The Economics of Digital Product Passports

From Materials to Market

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Executive Summary

The European Union's commitment to sustainability has led to the introduction of the Digital Product Passport (DPP), a tool designed to foster circularity, drive resource efficiency, and simplify reporting obligations. Beyond compliance, DPPs are poised to become a cornerstone of innovation by improving product transparency, traceability, value chain collaboration, and consumer engagement throughout the product life cycle.

This white paper examines the economics of DPPs, including estimates of their initial implementation costs, the value they can unlock across supply chains, and key implementation considerations for companies. The economic potential of DPPs extends beyond regulatory compliance; they enable the creation of business value by shifting industries from document-centric processes to real-time, machine-readable, data-centric exchanges. This transformation facilitates collaboration, enhances operational efficiency, and paves the way for new business models that could reshape entire industries, fostering a more sustainable and circular global economy.

Keywords: Digital Product Passport (DPP), Circular Economy, ESPR, Supply Chain Transparency, Material Traceability, Lifecycle Data Sharing, Cost of DPP, Value Creation, Regulatory Readiness, DPP Implementation, DPP Cost Structure, DPP Economic Impact, Eco-Design Requirements, Regulatory Readiness

I.   Introduction

A DPP-enabled Circular Economy

In the face of mounting environmental concerns, industries have the opportunity to develop innovative solutions that transform their business models towards greater sustainability. Against this background, the circular economy has emerged as a key political and economic framework for advancing sustainability at the product, business model and ecosystem levels. In a circular economy products and materials are kept at their highest value through multiple use cycles. Services such as repair, reuse, remanufacturing and recycling operationalise circular business models and help ensure the availability of critical raw materials.

However, several organisational and technical barriers hinder circularity, including low transparency in supply chains as well as a lack of information about the product life cycle. To overcome these barriers and foster the transition to a circular, sustainable and competitive economy, the European Union has launched a comprehensive policy package. These initiatives are central to achieving the goals of the European Green Deal and the Circular Economy Action Plan.

One key policy is the Ecodesign for Sustainable Products Regulation. At the heart of this initiative lies the Digital Product Passport (DPP), an information system that ensures transparency and promotes traceability across product value chains. The DPP provides consumers, manufacturers, regulators, recyclers and circular economy operators with a holistic view of product life cycle information, enabling informed decision-making from design through to product reuse or disposal. The DPP is intended to be a "living document", updated throughout the product lifetime to reflect relevant changes, from entering the market to exiting it.

At its core, a DPP is a structured collection of product related data with predefined scope, agreed data ownership and access rights. This data is stored in a structured, machine-readable format and will be conveyed through a unique identifier and a data carrier (e.g., a barcode, QR code or RFID chip). The DPP will serve as a container for digital labels, manuals, technical documentation and other relevant product life cycle information. It will also enable communication across the value chain, connecting the multitude of actors (e.g., manufacturers, consumers, remanufacturers, recyclers, etc) in a circular ecosystem (Figure 1).

Drawing on insights from the CircularTech community, industry events, international projects such as CIRPASS and the evolving EU regulatory landscape, this white paper delves into the economics of the digital product passport. It examines the immediate costs, opportunities and efficiencies for value creation, as well as implementation considerations for DPP adoption.
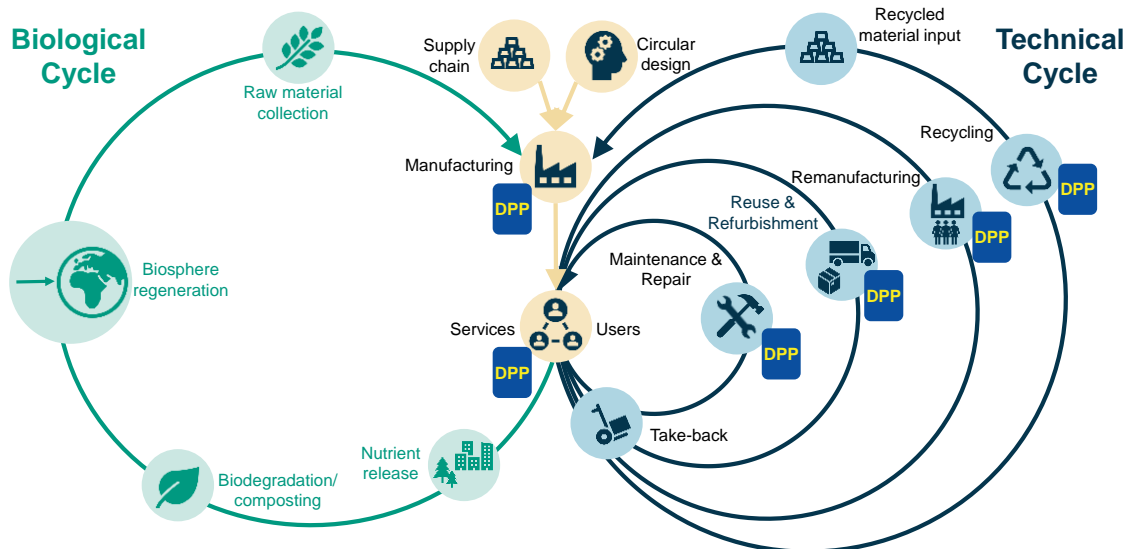

Figure 1: The DPP-enabled Circular Economy. Own representation based on EMF (2013) © Andres Alcayaga

The ESPR Working Plan

The Ecodesign for Sustainable Products Regulation 2024/1781 (ESPR) is part of the European Commission's broader strategy of digitalisation and sustainability that modernises product regulations. The ESPR replaces the Ecodesign Directive 2009/125/EC, extending its scope to cover nearly all categories of physical products in the economy. As an umbrella legislation, the ESPR introduces horizontal ecodesign requirements applicable across product categories. These include durability, repairability, reusability, recycled content, or the presence of hazardous chemicals in products, among others. These requirements will be specified and implemented through Delegated Acts relevant to individual product groups. Once a Delegated Act has been adopted, economic operators such as manufacturers, retailers or importers will have 18 months to comply with the outlined requirements.

The Digital Product Passport is a foundational element of the ESPR, designed to improve sustainability, support circular practices and reinforce legal compliance through the collection and exchange of product-specific data. To ensure consistent application of the DPP across multiple industries, the EU will establish harmonised technical standards as well as data requirements for various product categories, including high-priority sectors such as electronics, textiles and batteries. Developing cross-sector data standards to enable seamless data exchange remains critical and continues to be a key implementation challenge.

In April 2025, the European Commission adopted the first ESPR and Energy Labelling Working Plan 2025-2030. The plan aims to reduce the environmental, energy and climate impacts of products, help consumers make better informed purchase decisions, create economic benefits for producers of more sustainable products, simplify regulations and reduce the administrative burden on businesses, and position the EU as a leader in the circular economy. The first working plan will apply to the following product categories (Figure 2):

- **Textiles, Tyres, Furniture, Mattresses**

- **Specific ICT products (e.g., dishwashers, washing machines)**
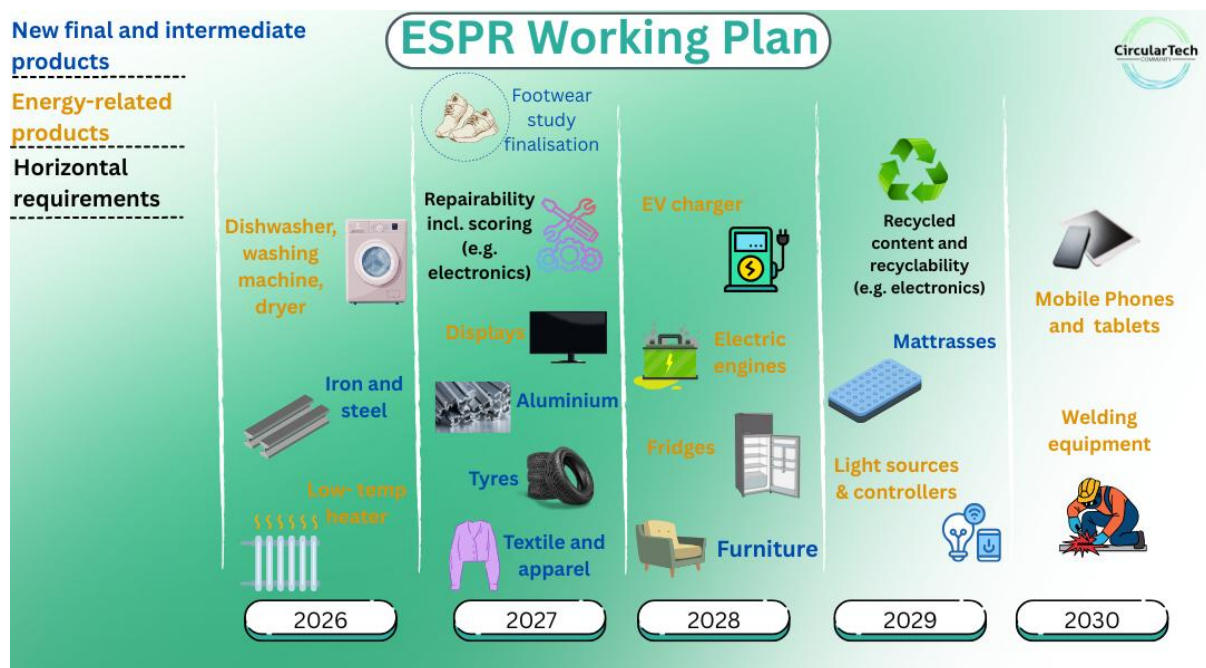
- **Iron, Steel and Aluminium**

Figure 2: ESPR Working Plan. Own representation © CircularTech

The European Commission will also introduce horizontal requirements on repairability (e.g., repairability score) and recycled content and recyclability of electrical and electronic equipment. Additional sectors are expected to be included in the future. Each of these sectors will need to adapt to the evolving regulatory landscape by defining the data requirements, communication protocols and technical infrastructure to support the transition to a DPP-enabled circular economy.

Advancing Supply Chain Communication for Materials

Today, many industries rely on outdated document-centric systems to manage product data. This includes emails, spreadsheets or Safety Data Sheets, which often lead to fragmented information flows. This lack of interoperability impedes cross-industry collaboration, difficulties compliance, and results in inefficiencies throughout the supply chain.

For example, the chemical industry faces increasing complexity of sector-specific regulations. The inability to efficiently exchange critical product and material data slows down progress toward sustainability and hinders new business models. To address these challenges, several actors of the chemical industry have launched the Chem-X Project (see https://www.chem-x.de/ for further information). One of the central components of the project is the Digital Material Passport (DMP). The DMP enables consistent, interoperable data representation across industries from the product conception phase to the collection and sorting of end-of-life products. It enables circularity by enhancing material traceability, reducing waste and supporting more efficient recycling and reuse processes. By capturing the full product life cycle, from material sourcing to disposal, the DMP creates a robust foundation for the DPP. It facilitates:

- **Cross-sector Material Representation**: Ensures data consistency and compatibility across diverse product categories.

- **Harmonised, Machine-readable Data**: Enables seamless communication and integration across supply chain partners.

- **Public/Private Data Layers**: Allows companies to maintain control over sensitive information while still sharing necessary data for compliance and reuse.

- **Visibility**: Provides one-level-up and one-level-down visibility in the supply chain, facilitating informed decision-making.

- **Decentralised, Tech-agnostic Infrastructure**: Enables a flexible, scalable solution for companies of all sizes and sectors.

II.   Cost of Digital Product Passports

Key Cost Components

The implementation of DPPs involves a range of initial costs, which can vary based on several factors, including product type, industry and technological infrastructure. While in some cases the upfront investment may seem significant, the long-term economic benefits of DPPs—such as operational efficiencies, enhanced regulatory compliance and new business opportunities—are becoming increasingly evident. Some cost components are listed below:

- **Personnel Onboarding:** Building a diverse skill set that includes technical, business management, circular economy, innovation and regulatory expertise.

- **Supplier Engagement:** Ensuring that supply chain partners are aligned with the new requirements and understand how to input and manage product data. This may include the creation of KPIs, incentives programs and training initiatives.

- **Data Governance:** Managing different stages of data collection and readiness, including onboarding data for each product category, creating unique identifiers and product-specific attributes, generating data when it is missing or stored in non-digital formats, and conducting life cycle assessments (if needed).

- **IT Systems Integration:** Upgrading enterprise resource planning (ERP), product lifecycle management (PLM) systems to accommodate DPP workflows. Adapting existing systems to handle the volume and complexity of DPP data such as the Master Data Management (MDM).

- **DPP Applications:** Ensuring effective, secure and interoperable data exchange with external actors and stakeholders in both B2C and B2B markets to comply with regulatory requirements and build circular ecosystems.

Sample Cost Estimates

Cost[1]	Comments	Source
€0.001 per item annually	For labelling and traceability	Deloitte study commissioned by GS1
€9 per car amortised over 15 years	Volvo EV battery	Circulor CEO / Reuters
€0.0229 per instance	Apparel sector, projection for 2030	ABI Research on DPPs / Products of Change

Although the estimates presented above are per item (or instance) and may appear comparable, they do not account for differences in implementation granularity, nor do they always specify a clear time window. For example, some estimates might consider the DPP for a batch of items while others might overlook additional costs such as hosting, update frequency or backup services. This shows the early-stage nature of the estimation and the necessity to develop comparable services, pricing and costs measurements. In addition, the rate at which these costs scale can vary depending on the volume of products, lifespan and feature sets.

Factors Shaping the Cost Structure

While transparency is a key driver of DPP regulation, businesses often face hidden or indirect costs when integrating DPPs into operations. As seen above, non-recurring costs (NRCs) for initial assessments, training, stakeholder engagement and data setup represent a significant investment in the early stages of adoption. In addition, the cost of reading and interacting with the DPPs is influenced

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[1] For simplicity, the conversion rate is set at USD 1 = EUR 0.90

by multiple factors, including the (1) sector-specific regulatory framework, (2) technical infrastructure and (3) data access model. We delve into these three topics below:

1. Sector-Specific Cost Considerations

Sector	Read Access Mandate	Implications
Batteries	Free access mandated	As per EU Battery Regulation, recyclers and second-life operators must access data without cost.
Textiles	Likely free for consumers	Delegated Act will define specifics, but consumer-facing access will likely be mandatory and free.
Electronics	Mixed access expected	Combination of public and restricted data depending on business model and compliance needs.

2. Infrastructure Cost Drivers

Cost Driver	Estimated Costs
API Usage Fees	€0.001–€0.05 per request depending on data granularity, frequency and provider.
Blockchain Transaction Costs	€0.000005–€0.2 per transaction. Variable gas fees, depending on the token price. Relevant for decentralised DPPs.
Digital Wallet/Verified Interaction Fees	€1–€5 per interaction in trust-based exchanges (e.g., manufacturer–recycler credential handovers)
SaaS Platform Subscriptions*	€100–€5,000+ a month for companies accessing or managing DPPs at scale. Subscription costs rise considerably with more features and larger scale deployments.
Integration into IT Systems*	€5,000–€100,000+ one-time cost for ERP, MES, PLM, or compliance tool integrations.

* Costs depend on the company size

3. Cost drivers of different Access Models

Type	Characteristics	Use Case
Open/Public Access (Free)	Designed mainly for B2C transparency. These allow free access to basic product information such as material composition, carbon footprint or circularity indicators.	Any user can scan the QR code on a product label and view non-sensitive DPP data.
Controlled/Permissioned Access (B2B & Regulated Use Cases)	Designed mainly for complex value chains, particularly B2B. Access may be gated through APIs, digital wallets, or verified credentials. Certain DPP platforms or services may charge per API call, monthly subscription, or verified data interaction.	Authorised actors can read specific sensitive information (e.g., compliance declarations) due to data segmentation.

III. 10 Opportunities for Value Creation

Although the cost of reading a DPP may be very low, the true cost of operationalising DPP read access includes infrastructure, interoperability, authentication and integration efforts. Companies must plan for both upfront investments and ongoing usage fees—especially in regulated sectors with mandatory traceability requirements. DPPs that use European Digital Identity Wallets (EUDI Wallets) or blockchain anchoring may incur incremental costs per verified transaction, further shaping the business case around secure, interoperable data exchange. Despite the initial investments, DPPs offer significant opportunities for value creation across multiple business functions:

1. **Enhanced Supplier Collaboration**: With access to real-time, standardised product data, companies can collaborate more efficiently with suppliers, improving procurement processes and reducing the time and cost of sourcing materials.

2. **Efficiency Gains**: By eliminating the need for paper-based documents and enabling automated data exchange, companies can streamline their operations, reducing manual errors and administrative overhead.

3. **Consumer Engagement**: DPPs enable direct communication with consumers throughout the product life cycle, fostering trust and offering opportunities for upselling, loyalty programs, and personalised services.

4. **Unveiling the Black-box of Product Use:**

5. DPPs allow companies to understand customer behaviour and how they actually use their products, enabling rich market analyses, segmentation, profiling, and new use cases for their product portfolio.

6. **Product Development:** Through communication with both the customer and supplier networks, producers can use feedback to make improvements in product design and accelerate the time to market of innovations.

7. **New Business Models**: DPPs open the door to innovative business models such as product-as-a-service, data analytics, extended product warranties, and circular value chains, where the customer returns valuable products to be reused, repaired or remanufactured based on accurate data (Figure 3).

8. **Ecosystem Leadership:** Interaction with a wide array of actors across an ecosystem (e.g., customers, repairers, service providers, etc.) allows companies to manage relationships for a competitive advantage, such as detecting value creation opportunities early on.

9. **Brand Management:** Companies can leverage the transparency of the DPP to showcase certifications, ESG commitments and circularity efforts, increasing brand reputation and customer loyalty.

10. **Critical Raw Material Control**: By tracking and assessing critical raw materials that are scarce in the European economic space, companies can manage them as strategic assets — similar to a "material bank". This approach enables better alignment between material demand and the availability of end-of-life products in the market.

11. **Regulatory Readiness and Risk Management:** DPPs help companies ensure compliance with data transparency requirements and standards. By embedding traceability and verifiable data into their products, companies can reduce the risk of non-compliance, improve auditability and respond more swiftly to legal inquiries.
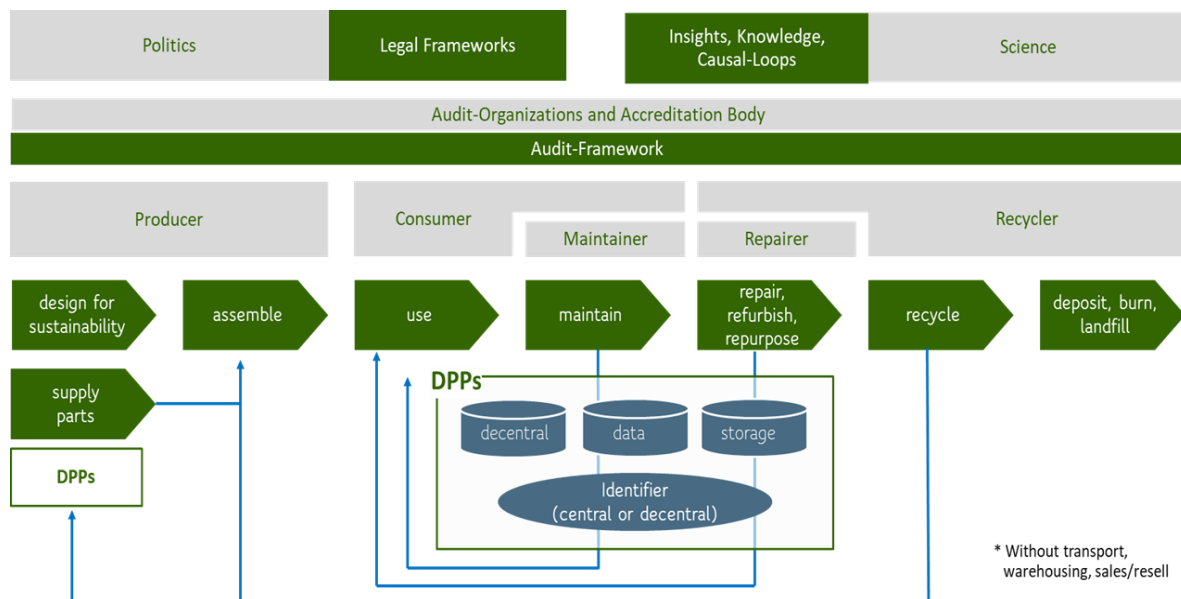
Figure 3: DPPs integration in the value chain © Elliana Jensen-Abieva

IV. Towards DPP Implementation

Implementing the Digital Product Passport requires a structured and cross-functional approach across the value chain. In this section, we outline key stages, from strategic planning and stakeholder engagement to data and systems integration.

1. **Strategic Planning and Roadmap:** Define a strategy and roadmap for implementing the DPP within the company and its supplier network. Identify and establish the relevant cross-functional team(s) that shall lead the implementation.

2. **Defining Business Processes:** Align internal departments, organise training and awareness programmes, and define the activities required for DPP implementation.

3. **Stakeholder Engagement:** Prepare training for external stakeholders (e.g., suppliers, circular economy operators) and define KPIs to ensure efficient data collection. Suppliers are to be equipped to provide high-quality data and engage with the DPP for it to work.

4. **Data Management**

   4.1. **Data Collection**: Gather accurate product data from various sources, including suppliers, manufacturers, internal departments and regulatory bodies.

   4.2. **Data Processing**: Standardise and structure the data to meet DPP requirements, using accessible tools such as simple databases or cloud-based platforms. Where appropriate or feasible, involve engineers or IT partners to implement more advanced solutions such as a data lakehouse or a DPP data mart.

   4.3. **Data Exchange**: Ensure that data can be exchanged seamlessly across the value chain.

   4.4. **Access Management**: Control access to different levels of product data based on their role in the supply chain.

   4.5. **Life Cycle Updates**: Continuously update information on the DPP as the product moves through different stages of the life cycle. Consider data from ecosystem partners to reflect the product's real-time condition, usage and end-of-life status.

5. **Systems Integration**

   5.1. **ERP, PLM, PIM and CRM Integration**: In larger companies, DPPs require integration with various enterprise systems to ensure smooth data flow across the organisation and alignment with existing IT infrastructures in legacy systems

   5.2. **Role-Based Content Management**: Ensure that data is accessible and manageable according to the user's role in the value chain, balancing the need for data accessibility with the necessity of protecting sensitive information.

   5.3. **Cloud vs Blockchain Storage vs Data Spaces**: Decide on the appropriate data storage solutions based on scalability, security and cost considerations.

   5.4. **Reference Architectures:** In larger companies, the adoption of sophisticated IT architectures is beneficial to separate concerns such as high-volume industrial DPP

production, long-term DPP hosting and preparatory systems for data consolidation (e.g., data marts) and DPP templates.

Conclusion

The Digital Product Passport is not just a compliance mechanism but a strategic asset capable of transforming industries and business models. As the European Union moves toward a circular economy, the DPP will serve as a critical enabler of sustainability, operational efficiency and consumer trust. The journey from materials to market and end of life via digital passports is a powerful opportunity for businesses to drive innovation, enhance transparency and contribute to a more sustainable future.

The introduction of DPPs signals a shift from fragmented, document-based systems to structured, interoperable data ecosystems. This shift demands cross-sector collaboration, harmonised standards and secure, scalable IT infrastructure. While the initial implementation may involve significant costs and challenges, per-instance costs can be remarkably low—especially when amortised over product lifespans. The real cost lies not in adoption, but in inaction. Delaying implementation can lead to compliance risks, missed innovation opportunities, and rising integration expenses as the ecosystem matures. Therefore, companies must seize a first-mover advantage and ensure ecosystem leadership.

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