

Jansen, Maïke et al.

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Current Approaches to the Digital Product Passport for a Circular Economy

An overview of projects and initiatives

Maike Jansen

Bastian Gerstenberger

Jan Bitter-Krahe

Holger Berg

János Sebestyén

Jonas Schneider

Publisher:

Wuppertal Institut für Klima, Umwelt, Energie gGmbH
Döppersberg 19
42103 Wuppertal, Germany
www.wupperinst.org

Authors:

Maike Jansen, Bastian Gerstenberger, Dr. Jan Bitter-Krahe, Dr. Holger Berg,
János Sebestyén, Jonas Schneider
E-mail: maike.jansen@wupperinst.org

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List of Abbreviations

Abbreviations

AMA	Amsterdam Metropolitan Area
BAMB	Building As Material Banks
BIM	Building Information Modelling
BMUV	German Federal Ministry for the Environment, Nature Conservation, Building and Reactor Safety
CE	Circular Economy
DPP	Digital Product Passport
ERSP	Ecodesign Requirements for Sustainable Products
ID	Identification
KEEP	Keep Electrical and Electronic Products
MPP	Material Passport Platform
NFC	Near Field Communication
PCDS	Product Circularity Data Sheet
QR	Quick Response
SOC	Substance of Concern

Abstract

A large number and variety of activities are being undertaken to introduce Digital Product Passports (DPPs). However, only a few DPPs have made it into practice so far, so there is some uncertainty about which impact DPPs will actually have. With this paper, we aim to provide a structured overview of the current development of DPPs. We provide insights of 76 current corporate, policy, and research activities that exist and their objectives. To allow for a structured assessment and discussion of the diverse approaches we defined 13 criteria for a comparable description, categorization and evaluation. We expect that this overview will not only encourage feedback and contributions from the DPP community, as well as valuable discussions with and among experts. It is also intended to help promote and facilitate the adoption of DPPs for the Circular Economy by facilitating collaborations and suggestions for ongoing activities.

1 Introduction

Digital Product Passports (DPP) have received increasing attention recently. They have been defined as “[...] a set of data summarising a product’s components, materials, chemical substances and/or information on reparability, replacement parts and proper disposal. The data originates from all phases of the product life cycle and can be used for various purposes in all these phases (design, manufacture, use, disposal)” by the German Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV, n.d.).

DPPs are seen as important ingredients to the establishment of a Circular Economy (CE), which is a cornerstone of the European Union’s “Green Deal” and its “Twin Transition” strategy (Berg et al., 2021; Götz et al., 2021). DPPs are therefore an important part of recent regulation activities for Circular Economy. For the same reasons, actors on the side of nation states unfold increasing activities as well. DPPs have therefore found their ways into digital strategies relating to environmental policies, see for example the “Umweltpolitische Digitalagenda” (BMUV, n.d.), and into publicly funded research grants both in national and European funding schemes.

The EU’s Battery Directive (Halleux, 2022) foresees the introduction of a product passport for traction batteries and industrial batteries from 2026 on. The regulation of the European Parliament and the Council establishing a framework for setting ecodesign requirements for sustainable products (ERSP) postulates the introduction of DPPs for various products. DPPs shall, inter alia, become mandatory for products that include substances of concern (SOCs). In the ESPR, SOCs include substances that negatively affect the ability of a product to be subject to reuse and recycling (European Commission, 2022). In other words, such products may have to have a DPP before market entry is permitted, which will make the DPP a powerful tool towards more sustainable products and product design.

The DPP’s role as an enabler of more circular and sustainable supply chains has also gained the attention of industries and enterprises. Companies are increasingly introducing a focus on the Circular Economy in their strategies and business activities. Circular Economy may serve their purposes in several ways. It can secure their material supply, enable new business models, but also considerably lower their environmental footprint, including greenhouse gas emissions. Their efforts are also fuelled by rising pressure from stakeholders to become more environmentally friendly, and by the prospect of the EU regulation mentioned above. Therefore, the DPP is intensively discussed in the economic sphere. First approaches are being developed and introduced.

In sum, a large number and high diversity of activities are being pursued towards the introduction of DPPs. However, few DPP schemes have so far made it into practice, lending some extent of uncertainty as to what the DPPs’ impact really will be. Also, at present, there is no unifying DPP scheme technologically or contentwise, rather, new schemes and new suggestions for technological solutions flourish. As the DPP is also suggested to serve several stakeholders’ interests – inter alia those of consumers, suppliers, and public administration – it is even unclear if there will be one or several passports for one and the same product.

With this paper, we therefore aim to bring an overview to the current development of DPPs. We provide a synopsis of the current activities in the spheres of businesses, policies and research that currently exist, and what they are aiming at. We expect that this overview will not only encourage feedback and inputs from the DPP community as well as valuable discussions with and among experts. It should also help to promote and simplify the introduction of DPPs for Circular Economy by enabling cooperation and inspiration for current activities.

The paper proceeds as follows. The next chapter briefly describes the methodology of our research. The third chapter provides insights into current activities related to DPPs that were identified within business, politics and research. Finally, in the fourth chapter, we discuss our findings and draw conclusions regarding the current state of development of DPPs for Circular Economy.

2 Method

The goal of this work is to collect, present and discuss diverse approaches to DPPs and related fields, such as databases or digital twins. This includes a wide range of approaches, differentiated by, inter alia, focus, operator model, target group, role of state actors and (development) status. In light of the resulting diversity of approaches and in order to reach the objectives of this work, we follow a stepwise and structured approach. As a first step, we performed broad online research to collect potentially relevant approaches. Here, our goal was to provide a comprehensive overview of current approaches. Thus, we included both, scientific as well as grey literature in our first research step. Based on this, 86 potentially relevant approaches were collected. In order to further limit our analysis to relevant approaches, in a second step, we excluded a total of 10 approaches which do not or only marginally relate to Product Passports, are not based on digital technologies or which are not (yet) satisfyingly documented. Thus, at the time of publication, 76 approaches are included in our collection. To allow for a structured overview and discussion of the diverse approaches, in a third step, we defined 13 criteria for a comparable description, categorization and evaluation. These are:

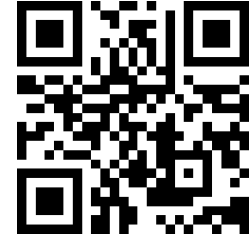
- *Country/Countries*: Country or countries of origin or main geographical focus
- *Operator Model*: Type of actors involved and type of involvement
- *Lead Actor(s)*: Actor(s) with a leading role in development/implementation
- *Partner(s)*: Other involved actor(s)
- *Promotion/Funding*: Whether and how the approach is funded
- *Focus*: Specific focus on sector(s), product(s), material(s), etc.
- *Description*: Short description of the approach
- *Benefits*: Short overview of (potential) benefits of the approach
- *Target Group(s)*: Actors, markets, sectors etc. that are addressed
- *Role of State Actors*: Type of involvement of state actors
- *Product or Market Maturity*: Current state of development or market readiness
- *Granularity/Level of Aggregation*: Focus on materials, components or products
- *Technologies*: (Digital) technologies used in the approach

In a last step, the collected approaches were transferred into an overview table structured along the criteria. However, this overview is to be understood as a “living document”, as our aim is to continuously extend and/or revise the collection based on

further developments, new insights and feedback or inputs from experts in the field. In the following, the overview table, at the time of publication, is discussed.

3 Current Approaches to the Digital Product Passport

As mentioned above, information about the initiatives is described within 13 categories for better clarity, increased comparability and final evaluation. The “living document” of the overview table can be accessed under the link below. A simplified version of the table, at the time of publication, can be found in the appendix (cf. Tab. 1). In the following, several observations regarding the overview table are presented and discussed.



- <https://tinyurl.com/widpp22> (see also QR-Code above)

The column "Country/Countries" describes the country or countries where the initiative originated or where its geographical focus lies. The initiatives were almost exclusively related to Europe. One exception was the Circular Product Data Protocol, which originated in the United States, and the Global Battery Passport, which is to be understood as a global initiative. More than 80 % of the DPP projects originate from countries in Central and Northern Europe. With about 30 % of all of the 76 initiatives found, Germany is the most represented country. However, it must be also mentioned that some initiatives extend across several countries or entire Europe.

The column "Operator Model" describes the way in which the actors involved in the initiative are related to each other, i.e., who is responsible, how the ownership or decision-making is clarified. Fig. 1 shows the shares of initiatives with different operator models. The largest category is the one of "single private", which comprises 31.6 % of all projects. It describes projects in which a single private company is the initiating organisation and thus the sole "lead actor". These initiatives are mainly profit-oriented. In the case of Minespider or SundaHus, for example, it manifests itself in the fact that the DPP they developed themselves serves as the companies' product. Other parties involved, which take on a supporting role, are categorised in the overview table as "partners". Another category is "collaborative private", meaning initiatives in which private organisations have jointly launched the project. In the overview table, these initiatives make up 14.5 %. One example is the Swedish project "Product work as a precursor for circular furniture flows", in which 18 companies and organisations are collaborating to achieve increased traceability of furniture, including through research into DPPs.

The term "single public" refers to 11.8 % of the approaches, which are under the leadership of a public actor, such as a government. Often, there are no partners, as these projects are basically self-financed. For instance, the German federal government aims to introduce DPPs and support companies with the introduction of DPPs as indicated in the coalition agreement in Germany. The category "collaborative public" describes the fact that several public parties have created and are leading a project together. Only 3.9 % of the projects can be assigned to this category.

Further 14.5 % of all initiatives belong to the category of "public-private partnership", which refers to an operating model in which private organisations and state actors cooperate on an equal footing or have jointly initiated the project. The last category,

"research project", includes initiatives that exist solely for the purpose of research and increasing the knowledge on DPPs. With 23.7 % of all projects, this category is strongly represented.

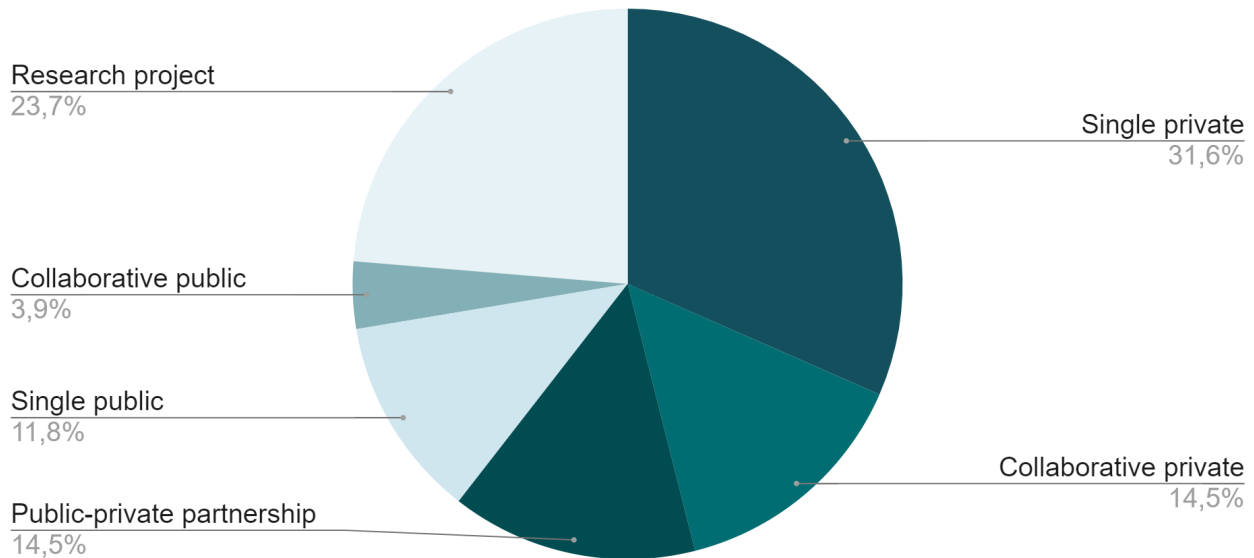


Fig. 1 Shares of different operator models of the initiatives (own representation)

The "Role of State Actors" column is closely linked to the column "Operator Model" and indicates the extent to which state institutions are involved in the respective initiatives. The categories "single public" and "collaborative public" show that the state takes on a coordinating or leading role in the relevant initiatives. However, this is only sporadically the case for other categories. The Product Circularity Data Sheet (PCDS) from Luxembourg or the Action team "passports for the construction industry" of Platform CB '23 from the Netherlands are two examples in which state organizations play a leading role in a public-private partnership. In projects of a "collaborative-private" oriented operator model, the state usually finds itself as a supporting part. This support includes both financial support and other support, for example through the provision of infrastructure. An example of this is the City Loops Horizon2020 project, in which several European cities volunteered to serve as pilot cities for the project. Or the collaborative work of Madaster and the Amsterdam Metropolitan Area (AMA), in which municipalities and provinces within the AMA were offered a material passport for one of their buildings to explore the need and usefulness of material passports. The situation is similar to "research projects". In the case of "single private" based operator models, however, there is no participation on the part of the state in around 70 % of all initiatives we looked at. An overview of the correlations between the role of the state actor and the operator models used by the initiatives is illustrated in the chart below (cf. Fig. 2).

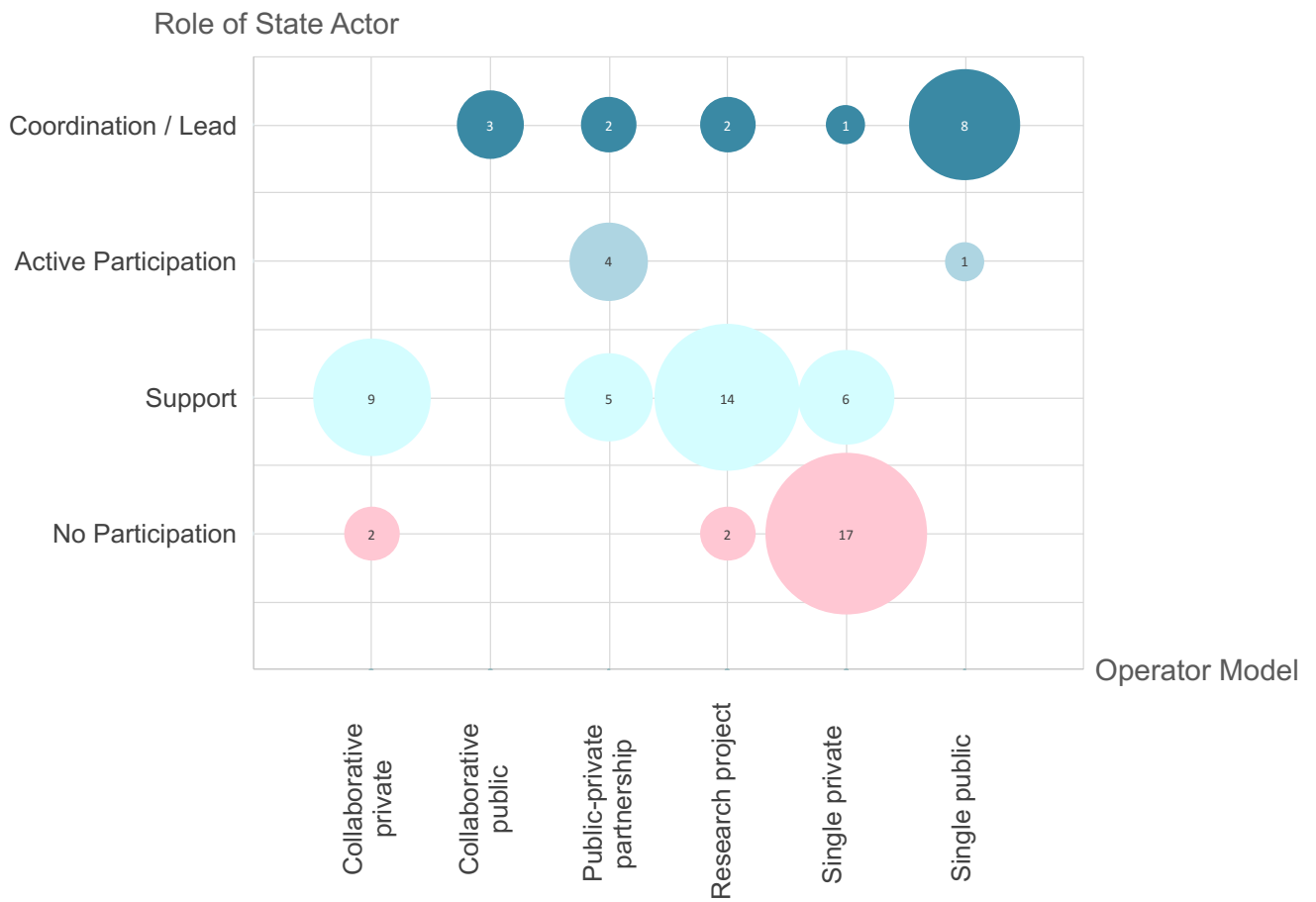


Fig. 2 Correlations between role of the state actor and operator models (own representation)

The column "Product or Market Maturity" deals with the current progress of the initiatives and states the extent to which a DPP has already been implemented and developed to market maturity. It is illustrated in Fig. 3 which shows that of all the initiatives, almost 45 %, have already been developed and are thus integrated into the market or are already at least in the testing or validation phase. Another 17.2 % are currently in the development phase. In the case of 38.4 % of all listed initiatives, these are merely proposals for the development of digital product passports or requirements analyses that examine which means are required for the development of a product passport.

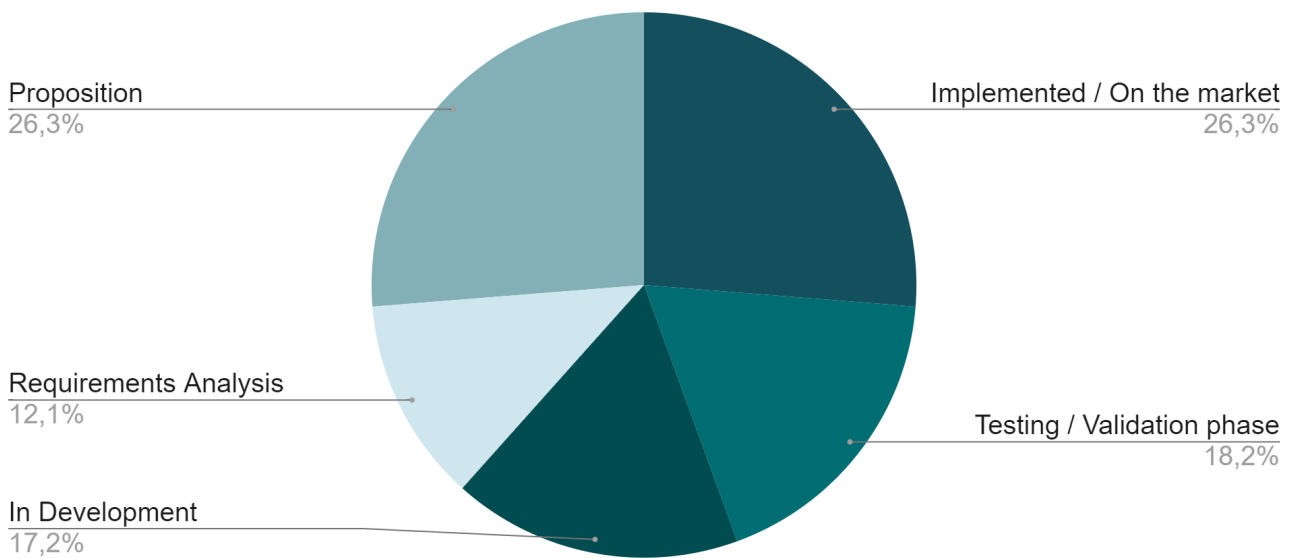


Fig. 3 Shares of product or market maturity of the initiatives (own representation)

The column "Focus" describes which industries or product categories are addressed by each initiative, in other words for which products a DPP is to be developed or has already been developed. Particularly noteworthy is the construction sector, which represents the largest sector with 42 % of all listed projects. Other sectors that stand out due to the variety of initiatives identified and their importance are the automotive and manufacturing industries, textiles, batteries and electronic devices.

From the column "Technologies" it can be seen that, depending on the requirements, the approaches to the development and design of a DPP differ. Some companies in the construction sector, such as Madaster or SundaHus, offer the DPP as a web-based, licensed platform that is linked to other data sources, such as Building Information Modelling (BIM). These passports contain information about the quality, origins and location of materials and products, but can also provide information about the material, circular and financial (salvage) value of those buildings. The Woningpas for example is not even a database, but it re-uses and links information that already exists in different databases. This one is accessible by an electronic Identification (ID), the information is finally accessible on a central platform. Other initiatives, such as the PCDS or Building as Material Banks (BAMB), which developed the Materials Passport Platform (MPP), rely on cloud-based databases in which each individual DPP also has its own ID, but the information is freely accessible and stored in a decentralized manner.

For sectors such as the textile industry (for example EON, TrueTwins, Circularity.ID, Threadcounts), batteries and electronic devices (for example Minespider, Keep Electrical and Electronic Products (KEEP)), consumer goods (HolyGrail 2.0) or even the construction sector (Elementpaspoort), the existence of a unique identifier is essential to access the DPP or to sort products. Here, the technologies range from classic Quick Response codes (QR codes) to Near Field Communication (NFC) and other technologies such as the digital watermarking technologies of the HolyGrail 2.0 project. A trend towards the increasing use of blockchain technology for purpose-driven, non-corruptible, decentralised data storage can also be seen. The use cases

addressed range from conflict materials from Africa and batteries (Minespider) to the textile industry and consumer goods (TrueTwins, Threadcounts & CircularTree) over food (Food Trust) to general life cycle analyses (Dibichain).

The column “Target Group(s)” of the overview table, also shows to what extent different initiatives address different target groups. The subdivision of the target groups for the product created by the initiative was done according to the following pattern. The top category consists of those initiatives for which the target group was either not explicitly communicated, respectively not limited, or not defined at all. The second category includes those initiatives that address all stakeholders of a value chain or an industry with its respective DPP. In most cases, however, the initiatives only address individual stakeholders of a value chain or an industry. These can be producing and supplying companies or other actors of the respective industry. Explicitly, the initiatives also apply to CE-related companies, such as recyclers, refurbishers or waste management actors. In addition, some projects target governmental institutions, regulators and authorities, while others focus mainly on their consumers or private individuals.

Another element that distinguishes DPP approaches from each other is the granularity or level of aggregation (cf. column “Granularity/Level of Aggregation”) concerning the included information. The DPP can either provide information about the product itself, about its components or even for the materials used. While there is no definitive trend visible, the vast majority of DPPs go beyond the product level, towards component and material level. This means that the focus is partly on the components that make up the product and partly on the materials that make up the product or even the components.

4 Discussion and Conclusion

In the following, we briefly outline which conclusions can be drawn from the overview of the researched initiatives that have just been presented.

Geographically, most of the initiatives studied have their origin or focus in Central and Northern European countries. This is expressed both in the private-sector efforts of individual or several companies as well as in the efforts of state institutions and regulators. While some Central and Northern European countries are actively involved in the research and development of DPPs or at least commit to the introduction of such DPPs, there is no consideration of the DPP as an important instrument to strengthen the Circular Economy in several European states. It should also be added that not all countries have yet made significant efforts to strengthen the Circular Economy which is closely linked to the adoption and diffusion of the DPP. On the other hand, the resulting focus on Central and Northern European countries may also be caused by a bias in our research. Therefore, further research is needed to clarify this interpretation.

In this study, also those commitments of governments to the introduction of DPPs were included which mostly do not yet represent tangible projects or only issued research mandates in which a requirements analysis was the declared goal. Similarly, research initiatives are predominantly concerned with the requirements analysis and thus serve more as a basis for the development of DPPs rather than the actual creation of new DPPs. It can therefore be stated that the majority of DPP approaches already in existence or under development have their origins in the private sector, mainly

through individual companies or company networks. Frequently, however, state actors support private projects financially or help projects to test their products in practice through active participation. Here, the state takes the position of a regulator. From our point of view, critical to the scalability, interoperability, and thus the longevity and sustainability of the DPPs is a coordinating role of the state actors who keep the above-mentioned long-term vision of the DPPs in focus and steer the current movements from the private sector in a unified direction.

It can be assumed that most companies or company collaborations, even if they may indeed act for the sake of circularity and thus sustainability, do so mainly out of self-interest and profit-orientation, or with regard to future regulations, as envisaged by the EU. For companies, DPPs often serve as a product or are intended to enable the company to gain a competitive advantage. Accordingly, privately developed DPPs (i.e., developed by companies) that are supposed to fulfil the same function in the same sector are in competition with each other. In this context, as companies operate primarily in their own sector and develop DPPs tailored to it and the company, there is hardly a uniform product passport system that exists across sectors and companies. This issue is also based on the fact that products and materials from different sectors as well as the purpose of the developed DPP have different demands towards the DPP. An organization that deals with DPPs for the construction sector for example has different requirements than those that employ a DPP for the textile or automotive industry in terms of information content, procurement and design. A wide range of available technologies also make it possible to design the DPP in different ways for different sectors or industries.

All those previously explained observations of different approaches to DPPs indicate that a broad variety of approaches exist or are under development. The question of the interoperability between different DPPs cannot be answered on the basis of the research that has been carried out and requires further studies. Nevertheless, similarities and trends can be discovered. In terms of the number of initiatives that have been launched in the last 5 years, it can be assumed that there will be increased interest in the development of DPPs from both politics and business. Most of the projects are clearly interested in addressing as many stakeholders as possible. Although there is still no clarity regarding standardized procedures and technologies, many projects are trying similar methods as, for example, the use of unique identifiers or the integration of blockchain technology.

Summarized, the overview table represents an accumulation of DPP initiatives and projects in Europe, setting the stage for future research. At the time of publication, it provides an overview on 76 recent DPP initiatives. Among other aspects, information is provided on the following questions:

1. Where and by whom are these initiatives run?
2. What do the operator models of these initiatives look like?
3. How is the DPP approach designed for each initiative?
4. Which technologies are used for each initiative?
5. Which state actors play a role in these initiatives and how does it look like?
6. Which target groups do the DPPs address?

We explicitly do not claim that the current overview table of DPP approaches is complete. It is intended to serve as an initial basis for future research that contributes to the development of DPPs. ***Therefore, we call upon the DPP community to further expand and update the collection and are looking forward to receiving feedback and inputs regarding further DPP approaches.*** Overall, we would like to use the overview of initiatives, provided in this paper, to further exchange insights with the DPP community to gradually gain a more holistic understanding of the current situation around DPP initiatives and developments.

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Appendix – Overview Table

The “living document” of the overview table can be accessed under the link below.

- <https://tinyurl.com/widpp22> (see also QR-Code)



This appendix, as seen below, contains a simplified version of the table (cf. Tab. 1) at the time of publication (September 2022). For better clarity and presentability, the overview table has been reduced here to the most important columns in terms of content, and it also contains the respective sources.

Tab. 1 Simplified version of the overview table of DPP-Initiatives

No.	Project / initiative	Country / Countries	Operator Model	Lead Actor(s)	Focus	Product or Market Maturity	Source
1	Catena-X	Germany	Collaborative private	Catena-X Automotive Network e.V.	Automobile	In Development	https://catena-x.net/en/
2	CE-Pass	Austria	Collaborative private	Salzburg Research Forschungsgesellschaft m.b.H.	Automobile	In Development	https://projekte.ffg.at/projekt/4141442
3	KEEP (Keep Electrical and Electronic Products)	Sweden	Collaborative private	Chalmers Industriteknik	Electronic devices	Testing / Validation phase	https://keepelectronics.com/#/
4	Product work as a precursor for circular furniture flows	Sweden	Collaborative private	Chalmers Industriteknik	Furniture	In Development	https://www.mynewsdesk.com/se/chalmers-industriteknik/pressreleases/nytt-projekt-ska-oeka-spaarbarheten-foer-svensk-moebelbransch-3159098
5	DIBICHAIN	Germany	Collaborative private	DIBICHAIN (Capgemini/Altran)	General Life Cycle Analysis	In Development	https://dibichain.com/ https://innovative-produktkreislaeufe.de/Projekte/DIBICHAIN.html
6	Digitale Lebenslaufakte	Germany	Collaborative private	DIN e.V. (Deutsches Institut für Normung e. V.)	Machinery and plant engineering	Requirements Analysis	https://www.din.de/de/mitwirken/normenausschuesse/nia/aufruf-zur-mitarbeit-digitale-lebenslaufakte--309140
7	Knowledge Centre for Circular Economy in Construction	Denmark	Collaborative private	Danish Construction Association	Buildings	Proposition	https://www.oecd-ilibrary.org/sites/d1eaaba4-en/index.html?itemId=/content/component/d1eaaba4-en
8	Digital Material Passport	Germany	Collaborative private	Concular GmbH	Buildings	Implemented / On the market	https://concular.de/de/projekte/ https://hollandcircularhotspot.nl/wp-content/uploads/2022/03/circular_buildings_and_infrastructure_brochure.pdf
9	Building renovation passports	Europe	Collaborative private	BPIE (Building Performance Institute Europe)	Buildings	Requirements Analysis	https://www.bpie.eu/publication/renovation-passports/#
10	Energy Efficiency Passport	France	Collaborative private	P2E Experience	Buildings	Implemented / On the market	https://theshiftproject.org/experience-p2e/ https://www.experience-p2e.org/presentation/objectifs/

No.	Project / initiative	Country / Countries	Operator Model	Lead Actor(s)	Focus	Product or Market Maturity	Source
11	Elementpaspoort	Belgium	Collaborative private	In-Vast-Group / MOSARD	Buildings	Testing / Validation phase	https://info726042.wixsite.com/elementpaspoort https://bouwen.vlaanderen-circulair.be/nl/projecten/detail-2/in-vast-group-mosard-3
12	Woningpas / Building Passport Flanders	Belgium	Collaborative public	Flemish Waste Agency (OVAM); Department of Environment; Housing Flanders (W-V); Flemish Energy Agency (VEKA)	Buildings	In Development	https://joinup.ec.europa.eu/collection/egovernment/solution/building-passport-flanders-woningpas/about https://woningpas.vlaanderen.be/
13	Totem	Belgium	Collaborative public	Public Waste Agency Flanders (OVAM); Service Public de Wallonie (SPW); Brussels Environment (BE)	Buildings	Implemented / On the market	https://www.totem-building.be/
14	Demolition follow-up plan	Belgium	Collaborative public	Flemish Waste Agency (OVAM); Tracimat vzw	Buildings, Infrastructure	Implemented / On the market	https://www.vlaanderen.be/sloopopvolgingsplan https://ovam.vlaanderen.be/bouw-sloopopvolging https://www.tracimat.be/
15	Battery Passport	Global	Public-private partnership	Global Battery Alliance	Batteries	In Development	https://www.globalbattery.org/battery-passport/
16	Materials Passports Platform (MPP)	Europe	Public-private partnership	BAMB Materials Passports	Buildings	Testing / Validation phase	https://www.bamb2020.eu/topics/materials-passports/
17	Material Passport	Netherlands	Public-private partnership	Amsterdam Metropolitan Area (AMA); Madaster GmbH	Buildings	Implemented / On the market	https://madaster.com/amsterdam-metropolitan-area-uses-material-passports-to-boost-the-circular-economy-in-the-region/#:~:text=Together%20with%20Madaster%2C%20the%20Amsterdam,for%20one%20of%20their%20buildings.
18	Action team "Passports for the construction industry"	Netherlands	Public-private partnership	Platform CB'23, action group comprising more than 40 members (companies and public authorities)	Buildings / constructions	Requirements Analysis	https://platformcb23.nl/actieteams/lopend/paspoorten-voor-de-bouw https://platformcb23.nl/images/downloads/Platform_CB23_Guide_Passports_for_the_construction_sector_2.0.pdf

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19	Materials expedition	Netherlands	Public-private partnership	Dura Vermeer; Provincie Noord-Holland; Provincie Overijssel; TBI; VolkerWessels	Buildings, Infrastructure	Requirements Analysis	https://hollandcircularhotspot.nl/wp-content/uploads/2022/01/NL-Branding-Circular-Infrastructure.pdf https://www.bouwendnederland.nl/media/7857/lessons-learned-materialen-expeditie-def_september_2020.pdf
20	Circular Amsterdam	Netherlands	Public-private partnership	Circle Economy, Fabric, TNO, Municipality of Amsterdam	Buildings & Built Environment Consumer Goods Food & Organic Waste Streams	Proposition	https://www.circle-economy.com/resources/developing-a-roadmap-for-the-first-circular-city-amsterdam https://www.oecd-ilibrary.org/sites/fdda19f3-en/index.html?itemId=/content/component/fdda19f3-en
21	Universal-Material Passport for "Raw material depot 2.0"	Belgium	Public-private partnership	TEN-Agency	Buildings	Testing / Validation phase	https://vlaanderen-circulair.be/nl/doeners-in-vlaanderen/detail-2/universeel-materiaalpaspoort-6
22	Product Circularity Data Sheet (PCDS)	Luxembourg	Public-private partnership	Luxembourg Ministry of the Economy	Industrial production	Testing / Validation phase	https://pcds.lu/
23	myEcoCost	Germany, United Kingdom, Sweden, Belgium	Public-private partnership	TriaGnoSys	CO2 emissions	Testing / Validation phase	https://www.myecocost.eu/index.php/about-myecocost/objectives
24	Circular economy Roadmap for Germany	Germany	Public-private partnership	Circular Economy Initiative Deutschland	No specific product	Proposition	https://www.acatech.de/publikation/circular-economy-roadmap-fuer-deutschland/
25	City Loops H2020	Europe (Denmark, Finland, Netherlands, Portugal, Spain, Sweden)	Public-private partnership	ICLEI Europe	Bio-Waste construction and demolition waste	In Development	https://cityloops.eu/construction-demolition/transformation https://hollandcircularhotspot.nl/wp-content/uploads/2022/03/circular_buildings_and_infrastructure_brochure.pdf
26	ReDiBlock	Germany	Research project	Karlsruher Institut für Technologie (KIT)	Industrial production	Testing / Validation phase	https://www.hs-pforzheim.de/forschung/institute/inec/projekte/rediblock

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27	Lebenszyklusakte (Life Cycle Record)	Germany	Research project	ReCircE project (see partners)	Machinery and plant engineering	Testing / Validation phase	https://www.recirce.de/partner/
28	Das Digitale Typenschild 4.0	Germany	Research project	ZVEI e.V.; Helmut-Schmidt-Universität Hamburg	Machinery and plant engineering	In Development	https://www.zvei.org/themen/industrie-40/das-digitale-typenschild-40-konsistent-nachhaltig-zukunftssicher-vernetzt
29	Produktinformation 4.0	Germany	Research project	TU Berlin, Circular Fashion UG, BSB Quack Gutterer	Electronic devices, Textiles	In Development	https://www.tne.tu-berlin.de/menue/forschung/projekte/pi/
30	DigInform	Germany	Research project	Fraunhofer IWKS	Industrial production and recycling, waste management companies	Testing / Validation phase	https://www.diginform.de/ https://www.iwks.fraunhofer.de/de/presse-und-medien/pressemeldungen-2021/projektstart-diginform.html
31	Circular Economy in the nordic construction sector	Denmark, Finland, Norway, Sweden	Research project	Nordic Council of Ministers	Buildings / constructions	Proposition	https://www.diva-portal.org/smash/get/diva2:1188884/FULLTEXT01.pdf
32	A proposed Material Passport ontology to enable circularity for industrialized construction	Switzerland	Research project	Institute of Construction and Infrastructure Management, ETH Zurich	Buildings / Industrial construction	Proposition	https://ec-3.org/publications/conference2021/papers/Contribution_159_final.pdf
33	Action Line Research Materials Passport	Netherlands	Research project	Netherlands Enterprise Agency (RVO)	Buildings	Requirements Analysis	https://www.comcon.nl/wp-content/uploads/2022/01/Eindrapport-Actielijn-onderzoek-Materialenpaspoort.pdf
34	BIMaterial: Process-Design for a BIM-based Material Passport	Austria	Research project	Institut of Interdisciplinary Construction Process Management, Institut of Water Quality, Resources and Waste Management, Vienna University of Technology	Buildings	Requirements Analysis	https://www.sciencedirect.com/science/article/abs/pii/S2352710218309392

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35	Rethinking ownership - Producer ownership models in a circular economy	Finland	Research project	Sitra, the Ministry of Environment	Industrial Production	Proposition	https://media.sitra.fi/2020/12/02164106/rethinking-ownership.pdf https://www.sitra.fi/en/publications/rethinking-ownership/
36	Coherent Investigation on a Smart Kinetic Wooden Façade Based on Material Passport Concepts and Environmental Profile Inquiry	Sweden, Turkey	Research project	Jönköping University, Karlstad University, Akdeniz University	Wood	Requirements Analysis	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8307020/
37	Building passport	Norway	Research project	The Federation of Norwegian Construction Industries; Norwegian Association of Heavy Equipment Contractors	Buildings	Proposition	https://www.diva-portal.org/smash/get/diva2:1188884/FULLTEXT01.pdf
38	Digital battery passports	Austria	Research project	Institute of System Sciences, Innovation and Sustainability Research, University of Graz	Batteries	Proposition	https://osf.io/preprints/socarxiv/e3pmq/download
39	Building a circular economy: The role of information transfer	Europe	Research project	EPC	No specific product	Proposition	https://www.epc.eu/content/PDF/2021/DP_the_role_of_information_transfer.pdf
40	DIGITALEUROPE's supporting paper on the public consultation on the Sustainable Products Initiative	Europe	Research project	DIGITALEUROPE	ICT-Products	Proposition	https://www.digitaleurope.org/resources/digital-europes-supporting-paper-on-the-public-consultation-on-the-sustainable-products-initiative/

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41	TagItSmart project	Europe	Research project	DunavNET, VTT Technical Research Centre, Institute for Communication Systems, University of Surrey, UpCode Ltd, Durst Phototechnik Digital Technology GmbH, Resonance Design	No specific product	Proposition	https://www.mdpi.com/1424-8220/19/3/586
42	Environmental Policy and Digitalization (project)	Germany	Research project	Wuppertal Institute	No specific product	Proposition	https://www.mdpi.com/1996-1073/14/8/2289
43	Approaches to creating a digital passport for electronic products	Russia	Research project	ITMO University St. Petersburg	Electronic devices	Proposition	https://stumejournals.com/journals/i4/2020/3/101.full.pdf https://ntv.ifmo.ru/en/article/20902/metod_formirovaniya_i_ispolzovaniya_cifrovogo_pasporta_elektronnogo_izdeliya_na_predpriyatiyah_priborostroitelnoy_otrasli.htm
44	GREENPASS	Austria	Single private	GREENPASS GmbH	Buildings / cities	Implemented / On the market	https://greenpass.io/
45	TrueTwins (Digital Passport for products)	Denmark	Single private	TrueTwins	Textiles Consumer goods	Implemented / On the market	https://www.truetwins.com/
46	CarPass®	EU-members	Single private	CAR Information Services GmbH	Automobile	Testing / Validation phase	https://car-pass.de/carpass.php
47	myUpcyclea	France	Single private	UPCYCLEA	Buildings	Implemented / On the market	https://www.upcyclea.com/en/myupcyclea/
48	CarbonBlock	Germany	Single private	CircularTree	Automobile, Fast Consumer Goods	Testing / Validation phase	https://www.circulartree.com/projects/carbonblock
49	Digital Product Passport	Germany	Single private	Spherity GmbH	Batteries Manufacturing industry	Testing / Validation phase	https://spherity.com/spherity-product-pass/
50	iPoint Suite	Germany	Single private	iPoint-systems GmbH	Industrial production	Implemented / On the market	https://www.ipoint-systems.com/software/
51	Food Trust	Germany	Single private	IBM (International Business Machines Corporation)	Food	Implemented / On the market	https://www.ibm.com/de-de/blockchain/solutions/food-trust

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52	circularity.ID® Open Data Standard	Germany	Single private	circular.fashion UG	Textiles	In Development	https://circularity.id/static/circular.fashion_circularityID_white_paper_2021.pdf
53	Threadcounts	Germany	Single private	Threadcounts	Textiles	In Development	https://www.threadcounts.io/ https://uploads-ssl.webflow.com/5e1c147e4b6c087a2680db97/5e26a1ad16b6d1c966fc5933_Minespider_Whitepaper.pdf
54	Minespider	Germany	Single private	Minespider AG	Batteries Conflict Materials	Implemented / On the market	https://www.minespider.com/upstream-producers https://www.minespider.com/battery-passports https://uploads-ssl.webflow.com/6098de8910ab20fb71ac62b9/60cb022e84f17b18e4a46575_Minespider%20v0.4%20-%20Light%20Paper.pdf https://www.crunchbase.com/organization/minespider
55	MATERIAL PASSPORT	Germany, Netherlands, Norway, Switzerland, Belgium	Single private	Madaster Germany GmbH (also: Madaster from The Netherlands, Norway, Switzerland and Belgium)	Buildings	Implemented / On the market	https://madaster.com/material-passport/
56	eXponentia Database	Italy / Europe	Single private	eXponentia S.r.l.	Automobile	Implemented / On the market	https://www.exponentia.org/solution/database/
57	Cradle to Cradle Passport	Netherlands	Single private	Cradle to Cradle Products Innovation Institute (C2CP II)	Industrial production (Global standard)	Implemented / On the market	https://www.c2ccertified.org/get-certified/product-certification
58	Circular Product Data Protocol	USA	Single private	EON Group Holdings, Inc.	Textiles	Testing / Validation phase	https://www.eongroup.co/circular-product-data-protocol

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59	Inventory of origin of ICT hardware	Netherlands	Single private	Dutch governmental ICT procurement agency (DICTU)	ICT Hardware	Implemented / On the market	https://hollandcircularhotspot.nl/wp-content/uploads/2021/06/Manufacturing-the-future-is-circular-April2021-1.pdf
60	Material Data	Sweden	Single private	SundaHus i Linköping AB (publ)	Buildings / Construction and property sectors	Implemented / On the market	https://www.sundahus.se/en/services/material-data/
61	Building Material Passport	United Kingdom	Single private	Tata Steel Europe Limited	Buildings	In Development	https://www.tatasteeleurope.com/construction/blog/What-is-Tata-Steel%E2%80%99s-vision-for-sustainable-construction
62	The cradle to cradle® design principle for buildings: The Building Circularity Passport	Germany	Single private	EPEA GmbH – Part of Drees & Sommer	Buildings	Implemented / On the market	https://changelab.exchange/building-circularity-passport/ https://epea.com/fileadmin/user_upload/5.0_News/C2C_Booklet_EPEA_PART_II_Gebaeude.pdf https://epea.com/fileadmin/PCP_Explanation.pdf
63	Passport	Germany	Single private	Swapfiets GmbH	Bikes	Implemented / On the market	https://hollandcircularhotspot.nl/wp-content/uploads/2021/06/Manufacturing-the-future-is-circular-April2021-1.pdf
64	Material Passport	Europe	Single private	Mitsubishi Elevator Europe B.V.	Elevators	Implemented / On the market	https://hollandcircularhotspot.nl/wp-content/uploads/2021/06/Manufacturing-the-future-is-circular-April2021-1.pdf
65	BIM-Integrum	Belgium	Single private	Beneens Bouw en Interieur	Buildings	In Development	https://vlaanderen-circulair.be/nl/doeners-in-vlaanderen/detail-2/bim-integrum-8
66	HolyGrail 2.0 - Digital watermarks project	Denmark	Single private	AIM – European Brands Association	Consumer goods Plastics	Testing / Validation phase	https://www.digitalwatermarks.eu/ https://www.aim.be/wp-content/themes/aim/pdfs/2020-05%20HolyGrail%202.0%20Charter_FINAL.pdf? t=1603191992
67	Digital Product Passport	Global with headquarters in Germany	Single private	Armaturenfabrik Franz Schneider GmbH + Co. KG	Valves Manifolds	Implemented / On the market	https://as-schneider-inbound.com/digital-product-pass/

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68	Circular economy strategy	Austria	Single public	Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology	Resource- and energy-intensive product value chains or infrastructures such as buildings, smartphones or textiles	Proposition	https://www.bmk.gv.at/themen/klima_umwelt/abfall/Kreislaufwirtschaft/strategie.html
69	Strategy for Circular Economy	Denmark	Single public	Ministry of Environment and Food; Ministry of Enterprise	Buildings	Proposition	https://www.regeringen.dk/media/5626/strategi-for-cirkulaer-oekonomi_web.pdf
70	Coalition treaty 2021-2025	Germany	Single public	Governing parties of Germany	No specific product	Proposition	https://www.bundesregierung.de/resource/blob/974430/1990812/04221173eef9a6720059cc353d759a2b/2021-12-10-koav2021-data.pdf?download=1
71	Circular Economy Strategy Luxembourg	Luxembourg	Single public	Ministry of Energy and Spatial Planning; Ministry of the Environment, Climate and Sustainable Development; Ministry of the Economy	Buildings / construction	Proposition	https://gouvernement.lu/dam-assets/documents/actualites/2021/02-fevrier/08-strategie-economie-circulaire/Strategy-circular-economy-Luxembourg-022021.pdf https://economie-circulaire.public.lu/en/inpractice/sectors-projects1.html
72	National Waste Plan	Finland	Single public	Ministry of the Environment; The Finnish Innovation Fund (Sitra)	Buildings / constructions	Requirements Analysis	https://www.sitra.fi/en/cases/building-database-enhances-circulation-materials/
73	Circular Economy Implementation Programme	Netherlands	Single public	Government of Netherlands (The Ministry of Infrastructure and Water Management, also on behalf of the ministries of Economic Affairs and Climate Policy, Interior and Kingdom Relations, Agriculture, Nature and Food Quality, and Foreign Trade and Development Cooperation.)	Buildings / Constructions Consumer Goods Plastics Manufacturing industry Consumer Goods	Proposition	https://hollandcircularhotspot.nl/wp-content/uploads/2019/09/Circular-Economy-Implementation-Programme-2019-2023.pdf https://www.government.nl/topics/circular-economy/accelerating-the-transition-to-a-circular-economy

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74	Circular economy - Action plan for the conversion of Sweden	Sweden	Single public	Government of Sweden	No specific product	Proposition	https://www.regeringen.se/48f821/contentassets/561eea8cac114172b993c1f916e86a9b/cirkular-ekonomi-handlingsplan-for-omstallning-av-sverige.pdf
75	Circular Buildings project	Portugal	Single public	Portugal Ministry of Environment and Climate Action	Buildings	Requirements Analysis	https://construcaocircular.pt/assets/files/Guideline_MaterialPassports.pdf https://construcaocircular.pt/edificios
76	Ten seeds for a circular ecosystem	Finland	Single public	The finnish Innovation Fund Sitra	Buildings Manufacturing industry	Proposition	https://www.sitra.fi/en/publications/ten-seeds-for-a-circular-ecosystem/#6-7-a-single-point-of-entry-to-the-authorities-for-firms-operating-with-circular-business-models