible for the correctness of the data or someone else?

When considering the options for sharing the data in the DPP, one major discussion topic is the compartmentalization of data. Since different value chain members have different use cases and needs for the DPP, should it be possible to create different views on the data? Different access rights could help tackle the issue of sharing sensitive business information among stakeholders. Also, for the final B2C user, most of the value in the DPP may not come from the technical details of the batteries but from general safety and ESG-related attributes. Thus, creating different views to different members could be valuable. However, if different parties know that they do not see all data, it could also lead to mistrust in the value chain.

Possible challenges for implementing DPP for batteries

Although the general concept of the DPP is regarded as valuable, there are some possible challenges that were highlighted by the interviewees and participants of the workshop. One theme mentioned was how to guarantee smooth implementation of the DPP. Especially when it comes to SMEs, they don’t always have the required resources to implement the concept if it demands sophisticated technical know-how. Also, if raw material importers are responsible for filling in the DPP data on materials that originate outside the EU, they might need support on how to do the needed due diligence to acquire the DPP data (origin, environmental, social and governance related information etc.). To tackle this issue, some interviewees raised the idea that one could use

a third-party certifier that grants certificates ensuring that the materials come from an approved source. Then again, this idea was considered laborious by some interviewees.

5.6.5 Applicability and pre-conditions to implement digital product passport

Business value is the key to positive societal and environmental impact

Economic actors representing different stages of industrial processing and commercial distribution of goods in the studied value chains identified that a the DPP implementation that enables sustainability-driven differentiation and new business models is more likely to succeed, as business value and competitive advantage create a stronger incentive to adopt and commit to the DPP than regulation alone.

Concerns about company competences, resources, and practicalities

Companies raised concerns about their ability to build compliance with the DPP given the competences, resources and practical limitations present in their day-to-day operations.

Digital maturity may limit companies' ability to produce the kind of information that the DPP requires, and this concern is especially prevalent in upstream value chain actors' business. Companies may not have the data collection and data management practices in place, or they may lack the enterprise systems and technical capabilities required.

To tackle these challenges, the DPP should be implemented in a way that minimizes the data collection needs in the first phase and makes it clear where to start. This means coherent data collection practices, ground rules and data structure across industries. Similarly, the DPP should leverage existing data and standards while enabling integration to existing enterprise systems whenever possible. In this way, the DPP can help lay the groundwork for a faster digital transformation in low-maturity industries while maintaining a value-effort balance for companies.

Further, the DPP could act as the foundation for an ecosystem of third-party tools, such as integrations and new innovations.

Concerns about reliability and openness of data

In connection with companies' concerns about their own data and digital maturity, companies also raised the question of whether DPP data can be trusted. Companies see the challenges of their everyday work with regards to data reliability and are concerned that most actors working in the same value chains will likely have the same data quality challenges.

Companies are concerned about data staying up to date as production methods or raw material sources change. At the same time companies question whether the data in the DPP will remain usable and trustworthy, as the amount of data collected from each step of the production process, product lifecycle and repurposing can be very large.

Proprietary data and trade secrets are seen as a potential problem, as companies are concerned about the openness of data potentially harming their ability to compete in the marketplace.

To tackle or minimize these issues, value chain actors are responsible for producing data from their business systems to the DPP in a standardized manner that is verifiable by certifiers and other actors. the DPP should be built in a way that enables decentralized, low-management information transfer and verification. One way of accomplishing this is Verifiable Credentials (W3C-VC), which are digitally signed pieces of trustworthy information that are issued by an issuing entity (e.g. companies, governments or trade associations) and can be verified by third parties.

Only realized production is represented in the DPP system. The DPP leverages existing and upcoming solutions and concepts to provide verifiable, trusted data. Data that is considered a trade secret should be either omitted or secured in some fashion, but this requires more detailed specification.

Concerns about long-term data management

A risk that companies see is that they are forced to develop, license or maintain too many systems and applications to remain compliant. Furthermore, they may lack the technical competences or human resources to manage all of the data and reporting requirements related to the DPP. Companies are also concerned that the data storage and reporting requirements may lead to increased CO2 consumption of their data operations, which would run counter to the DPP's goals.

To avoid these problems, the DPP should be built in a way that complements enterprise systems and is able to integrate to them via application programming interfaces (APIs) or data connectors. It should not attempt to supplant existing systems or become an all-encompassing product information system. The DPP should leverage existing systems and link to ongoing value chain transparency initiatives as much as possible to provide verifiable, trusted data.

The DPP's decentralized data management model must be implemented in a way that takes into account the environmental footprint of decentralized systems.

Concerns about regulation

Companies expressed concern that if the DPP and the regulation associated with it only apply to EU economic actors, the EU single market might become distorted as actors from outside the EU might be able to circumvent the data

and reporting requirements, and a large part of the value chain could remain opaque. EU actors forced to invest in compliance and sustainability might not be able to compete with non-EU actors that might be able to continue their operations as-is.

Companies are also concerned about how soon they must start complying with new data collection and reporting needs.

For the DPP to be effective, regulation must not create blind spots like this. If regulation factors in products produced in the EU, it must also factor in products imported from outside the EU. Regulation needs to be able to adapt to changing demands and new business models created by the DPP, and regulatory changes and initiatives should be openly communicated with sufficient lead-time to allow companies to determine the most cost-effective ways to build the necessary capability.

5.7 Discussion of results

The following themes should be developed after the first-phase implementation of Digital Product Passport: data collection during the full life cycle, lengthening the product life cycle and proof of sustainability. One big theme to clarify is also reporting opportunities the DPP will provide for legislation and research.

Data collection during full lifecycle

Collecting data during the lifecycle of a product will demand more complex data models and new user interfaces for consumers, end users, service providers and recyclers.

Data could be collected from product testing and auditing, purchases and repurchases, during use cycles and maintenance with data on condition, about repairs and changed parts, and finally end of life recycling.

This would increase knowledge about product and material durability and enable calculation of the products' true environmental impact.

Proof of sustainability

Adding data on used water and energy before and during use, generated production side streams and transportations would help companies in calculating the sustainability of their products and value chains. It would also help achieving the Scope 3 emission accounting and reporting.

The Digital Product Passport could also incorporate actor, material and product related certificates. Third party certifiers could update the certificates straight from their own systems and this could increase trust for the certificates and decrease fake certificates. However, third party certificates should be considered non-mandatory, as they may make compliance prohibitively costly for SMEs.

Full image of product sustainability would demand data from the full life cycle of a product. From raw materials to the end of life.

Extending product lifecycle

The product passport could have up-to-date information on official repair service providers and include repair instructions on products that anyone can fix. Use instructions and more in-depth maintenance instructions could be offered in digital form through the digital product passport. Commercial warranties would stay saved.

When life cycle length of similar products can be measured the digital passport could give real time estimation on how long the product should last and how the life cycle could be lengthened.

Reporting

Offering big data from the DPP database can have many different use cases and benefits. Legislation can be directed with better view on global material flows. It could enable innovation and new business models. It would also benefit market research. There are different options on making the data widely available like public API with restricted access or public user interface. Big data could offer views on different levels e.g., global, local, and regional areas, industry, and producer levels. It could also enable for example time based and sustainability comparisons.

6 Conclusions

6.1 Role and offering of the DPP to the European CEAP

At the moment, half of total greenhouse gas emissions and over 90% of biodiversity loss and water stress come from resource extraction and processing. Global consumption of materials, like biomass, fossil fuels, metals and minerals is expected to double over the next four decades, with annual waste generation projected to increase 70% by 2050.

The Digital Product Passport can help in making almost all physical goods in the European Union market more durable, more environmentally friendly, circular and energy-efficient throughout their lifecycle. It can help make sustainable products the norm in the EU. By providing standardized information on the lifecycle of products regulated under the ESPR, the DPP can provide consumers with a better opportunity to make conscious decisions while enabling new kinds of business models for extending product lifecycles.

The Digital Product Passport also provides a scalable technical framework for making companies' claims about product sustainability and environmental footprint reliable, comparable and verifiable, thus reducing the prevalence of greenwashing in the EU market.

While the Digital Product Passport is aimed towards supporting sustainable production and sustainable consumption, it is also well-positioned to promote and accelerate the digital transformation of the European economy, industry and society. The transparent data collection and new data opportunities associated with the DPP create incentive for economic actors to increase their data and digital maturity especially in low digital maturity value chains. As value chain actors' digital maturity increases, they create positive pressure for other parts of the value chain to do the same.

6.2 Benefits of the DPP to European industries

Business value is key to rapid adoption of the Digital Product Passport, and a prerequisite for the transition to circular economy. Value chain data from the DPP will enable companies to generate new value and explore new business ideas built on product traceability and transparency. Upstream actors can build stronger relationships with downstream customers and consumers.

New business ideas and innovation around circular economy and transparent value chain data will create new revenue streams and new jobs. Due to the possibility to track product life, it will be possible to innovate on the business model and earning logic. Products will have a higher value as their lifecycle becomes longer – through digital id customers and consumers can e.g., return the purchased goods back to brands and marketplaces of recycled and earn money on them.

Increased value chain transparency enables companies to critically evaluate their own value chain, including partners and subcontractors. Companies will be better positioned to select verifiably sustainable partners.

Verifiable credentials about product quality, sustainability and green values will create brand and reputation benefits.

The DPP will enable longer product lifecycle, with better ability for both producers and third parties to maintain and repair products. And when products come to the end of their lifecycle, recycling becomes safer due to the product composition and safety data stored in the DPP. Recycling becomes more effective creating new material streams and decreases companies' reliance on natural resources and scarce materials.

6.3 Recommendations to European the DPP concept

The technology exists to implement an effective Digital Product Passport, but businesses will remain skeptical until the concept has been trialed at scale and across a variety of value chains.

The DPP should be built using a decentralized verifiable credentials (W3C Verifiable Credentials) mechanism, where digitally signed pieces of trusted information are issued to represent product, sourcing or service attributes and can be verified by economic actors, governments, trade associations and others using software business logic or manual auditing.

The Digital Product Passport should be built in a way that leverages APIs and that companies can integrate to via existing enterprise systems. When done effectively, this approach enables the system to run with minimal human intervention. However, to ensure wide adoption, a data input interface should be offered, as SMEs may not have the immediate funding or resources to integrate their own systems with the DPP.

The Digital Product Passport concept is so complex that trying to implement the long-term vision in one broad stroke is not feasible. The Digital Product Passport exists in an ecosystem where there are several actors and needs. It is appropriate to start with the actors upstream in the value chain as they have the rawest data about product composition and sourcing. The system should evolve in a modular way over the years, step by step, towards a solution covering the whole value chain.