

Materials & Products Taskforce



Digital Product Passport:

funded by



The ticket to achieving a climate neutral and circular European economy?



The University of Cambridge Institute for Sustainability Leadership

The University of Cambridge Institute for Sustainability Leadership (CISL) partners with business and governments to develop leadership and solutions for a sustainable economy. We aim to achieve net zero, protect and restore nature, and build inclusive and resilient societies. For over three decades we have built the leadership capacity and capabilities of individuals and organisations, and created industry-leading collaborations, to catalyse change and accelerate the path to a sustainable economy. Our interdisciplinary research engagement builds the evidence base for practical action.



CLG Europe

CLG Europe develops credible, ambitious positions amongst its membership and deploys effective strategic communications to engage with the highest levels of policy audiences. CLG Europe is diverse in its membership and representative of Europe in both geography and sector, welcoming the innovative talent of SMEs as well as leading established companies. The group works closely with policymakers – particularly the Green Growth Group of EU climate and environment ministers, and supportive Members of the European Parliament through its Green Growth Partnership. The group also maintains a network of sister groups across the EU and works in partnership with some of the largest business-focused organisations in support of climate action as one of the founders of the We Mean Business Coalition, for which it provides the EU policy lead.

Materials & Products Taskforce

Taskforce for climate neutral and circular materials and products

The Taskforce for climate neutral and circular materials and products was created in September 2021, with the aim of driving forward policy action on sustainable materials by bringing together a group of progressive businesses across sectors and value chains. The group brings together companies that are actively committed to producing and using climate neutral and sustainable materials, and who want to work together to promote and support EU-wide measures to decarbonise material production and use.



The Wuppertal Institute

The Wuppertal Institute is a leading international think tank for sustainability research focused on impacts and practical application. Since it was founded in 1991, the Wuppertal Institute's core mission has been to contribute towards the achievement of the Sustainable Development Goals. One particular focus is on showcasing and actively helping to shape transformation processes for a climate-friendly and resource-efficient world. To this end, the work of the Institute's scientists includes researching and developing practical guidelines and strategies to support business, politics and society – at a local level, in Germany, in Europe, and all around the world.



We Mean Business Coalition

The We Mean Business Coalition is a non-profit coalition working with the world's most influential businesses to take action on climate change. The Coalition is a group of seven non-profit organisations: BSR, CDP, Ceres, CLG Europe, Climate Group, The B Team and WBCSD. Together, the Coalition catalyses business and policy action to halve emissions by 2030 and accelerate an inclusive transition to a net zero economy by 2050.

Written by

Wuppertal Institute for Climate, Environment and Energy
Döppersberg 19,
42103 Wuppertal, Germany
T: +49 202 2492-0
info@wupperinst.org

University of Cambridge Institute for Sustainability Leadership

Head Office
The Entopia Building,
1 Regent Street,
Cambridge, CB2 1GG
UK +44(0)1223 768850
info@cisl.cam.ac.uk

EU Office
The Pericles Building,
Rue de la Science 23,
B-1040 Brussels, Belgium
T: +32(0)2 894 93 19
info.eu@cisl.cam.ac.uk

Project Leads

Thomas Götz
thomas.goetz@wupperinst.org

Krisztina Zálnoky
krisztina.borbalazalnoky@cisl.cam.ac.uk

Authors

Thomas Götz, Holger Berg, Maike Jansen and Thomas Adisorn (Wuppertal Institute) and David Cembrero, Sanna Markkanen and Tahmid Chowdhury (CISL)

Acknowledgements

The authors would like to acknowledge the contributions of numerous people to the preparation of this study, including the employees of Ball Corporation, Hydro, Ingka Group, Niaga®, ROCKWOOL Group, Saint-Gobain, Signify, Spherity, thyssenkrupp and Unilever. While every effort has been made to faithfully reflect and build on the inputs provided, this paper does not necessarily reflect the views of these companies or the interviewees. We also wish to acknowledge the many helpful comments of reviewers from the We Mean Business Coalition, the World Business Council for Sustainable Development, the Taskforce for climate neutral and circular materials and products, the University of Cambridge Institute for Sustainability Leadership and the Wuppertal Institute. Special thanks are extended to Eliot Whittington, Ursula Woodburn, Martin Porter, Krisztina Zálnoky, Salomé Lehtman, Julia Pössinger, Lena Tholen, Dominic Gogol, Sophie Punte, Gitika Mohta, Polina Yaseneva, Maayke Aimée Damen, Luca De Giovanetti, Alessia Santoro, Anna Stanley and Robin Clegg.

Citing this report

University of Cambridge Institute for Sustainability Leadership (CISL) and the Wuppertal Institute. (2022). *Digital Product Passport: the ticket to achieving a climate neutral and circular European economy?* Cambridge, UK: CLG Europe.

Disclaimer and Copyright

The opinions expressed here are those of the authors and do not represent an official position of the Corporate Leaders Groups, CISL, the wider University of Cambridge, or clients.

Copyright © 2022 University of Cambridge Institute for Sustainability Leadership (CISL). Some rights reserved. The material featured in this publication is licensed under the Creative Commons AttributionNonCommercial-ShareAlike License. (Attribution-NonCommercial 4.0 International (CC BY-NC 4.0)).

“ *The EU fosters digitalisation and the transformation towards a climate-neutral, sustainable economy and describes this parallel process as the green and digital ‘twin’ transition. A Digital Product Passport (DPP) as envisaged in the EU’s European Green Deal and Circular Economy Action Plan is a great opportunity to modernise product information throughout the entire value chain. DPPs could be a big step forward for more sustainable products and consumption, boosting energy and resource efficiency by enabling new business models based on e.g. digital data sharing. DPPs could also substantially contribute to an improved security of energy and material supply for a resilient economy.* ”

Prof. Dr.-Ing. Manfred Fishedick,
Scientific Managing Director of the Wuppertal Institute

“ *The war in Ukraine is underlining that it is essential that we live within our means and find ways to be more geopolitically independent with our materials in Europe. A well-designed Digital Product Passport will be an invaluable policy and business tool in support of this goal, as it will enable businesses to create more sustainable and circular materials and products by monitoring how they are made throughout the supply chain. It will also support consumers to make well-informed choices based upon sustainability criteria. This could be game-changing in the effort to build a European circular economy.* ”

Eliot Whittington,
Director of Policy, University of Cambridge Institute for Sustainability Leadership

Contents

Executive summary	7
1. Introduction	
1.1 What is a Digital Product Passport?	9
1.2 Purpose and structure of the report	9
2. Why a Digital Product Passport is needed	
2.1 Economy-wide decarbonisation and environmental impacts	
2.1.1 Digital solutions as enablers for the transformation towards sustainable economies	10
2.1.2 Improved circularity and holistic CO ₂ reporting through DPPs	11
2.2 Sectoral decarbonisation	
2.2.1 Potential uses of DPPs	11
2.2.2 DPPs as an enabler for circular economy strategies and beyond	11
2.3 Business-level decarbonisation	
2.3.1 Expected long-term benefits of DPP systems for business	12
2.3.2 Benefits of DPPs beyond a circular economy	12
2.4 What remains unknown about DPPs	13
3. Policy evolution leading to a DPP	
3.1 Policy frameworks	14
3.2 Legislative initiatives	
3.2.1 The blueprint for DPPs in the EU	15
3.2.2 Digital Europe Programme	15
3.2.3 Ecodesign for Sustainable Products Regulation (ESPR)	15
3.2.4 Construction Products Regulation (CPR)	16
3.2.5 EU Strategy for Sustainable and Circular Textiles	16
3.3 Accompanying legislation for the decarbonisation of industry	17
3.4 More initiatives to come	17

4. Business perspectives and views on a DPP

4.1	Envisaged main benefits of DPPs	18
4.2	Expected general challenges to DPPs implementation	19
4.3	Potential solutions to general challenges	20
4.4	Case studies	
4.4.1	Construction industry	22
4.4.2	Furniture manufacturing	23
4.4.3	Metal industry	23

5. Conclusions and recommendations

5.1	Overall conclusions from industry perspectives	25
5.2	Recommendations	
5.2.1	Implementation principles	26
5.2.2	Guiding questions for further design	26

Annex: Stakeholder support for DPP adoption, and further initiatives with links to DPP stakeholder support **27**

Further initiatives **27**

6. References **31**

Table of abbreviations

BIM	Building Information Modelling
CBAM	Carbon Border Adjustment Mechanism
CDP	Former Carbon Disclosure Project
CEAP	Circular Economy Action Plan
CISL	Cambridge Institute for Sustainability Leadership
CLG	Corporate Leaders Group
CO₂	Carbon Dioxide
CPR	Construction Products Regulation
CTI	Circular Transition Indicators
DBP	Digital Battery Passport
DPP	Digital Product Passport
EBA	European Battery Alliance
EC	European Commission
EPD	Environmental Product Declaration
ESG	Environmental, social and governance
ESPR	Ecodesign for Sustainable Products Regulation
ETS	Emission Trading System
EU	European Union
GBA	Global Battery Alliance
GHG	Greenhouse gas
GPP	Green public procurement
IDDI	Industrial Deep Decarbonisation Initiative
IDSA	International Data Spaces Association
IEA	International Energy Agency
IPR	Intellectual property rights
PACT	Partnership for Carbon Transparency
PEF	Product Environmental Footprint
SBTi	Science Based Targets Initiative
SMEs	Small and medium-sized enterprises
UPI	Unique product identifier
WBCSD	World Business Council for Sustainable Development

Executive summary



iStock.com/metamorworks

The introduction of a Digital Product Passport (DPP) is an opportunity to create a system that can store and share all relevant information throughout a product's life cycle. This would provide industry stakeholders, businesses, public authorities and consumers with a better understanding of the materials used in the product as well as their embodied environmental impact.

With the COVID-19 pandemic, the Russian invasion of Ukraine and the cost-of-living crisis, now is a critical moment to transform our economic and business models, while also addressing the huge scale of material emissions. DPPs can be a pivotal policy instrument in this goal. Furthermore, DPPs can accelerate the twin green and digital transitions as part of EU efforts to deliver positive climate action and sustainable economies.

In 2020, the European Commission (EC) adopted a new Circular Economy Action Plan (CEAP), which emphasised the need for circular economy initiatives to consider the entire life cycle of products, from the production of basic materials to end-of-life disposal. The Circular Economy Package published in March 2022 includes a proposal for an Ecodesign for Sustainable Products Regulation (ESPR), which builds upon the Ecodesign Directive that covers energy-related products.

A DPP will form a key regulatory element of the ESPR by enhancing the traceability of products and their components. This will provide consumers and manufacturers with the information needed to make better informed choices by taking their environmental impact into consideration.

As discussed in the report, there is widespread agreement amongst business leaders that a well-designed DPP could have both short- and longer-term benefits, improving access to reliable and comparable product sustainability information for businesses, consumers and policymakers.

A well-designed DPP can unify information, making it more readily accessible to all actors in the supply chain. This will support businesses to ensure an effective transformation towards a decarbonised industry. It could also create incentives for companies to make their products more sustainable, as improving access to reliable and consistent information across supply chains will make it easier for customers to make comparisons.

The introduction of a DPP would deliver a range of benefits including:

- Access to reliable and comparable product sustainability information for businesses and policymakers, and also information to address product liability challenges more broadly.
- Access for consumers to information that enables them to make more informed and sustainable choices.
- Increased transparency, traceability and consistency for each player in each part of the value chain.
- Support for companies to monitor and report against sustainability indicators and claims through a digital tool.
- A tool that can facilitate innovative thinking on circularity and new practices.
- Potentially an enabler for the development of completely new business models.
- New data sources that can enable sustainable investment decisions.
- Enabling resource optimisation as well as energy efficiency strategies.

The key business concerns centred on what product groups and materials DPPs should cover, what information they should contain, levels of transparency and granularity, and how the data could be managed and shared without compromising confidentiality.

Conclusions and recommendations

DPPs are a great opportunity to modernise and digitalise product information to support industry transformation towards carbon neutrality and increased circularity. There is a strong belief that a DPP can be an important instrument to help consumers make better informed choices and create incentives for producers to make their products more sustainable.

Further development of DPPs should follow the following principles:

Coherence and consistency:

- **All forthcoming EU regulations and initiatives for which DPPs are discussed should be closely aligned and linked with the approach proposed for the ESPR** and experiences from the EU Battery Passport.
- **The digital infrastructure and software for IT implementation of DPPs should be interoperable and compatible** as far as possible with other systems.
- **The EU should manage the overall governance for implementing a DPP** through setting clear guidelines for use. The EU should also create an enabling environment through common standards, access rights management and an interoperability framework.

- **Existing international initiatives, approaches and stakeholders present in the harmonisation of product data and standards should be used** to avoid redundancies or duplication of efforts.
- **DPPs should be used to set criteria for green public procurement** and as a substantiation tool for ecolabels.
- **DPPs should enable a common framework for additional voluntary product information sharing**, by setting a standardised approach to exchange information such as recycled content or carbon and product footprints in complex supply chains

Flexibility and exploration:

- **Start small and modestly but promptly with DPP testing and pilots**, based on a phased approach with the possibility for continuous extension and further development to enable iterative learnings.
- **Start with a variety of clearly defined products and sectors as pilots**, to test the general approach and identify what commonalities exist between different product groups.
- **All detailed data included in DPPs should be product group specific** to be reliable and comparable rather than a one-size-fits-all approach.
- A **decentralised DPP approach** to product information storage is favoured by most businesses over a centralised approach.

Transparency and accountability:

- **Sufficient data should be provided for consumers, businesses and investors**, so that they can make more informed purchasing decisions that take sustainability criteria into consideration.
- **All information requirements for a DPP should be relevant and fit for purpose**; hence, each piece of information should be based on a clear scope and a concrete user benefit along the product life cycle.
- **Mandatory product information in DPPs should balance different levels of data access and data protection needs**, so that transparency is ensured as default along the value chain without infringing legitimate confidentiality concerns.
- **The operational implementation of DPPs should be carried out via trusted intermediaries** to ensure strong governance principles that have both technical expertise along with an understanding of the wider policy aims of DPPs to support a circular economy.

1. Introduction

The EU's Circular Economy Action Plan (CEAP) sets out that the global consumption of materials such as biomass, fossil fuels, metals and minerals is expected to double in the next 40 years, while annual waste generation is projected to increase by 70 per cent by 2050.^{1,2,3} For products, up to 80 per cent of their environmental impacts are determined at the design stage.⁴ A major reason for this is that the linear pattern of 'take-make-use-dispose' does not provide producers with sufficient incentives to make their products more circular. Many products break down too quickly, cannot be easily reused, repaired or recycled, and many are made for single use only.

The effect on the climate is dramatic; basic materials account for around 16 per cent of net annual greenhouse gas (GHG) emissions in the EU and 20 per cent globally. Therefore, speeding up the transition towards climate neutral materials and products is critical.⁵ The EU must **foster large-scale demand** for domestically produced circular and climate neutral materials and products to support industrial decarbonisation and reduce dependency on primary material imports.⁶ This will make it economically viable for companies to fundamentally transform their production and value chains.

DPPs are expected to play a **key role in facilitating innovative approaches** by enabling the exchange of information on the sustainability parameters of products, such as their carbon footprint and recyclability, across value chains. More broadly, DPPs could be key to enabling circular economy and carbon reduction strategies, including those for new markets and business models, and also to social compliance reporting. However, a broadly applicable DPP approach has yet to be established.

Following the EU's proposal for the Ecodesign for Sustainable Products Regulation (ESPR), the Commission will likely put in place a generic basic design for DPPs that is applicable to most materials and products, complemented by sectoral modulations to adapt the design to the core elements of different product groups. The DPP will need **to be interoperable with other similar systems** as products and materials may pass through various industries and applications during their lifetime.

In this report, we present the background on DPPs, their implementation process, and also the barriers and benefits from a business perspective within the EU. The EU is currently a front-runner in the DPP development process, and therefore its experience could serve as learning material and provide a blueprint for their global application.

1.1 What is a Digital Product Passport?

The European Commission (EC) defines a 'product passport' as a product-specific data set, which can be electronically accessed through a data carrier to "electronically register, process and share product-related information amongst supply chain businesses, authorities and consumers".⁷ The DPP would provide information on the **origin, composition, and repair and disassembly possibilities of a product, including how the various components can be recycled or disposed of at end of life.**

This information can enable the upscaling of circular economy strategies such as predictive maintenance, repair, remanufacturing and recycling. It also informs consumers and other stakeholders of the sustainability characteristics of products and materials.

1.2 Purpose and structure of the report

This study was carried out by the University of Cambridge Institute for Sustainability Leadership (CISL) in collaboration with the Wuppertal Institute for Climate, Environment and Energy. The report was commissioned by the CLG Europe Taskforce for climate neutral and circular materials and products. It focuses primarily on **business perspectives of introducing DPPs in the EU context**, with two key objectives:

- To provide key business perspectives on DPPs and how they might operate.
- To assess what steps need to be taken by policymakers and regulators to prepare for the implementation of DPPs.

This study contributes to the wider discussion on the twin European digital and green transitions by showcasing DPPs as a way to scale up digital solutions that can also accelerate the transformation towards a more sustainable European economy.

An extensive literature review (Section 2) provides a starting point for the rationale behind DPPs, and is followed by an overview of the relevant policies and initiatives that have already provided insight into the potential implementation of DPP-related concepts (Section 3).

The study addresses unanswered questions such as how to incentivise voluntary data sharing by companies during pilot stages, how data sharing could be regulated, and how companies feel about the benefits and potential risks of DPPs. Based on this practice-oriented research approach, the report presents the outcomes of the discussion with business representatives (Section 4), and then provides conclusions and recommendations (Section 5) for the future implementation of DPPs by policymakers.

The study also considers how DPPs could influence the wider climate and sustainability debate. Accordingly, it also provides initial considerations to stimulate further discussions.

2. Why a Digital Product Passport is needed

2.1 Economy-wide decarbonisation and environmental impacts

2.1.1 Digital solutions as enablers for the transformation towards sustainable economies

It is widely accepted that digitally-enabled solutions are central to the transformation to a more sustainable economy and the EU’s ‘competitive sustainability’.^{8,9} The EC describes the parallel transformation associated with digitalisation and the transformation towards a climate neutral, sustainable European economy as the “Twin Transition”.¹⁰ The Commission’s view is that this transition can only work if the two stated transformations are truly connected; in other words, digital technologies are crucial enablers for climate neutrality.¹¹ Likewise, meaningful technological change must be environmentally and socially sustainable to avoid negative impacts.

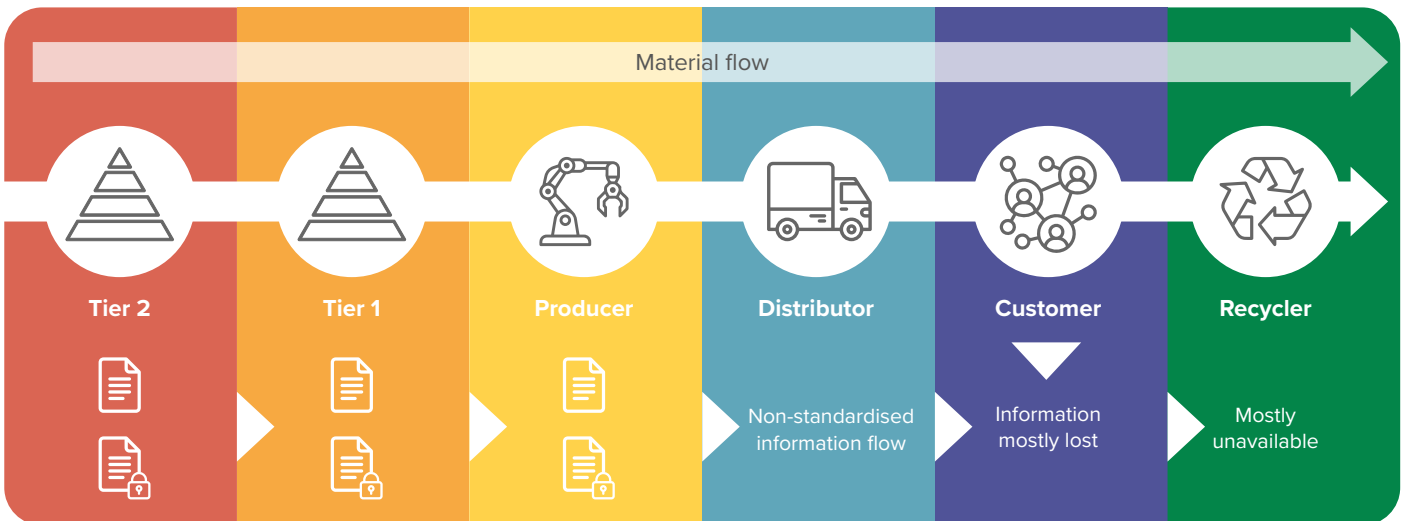
The creation of a more circular economy will act as a catalyst in the transition towards enhanced sustainability in value chains. It should be founded on renewable, recycled feedstocks, to keep products and materials in use as long as possible, after which

they can be transformed at the end-of-life stage into valuable commodities. The **circular economy has huge economic implications to enable new business models, new products and services**, and green markets. It has also become one of the most important sustainability strategies in policy, industries and companies.

However, circular economy markets require deep transparency on the properties of materials and products, such as on the quality of used products and recycled materials, as these are crucial for product functionality and safety. It is also essential to create trust in the quality of secondary materials. Armed with this type of information, consumers, businesses and public procurers can make better informed purchase or investment decisions for particular sustainable products.¹²

However, within the current linear economy, such information is largely unavailable due to a lack of standardised protocols and technologies for data or information transfer within the value creation chain or during a product’s ‘use’ phase. In effect, most of the information that is relevant to enabling a circular economy is lost at several steps along the supply chain (see Figure 1).¹³

Figure 1: Information flow and losses in a linear economy (own illustration, based on the Product Circularity Data Sheet¹⁴)



*The figure was developed by PositivImpaKT and the Ministry of the Economy of Luxembourg.

2.1.2 Improved circularity and holistic CO₂ reporting through DPPs

All advanced circular economy strategies, such as refurbishment of complex products or extensive high-quality recycling of materials, depend on the availability of reliable and recent data. The **creation of a fully functioning digital circular economy information system** must be considered a crucial prerequisite for improved resource efficiency and effectiveness.¹⁵

DPPs can be the prominent data carrier for a product or material, listing master data (product, manufacturer, composition, substances of concern, toxicity and sourcing) and new data (use, modification, maintenance, and wear and tear). They can enable information monitoring and management on the composition and life cycle of a product or material.¹⁶ Ideally, such digital data management might enable close to real-time environmental impact monitoring.

Given the information requirements that are needed to fully establish a circular economy, the upcoming DPPs could potentially be the main source of data and information.^{17,18} The exchange of stakeholder material and product information within DPPs will be central to upscaling them, as it will improve analysis and understanding. Furthermore, such information exchange will provide key knowledge for future circular economy strategies, and set **the necessary level of transparency**.¹⁹ Moreover, learnings from DPP data analysis could enable improvements for stakeholders and also at the policy level, such as through better informed science-based targets (see Annex).

For policymakers and public administrators, DPPs could support the implementation of demand-side policies on materials and products.²⁰ These policies would be essential for providing a level playing field for the transition to a circular and climate neutral economy. DPPs could also improve policy evaluation, as they would allow policymakers to better understand the implications of new or revised sustainable development policies. Moreover, DPPs may enable, or improve, market surveillance so that the compliance on EU domestic and imported goods could be effectively monitored and enforced.

2.2 Sectoral decarbonisation

2.2.1 Potential uses of DPPs

DPPs could be implemented in sectors producing batteries,²¹ textiles,²² furniture, electronics, and construction and building materials in a similar way to Material Passports,²³ Building Information Modelling (BIM)²⁴ and automobiles (Catena-X).²⁵ In particular, high-value products, such as the larger traction batteries used in the automotive sector, are suitable for item-specific DPPs. The recirculation of the precious materials and high-quality components that these products contain would result in direct environmental and economic benefits. For other, smaller and lower-value products that might be mass produced, it is more likely that DPPs will be created for a particular batch or product series.²⁶ Currently, these sectorial plans are at the conception or prototype stage.

Information on the origin, quality and availability of critical primary and secondary materials and products could also improve the security of supply, and hence the functioning of circular economy markets. Through this process, resilience against geopolitical or other external shocks could be improved by alleviating market failures, which are often the reason for the non-functioning of circular economy approaches.²⁷ This is particularly relevant in the context of recent geopolitical developments following the Russian invasion of Ukraine, which has brought a greater focus on the EU's dependencies on imports of materials and resources from outside its borders.

Additionally, DPPs could be relevant to industries as digital-based supply chain compliance tools for reporting duties such as GHG emissions, life cycle assessments or corporate social responsibility reporting. For example, they could provide detailed and recent information along the value chain to create the conditions for Scope 3 GHG reporting. Scope 3 emissions cover all indirect emissions, both upstream and downstream, that occur in the value chain of a reporting company.²⁸

The introduction of a DPP would deliver a range of benefits including:

- Access to reliable and comparable product sustainability information for businesses and policymakers, and also information to address product liability challenges more broadly.
- Access for consumers to information that enables them to make more informed and sustainable choices.
- Increased transparency, traceability and consistency for each player in each part of the value chain.
- Support for companies to monitor and report against sustainability indicators and claims through a digital tool.
- A tool that can facilitate innovative thinking on circularity and new practices.
- Potentially an enabler for the development of completely new business models.
- New data sources that can enable sustainable investment decisions.
- Enabling resource optimisation as well as energy efficiency strategies.

2.2.2 DPPs as an enabler for circular economy strategies and beyond

DPPs could inform manufacturers about the nature and qualities of secondary materials, including purity, substances of concern, materials used, additives, fillers, dyes. Clear and reliable information is essential when recycled materials need to fulfil the same criteria as primary materials for performance or product safety, for example.

DPPs could support circular economy strategies in:

- **Repair and predictive maintenance**, by enabling the determination of advice for repair, maintenance needs and timeframes.
- **Reuse**, by better determining a product's residual value and other properties, including expected number of rotations, travel and remaining lifespan.
- **Refurbishment**, by providing insight on use, abuse and abrasion, as well as on reparability and identification of spare parts.
- **Remanufacturing**, by determining which parts of a discarded product can still be used and in which applications.
- **Recycling and recovery of materials**, by providing information on product composition, additives and substances of concern.
- **Appropriate, safe and environmentally friendly disposal** at the end of life of unavoidable residues.
- **General reduction of environmental impacts** through renewable/recycled feedstocks, and energy and resource efficiency.

The expected capabilities of DPPs to **significantly improve transparency and knowledge** will provide deeper insights into the circular economy regarding the content, attributes and use of products and materials. As well as being enablers for the diverse circular economy strategies, DPPs could also be used to understand the broader state of the circular economy. Such insight is currently difficult to obtain, especially for the more product-oriented strategies such as reuse and refurbishment. Currently, only recycling rates are regularly monitored and reported on in Europe, including by Eurostat.²⁹ However, such monitoring will drive learning for more effective circularity policies.

Information stored in a DPP on a product or material could **also be used to integrate information beyond the circular economy** in the longer term, once basic ingredient transparency has been achieved. On sector-specific policies, a DPP's capability to include information on GHG emissions could inform additional measures to support and encourage industry climate neutrality. For instance, information contained in DPPs could be used to inform (carbon) border adjustment mechanisms or compliance with chain of custody certificates or supply chain acts.

DPPs are not an ecolabel or sustainability claim. They provide the basic information substantiating any such ecolabels or sustainability claims. DPPs as currently framed would include consumers as a prominent target group.³⁰ DPPs are envisioned as offering a tool for better informed consumption choices that lead to more sustainability-oriented purchases. Consumers may also be interested in reparability information to mend damaged or inoperable products.

2.3 Business-level decarbonisation

2.3.1 Expected long-term benefits of DPP systems for business

Businesses can benefit from **a range of positive impacts** from DPPs and their infrastructure systems. They can form the basis of a unified data collection method as well as having the ability to store, process and apply data as required for complex value chain creation. Increased knowledge and insight can improve both product and process management on circularity in terms of material sourcing, durability, material efficiency and product and material recyclability. A DPP can also integrate fully automatic predictive and prescriptive resource efficiency strategies.³¹

Circular business models can result in higher product quality, durability and recyclability, leading to improved logistics for innovative product-as-a-service business models. Information from DPPs can support the establishment of cross-sectoral value chains, **opening up new markets for producers and manufacturers**, as secondary products may be able to enter new value chains, given that their qualitative characteristics are clearer.

2.3.2 Benefits of DPPs beyond a circular economy

DPP systems could significantly improve the communication of a product's sustainability and other criteria for customers, investors or other stakeholders for reporting and auditing processes. This is relevant in the context of GHG reporting duties for companies. As such, DPPs can play a decisive role in industrial transformation towards climate neutrality, particularly in the production of energy- and material-intensive basic materials such as aluminium and cement.³²

Businesses urgently need to offer climate neutral products as an alternative choice for companies and customers. DPPs could automatically generate CO₂ footprint calculations for companies and the wider value chain. Value chain measurement and reporting of CO₂ emissions (as per Scope 3 reporting) could be another core application of DPPs, with the **ultimate goal of redesigning products and value chains**. An additional application would be to facilitate compliance with social governance criteria, including on modern slavery and child labour. Such information could be stored in DPPs for materials and products, and then passed along supply chains throughout their production and use phases. DPPs could become the single point of truth for such data.³³

2.4 What remains unknown about DPPs

Several questions remain about **the content of DPPs and the functioning of their underlying systems**. The current focus has been on the conceptual design, how it might be regulated, its data infrastructure and how it might integrate with other similar systems in development.^{34,35}

Although numerous DPP-related publications provide insight, there is still no universally accepted definition.³⁶ It is unclear whether technological elements, such as identifiers, underlying data spaces and knowledge graphs, will be included in DPPs. There is also a need to clarify the important issue of interoperability within, and beyond, a DPP system, including the design of interfaces.

It is also unclear how granular DPPs should be, or at what scale DPPs should be created. For example, it may make sense to have individual DPPs for complex products such as buildings, planes or cars. However, this approach may take time, or may not be feasible for materials such as plastics or substances such as chemicals.

Another unknown is whether there is a need for **different DPPs for diverse stakeholder groups**. For example, consumers could receive different information than businesses or public administration bodies because of their differing needs and levels of understanding.

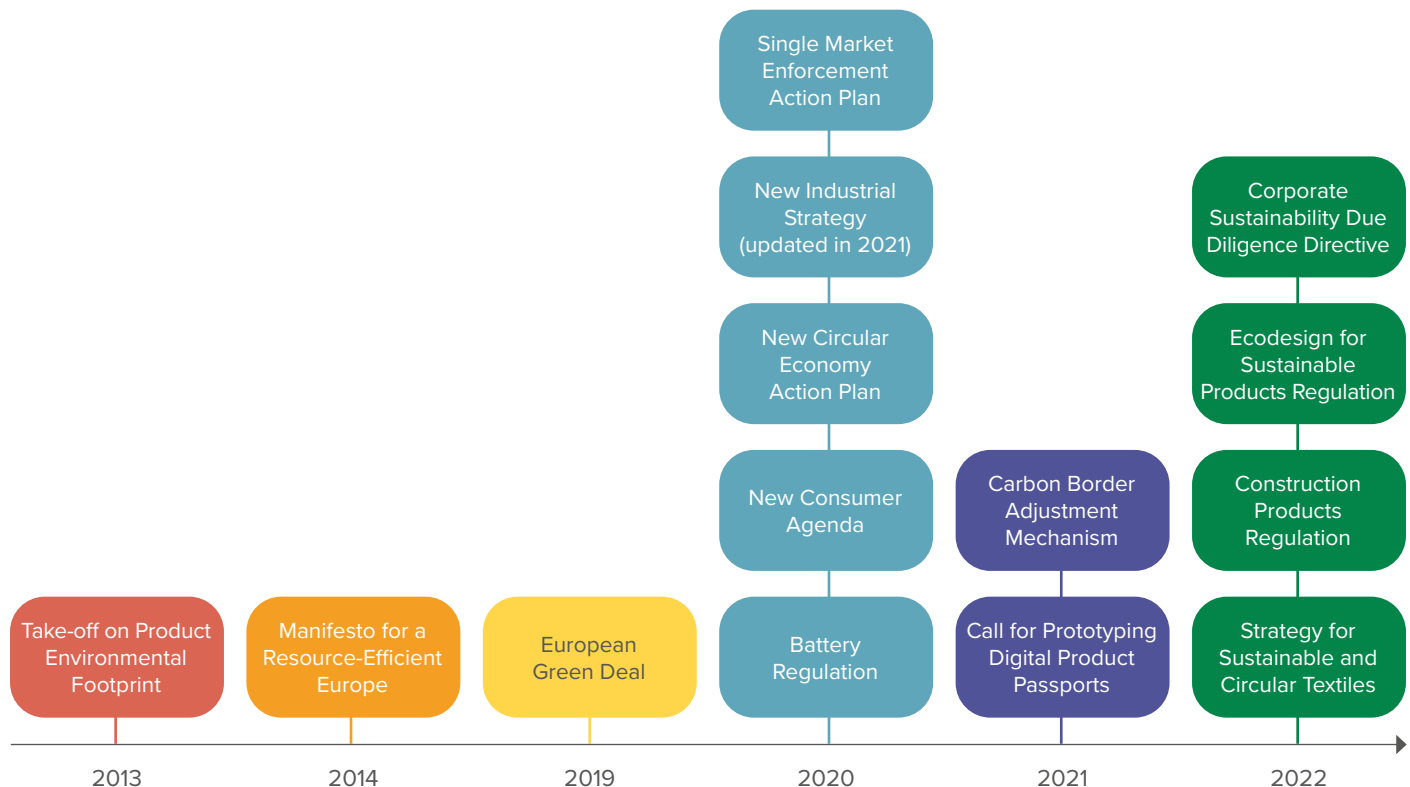
There is an open question on who manages publicly mandated DPP systems, and how they will do so. This is important in the context of know-how and intellectual property rights (IPR) protection, as these issues are frequently raised by businesses that fear losing their competitive advantage if sensitive product-specific data became publicly available. Regulating data access, anonymity and protection is therefore also a key consideration that will need to be clarified.

More widely, the EC sets the pace for the development and introduction of DPPs, which means it is currently perceived as a 'European' project. Thus, how partners from outside the EU fit into the equation will need to be established as many supply chains operate globally. The following Sections examine these and other questions.

3. Policy evolution leading to a DPP

When the European Resource Efficiency Platform instigated initial discussions on a DPP in 2014 (COM 2014),³⁷ they focused on the reuse of materials in the production process. Since then, the circular economy and product sustainability as thematic topics have shot up the political agenda. The introduction of a DPP was overshadowed by the European Green Deal in 2019 and the circular economy, heralding a new era of product-related EU policies, as shown in the timeline in Figure 2.

Figure 2: EU initiatives relevant to the introduction of a Digital Product Passport (source: own illustration)



3.1 Policy frameworks

The EC's 2020 Single Market Enforcement Action Plan³⁸ and the updated New Industrial Strategy³⁹ stress the role of digital tools in market surveillance. Improved identification of products that do not comply with market rules creates a fairer EU market and protects consumers from counterfeit or dangerous products. The EC intends to encourage market surveillance authorities to step up the digitalisation of product inspections and data collection by using state-of-the-art technologies to trace non-compliant and dangerous products. In the longer term, a **DPP could become a game-changer**, if it can confirm product information and whether certain standards are met.

The 2020 EU Consumer Agenda⁴⁰ seeks to empower consumers to make more informed purchasing decisions. The agenda specifically mentions a DPP's role as **an informative instrument allowing for comparisons between products** by comparing their carbon footprints and wider environmental impacts. As such, DPPs could be a powerful tool to tackle the issue of greenwashing. By also factoring in public procurement, DPPs could also enhance green public procurement measures, while manufacturers could showcase environmental credentials as a unique selling point.

3.2 Legislative initiatives

3.2.1 The blueprint for DPPs in the EU

In late 2020, the EC published the EU Batteries Directive to reduce negative environmental and social impacts throughout all life cycle stages.^{41,42} The Directive proposed the establishment of an electronic exchange system and a DPP (or 'Battery Passport') for rechargeable industrial and electric vehicle batteries with an internal storage capacity above 2 kWh.

The electronic exchange system covers different aspects including:

- Public information on the battery manufacturer or place of production.
- Sustainability information on the battery composition (including critical raw materials), the carbon footprint or the recycled content.
- Information relevant to specific economic groups, such as remanufacturers, second-life operators and recyclers – for example, disassembly sequences and detailed battery compositions.
- Information for government bodies, such as market surveillance authorities or the EC, that are mandated to receive test reports and to check product compliance with market rules.

With regard to compliance issues, the Batteries Directive foresees:

- All information will be provided electronically by the economic operator placing the respective battery on the market. The Battery Passport will include individual values for electrochemical performance and durability parameters (eg rated capacity, capacity fade, power and power fade) and is to be identified through a unique identifier on every single battery. The information must be available online and up to date. For both the electronic exchange system and the Battery Passport, future implementation must establish "rules for accessing, sharing, managing, exploring, publishing and reusing of the information and data".⁴³

Despite the Directive's specific focus on batteries, several aspects are relevant to DPPs. General environmental information is intended for consumers, while specific technical information is restricted to end-of-life and second-life operators and market surveillance.

3.2.2 Digital Europe Programme

In 2021, the EC published in its Digital Europe Programme a call to create at least three DPP prototypes, including data requirements and system architectures. Its objective is to prepare for the gradual deployment of a minimum of three DPPs (starting in 2023) in the key value chains of electronics, batteries and at least one other key value chain of the following as set out by the CEAP: information and communication technology, textiles, furniture and high-impact intermediary products such as steel, cement and chemicals.

3.2.3 Ecodesign for Sustainable Products Regulation (ESPR)

In March 2022, the EC published a package of new proposals (including the ESPR, which was previously called the Sustainable Products Initiative or SPI⁴⁴) to make sustainable products the norm, boost circular business models, cement Europe's resource independence and empower consumers for the green transition. The package includes a set of horizontal and sectoral legislation to accelerate the transformation towards a European circular economy, reducing geopolitical dependencies on raw material and energy imports through greater self-sufficiency while also protecting the environment.⁴⁵

The EC's proposal for the ESPR aims to reduce waste and ensure that products that are either made or sold in Europe are fit for a climate neutral, resource-efficient and circular economy. The original Ecodesign Regulation focused on energy-related products and minimum energy performance standards, while factoring in certain material efficiency aspects of energy-related products. The new ESPR extends the scope to almost all products, and focuses on the reduction of life cycle environmental impacts. The ESPR serves as a dedicated legal basis for a DPP. The DPP is thereby defined as "a set of data specific to a product that includes the information specified in the applicable delegated act [...] and that is accessible via electronic means through a data carrier."⁴⁶ The ESPR also sets criteria for green public procurement and delivers a framework for preventing unsold consumer products from being destroyed.

While the proposed framework directive of the ESPR sets the general basis for the EU's future product policy, delegated acts will determine the exact eco-design requirements for every regulated product group. Impact assessments and stakeholder consultations will be used to identify and align the respective requirements.

The current ESPR proposal lists the following aspects for improving performance and delivering more sustainable products:

- a. durability,
- b. reliability,
- c. reusability,
- d. upgradability,
- e. reparability,
- f. possibility of maintenance and refurbishment,
- g. presence of substances of concern,
- h. energy use or energy efficiency,
- i. resource use or resource efficiency,
- j. recycled content,
- k. possibility of remanufacturing and recycling,
- l. possibility of recovery of materials,
- m. environmental impacts, including carbon and environmental footprint, and
- n. expected generation of waste materials.

The ESPR differentiates between performance requirements and information requirements, as shown in Figure 3. In this context, ‘performance requirements’ are defined as those that are quantitative or non-quantitative and relevant to achieve a certain performance level. ‘Information requirements’ refers to the obligation for a product to be accompanied by defined information.

Key elements of a DPP will include a unique product identifier, compliance documentation, user manuals, instructions, warnings or safety information (as required by other EU legislation applicable to the product), information related to the manufacturer, such as its unique operator identifier, and information related to the person or company placing a product on the EU single market. The delegated acts will also specify the type of data carrier, whether the information has to be model, batch or item specific, and how the DPP is made available to customers before product purchase. Moreover, it will need to specify which group of stakeholders will need access to it, and what information they have access to. Furthermore, it will also need to be clarified who would introduce or update the data on a DPP.

The EC seeks to ensure that all those within the value chain have **access to relevant product information** to enable compliance checks for national authorities and to improve the traceability along the product life cycle. A data carrier (such as a QR code) must be “physically present on the product”, to enable connection to a DPP. Access to information must be free of charge, and the data must be stored by the economic operator responsible for its creation (or by representatives) and be available for the period specified in the relevant legislation. The EC also proposes setting up an overarching centralised registry, for customs purposes, storing only key data included in the DPP, which “at least include a list of the data carriers and unique product identifiers”.⁴⁹

3.2.4 Construction Products Regulation (CPR)

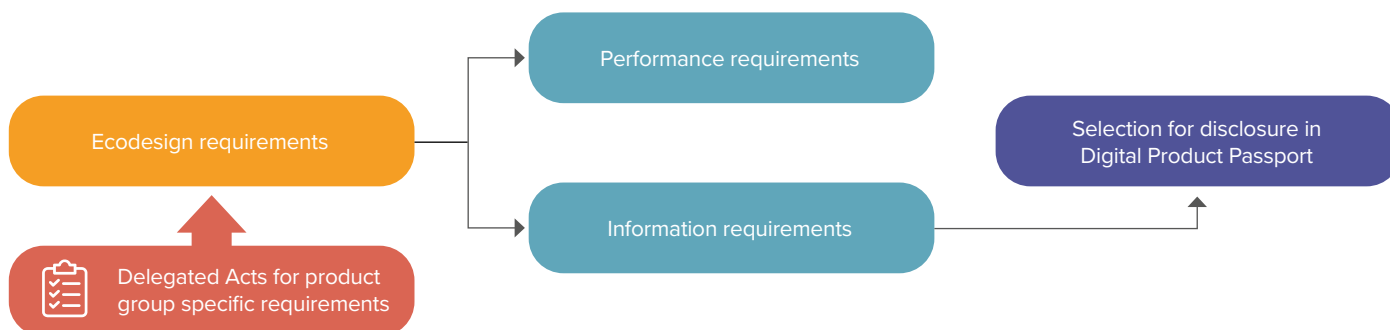
The review of the CPR is to strengthen and modernise the rules of the previous regulation from 2011. Certain shortcomings of the original CPR, including its insufficient contribution to the green transition, required a revision of the regulation. It now contains a target to create a harmonised framework to assess and communicate the environmental and climate performance of construction products. New product requirements will ensure they are more durable, repairable, recyclable and easier to remanufacture. Another target supports standardisation bodies during the creation of common European standards.

The proposal plans to set up an EU construction products database, or system, that “builds to the extent possible on the Digital Product Passport”.⁵⁰ Manufacturers will upload defined data, and all economic operators will have access to stored data “which regards them specifically”. In the products database, manufacturers will make available instructions for use and repair, as well as guides on how to remanufacture or recycle products. It is worth mentioning that the definition of ‘economic operators’ has been extended with the proposed revision of the CPR, to factor in “economic operators de-installing or dealing with used products for re-use or remanufacturing”.⁵¹

3.2.5 EU Strategy for Sustainable and Circular Textiles

The EU Strategy for Sustainable and Circular Textiles aims that by 2030 textile products placed on the EU market will be long-life and recyclable. They will be made as much as possible from recycled fibres, free of hazardous substances and produced respecting social rights and the environment. Measures include specific ecodesign requirements for textiles to minimise overall carbon and environmental footprints, an extended mandatory producer responsibility scheme, more user-oriented information and a DPP. Combined, these measures will ensure the accuracy of ‘green’ claims and provide a boost for circular business models through reuse and repair services. Thereby, a DPP will be at the centre of the twin transition of circularity and digitalisation in the textile sector.

Figure 3: Requirements envisaged in the Ecodesign for Sustainable Products Regulation proposal (source: own figure based on Malgaj (2022⁴⁷))⁴⁸



3.3 Accompanying legislation for the decarbonisation of industry

In 2021, the EC introduced a proposal to the Carbon Border Adjustment Mechanism (CBAM), a policy instrument designed to equalise differences in carbon costs between EU domestic and imported products. Initially, it was intended to apply to imports of cement, iron and steel, aluminium fertilisers and electricity.⁵² It addressed the fact that EU industries had been facing carbon costs from the European Emissions Trading System (ETS), unlike those in non-EU countries. This created a disadvantage for domestic producers.

Although not currently expected to be in the current version, an EU CBAM could be used in the future to mandate that importers of regulated products pay a price based on the carbon footprint of their product before it is sold on the EU Single Market. In the future, a DPP could be **an important tool to disclose the carbon footprint of products**. The need for reliable information throughout the whole product value chain is a key factor in calculating the carbon price through a CBAM.⁵³

In early 2022, the EC adopted a proposal for a Directive on Corporate Sustainability Due Diligence to foster sustainable and responsible corporate behaviour throughout global value chains. Companies will be required to identify and, where necessary, prevent, end or mitigate the adverse impacts of their activities on human rights (eg child labour) and on the environment (eg air, soil or water pollution).

These new due diligence rules will ensure legal certainty and a level playing field for businesses, and more transparency and accountability for consumers and investors. In particular, the rules are intended to apply to companies of a substantial size and economic power, or those operating in defined high-impact sectors, such as textiles or the extraction of mineral resources.

The proposal applies to the companies' own operations, their subsidiaries and entire value chains, including direct and indirect business relationships. Companies will need to identify, monitor and publicly communicate significant amounts of data. EU Member States will be responsible for supervising these new rules and may impose fines in cases of non-compliance. Accordingly, a **DPP could be beneficial to ensure that companies receive reliable information on their suppliers' operations** and to cover their whole business activities throughout complex global supply chains, including data on the environmental footprint and human rights track record of products.

3.4 More initiatives to come

Such policy initiatives and proposals, at a European level, illustrate the high priority for product policy and the DPP. Indeed, many other upcoming EU initiatives, such as on Substantiating Green Claims and on the Right to Repair, and also voluntary initiatives, such as the Sustainable Consumption Pledge, will further complement product, consumer and industry policies.

In addition, many voluntary initiatives (see Annex for more details) share the same target to improve the availability and comparability of product information, including Environmental Product Declarations (EPDs), the Greenhouse Gas Protocol, the Science Based Targets Initiative (SBTi), the European Battery Alliance (EBA), the Global Battery Alliance (GBA), the Industrial Deep Decarbonisation Initiative (IDDI), the World Business Council for Sustainable Development (WBCSD) and the Partnership for Carbon Transparency (PACT). For all these initiatives, strong, new, digital tools are needed and the **DPP could ensure data availability and exchange**.

4. Business perspectives and views on a DPP



iStock.com/Yozayo

This report presents insights from an intensive dialogue with members of the CLG Europe Taskforce for climate neutral and circular materials and products and other identified business stakeholders across sectors and value chains. An interactive workshop and interviews focusing on the business perspectives of DPP implementation were conducted with company representatives. The outcomes of this interactive discussion are presented according to the Chatham House Rule.

The workshop and interviews were attended by business representatives from across various sectors, including aluminium, construction, consumer goods, design, digital solutions, insulation, lighting, retail and steel.

4.1 Envisaged main benefits of DPPs

Based on overall feedback, there is strong agreement that DPPs could have several benefits in both the short term (< 5 years) and the long term (> 5 years). The **key benefits** of DPPs identified by the participating companies cover access to reliable and comparable product information for businesses, consumers and policymakers to substantiate sustainability claims, and also options for IPR protection, which could open up new business opportunities and models.

Recording sustainability data and improvements along cascading value chains are broadly considered as worthy in themselves. DPPs could improve general **access to information for businesses** across the value chain. This could further highlight product **benefits for consumers** as they could obtain

relevant information to substantiate the claims made on product ecolabels and thus be able to make more informed and sustainable choices. DPPs have the potential to provide **extra layers of reliable product information** about recycled content and raw materials. This information would help with data availability and transparency when improvements are being made to circular designs and practices, including recycling by end consumers. DPPs would, therefore, **increase transparency, traceability and consistency** in each part of the value chain.

DPPs could serve as **digital-based supply chain compliance tools** to monitor and report indicators, such as Scope 3 GHG emissions. This could result in long-term benefits for businesses, especially if other administrative burdens could be reduced. Based on standardised data, DPPs could also **allow a direct comparison** with other products and businesses on carbon footprints, circularity and recycling beyond recycled content. This could be facilitated by the inclusion of blockchain certificates for low carbon materials, which provide useful data to support the sustainability claims.

Another benefit is knowing more precisely whether a product is **recyclable** and how to recycle it. This information could be made available to recyclers and consumers. As a **tool to provide the underlying factual information** required to substantiate **sustainability claims**, DPPs could form a **basis for creating green markets**.

Information and data should be shared in a balanced way so commercially sensitive and confidential information could be omitted. It will not be necessary for all data to be available to everyone. DPPs could also tackle issues related to **IPR** protection as, in principle, every producer of components for a product would be obliged to provide data. This would imply that each product component would be linked to reliable and verified data, which is available, with different access levels, according to the specific stakeholder.

For the purpose of **better regulation**, DPPs would also provide access to dynamic information from the market, allowing regulators to better assess whether other issues should be considered in future policies. In addition, using a DPP as a reliable source of product-specific information could also **address product liability challenges**.

With the increase in **public awareness of sustainable practices** and informed choices, **consumers can be expected to increasingly demand access to information** on the recyclability and carbon footprint of the products they intend to buy. Consumers may choose to purchase a product to support a company's sustainability commitments, and thus it would be reasonable to assume that they would welcome the availability of clear, standardised data on sustainability in a DPP.

In the future, information taken from DPPs could also be **used for qualifying criteria** on specific decision-making purposes such as green public procurement.

Including additional aspects, such as product location and detailed recycling potential, in a DPP could bring additional benefits by improving **innovative thinking on circularity** and facilitating completely new circular practices. During a product life cycle, materials become components, which in turn become consumer goods or even buildings. The complexity of different product supply chains means that there are many requirements for data that a DPP could cover, such as the traceability of materials and components of products throughout their whole value chain.

This could also lead to the development of completely **new business models** (eg producer ownership models such as sharing and renting), including recycling services that disassemble complex products and sell the components for reuse or even upcycling. DPPs could be central to new business opportunities by solving the issue of currently unstructured data flows to the consumers that already occur without a DPP.

Overall, the benefits of DPPs build on the availability of reliable and uniform data, and include a **general improvement of material and product flows** to help 'close the loop', **supporting sustainable investment decisions for consumers and investors**, and providing the **ability to strengthen the overall level playing field** between different stakeholders. Another overarching benefit of DPPs would be their **enabling role for resource optimisation and also for increasing energy efficiency** via circular economy practices throughout the entire value chain. In the future, such practices could facilitate automated decision-making.

4.2 Expected general challenges to DPPs implementation

A major challenge will be deciding **what information a DPP can, or should, include** over the lifetime of a product, including repairs and usage, or if some of this information should be recorded separately by another 'digital twin' product. Ideally, all product-specific information could be part of a DPP, but from a systems perspective, comprehensive **implementation might prove to be complex in practice**.

Another question relates to how the storage of data for DPPs will be managed. From the perspective of the majority of industry, it would be important not to create a new, holistic, single database, as a **target-oriented decentralised approach** was considered to be most practical. Therefore, it will be important to define the main goals of DPPs at an early stage and focus on them. An accompanying roadmap will also be required to facilitate the move from a simple minimum viable product to a more complex instrument.⁵⁴

The **transparency** of information is also an important topic, as **business confidentiality** needs to be maintained through the provision of different access levels. One main concern is how exactly the **criteria** for DPPs are to be determined. Some business stakeholders commented that consumers and recyclers should be able to decide what information they 'need to know'. Questions were raised about how IPR and commercially sensitive information can be protected (especially when DPPs are implemented in a decentralised manner). However, such arguments should not be used as an excuse for not having to disclose elements such as hazardous substances in a product. If a 'need to know' principle would imply non-transparency as the default, rather than transparency, this could be incompatible with genuine circular economy targets.

For recycling, recyclers and consumers will require different information about a product's composition. **Consumers** will also need to be able to understand guidance on how they can repair or recycle a product, or whether manufacturers or retailers will accept their products for recycling. This information could be easily accessible via the internet using a QR code. In contrast, **recyclers** need to have more granular details on disassembling products and how the various components can be reused or recycled.

Whether **information taken from a DPP should form qualifying criteria for regulation** or whether other approaches such as an ecolabel should be used (eg for green public procurement rules) with the DPP acting as a data source was another question. Some stakeholders believed the two functions should be split or at least clearly defined, though there was no clear conclusion on this point.

From the perspective of some stakeholders, information on the **product location** could be a useful addition. Other stakeholders considered this as possible only in closed and clearly defined business-to-business environments, for example for buildings. However, privacy is often a major concern for consumers; thus, the availability of information on a product's location could cause conflict with other legislation such as the EU General Data Protection Regulation.

Some businesses would consider the inclusion of **commodity prices** in a DPP as useful, although this leads to questions about whether this is the public market price or the price paid between a supplier and a buyer. It would be challenging to constantly update databases to reflect commodity price changes.

Another open question relates to whether **social sustainability data** should be part of a DPP. Current plans for DPPs do not address specific data concerning social aspects, such as not using child labour further up the value chain. This is currently only monitored at the production location from a direct value chain company. For some stakeholders, such data sets could potentially provide valuable insight on the broader environmental and social sustainability footprint of materials or products. Others argued that the very limited availability of such social sustainability information is still a major barrier to prevent its inclusion in an early version of a DPP.

From the perspective of some companies, **DPPs for complex products consisting of many different components could be a challenge**, depending on a DPP's design and implementation. Businesses considered it would be better to undertake pilot exercises for clearly defined products that are easier to address. This approach could provide meaningful data to customers in the case of products that are made of many different parts. These results could then be discussed with customers.

Some industries currently think it would be difficult to implement DPPs in isolation, because a complete DPP ecosystem would be required to facilitate this approach. This would, in turn, require governance mechanisms, especially over how data points should be measured, validated and shared. Additional elements of a DPP are still to be explored with wider stakeholders.

Another challenge is that different policy instruments regulate different parts of sustainability information. For social information, the legislation for a DPP would have to be defined and identified. Thus, it will be important to see if the EC intends to integrate extended social and environmental information into a DPP.

4.3 Potential solutions to general challenges

The identified benefits and challenges of DPPs illustrate that the **way to obtain, and manage, verified and reliable data needs to be clearly determined**. During this process, it will be important to note that the needs of companies, regarding the information included in a DPP and the benefits of it, vary substantially depending on where a company sits within the value chain or its sector of operation. To address the needs of different stakeholders, it will be necessary to ensure that the specific data points for inclusion are well identified to prevent barriers for DPPs.

The first **technical details on a DPP** can offer common ground for discussion between policymakers and different industries as they underline the need for comparable and verifiable information using decentralised data sources to ensure correct information is contained in a DPP. The technical aspects already provided are a good place to start the discussion.

However, businesses need more specific details about the **intended design of a DPP**. Because of the lack of concrete technical information, some businesses are undecided about the creation of a single database and whether a decentralised approach should be taken. Industries emphasise that a DPP should be built on top of widely used existing systems, such as EPDs. Additional circularity indicators and other relevant information not already included, or similar approaches, could also be introduced into a DPP. The EC should therefore clarify their approach.

Industry perspectives point to the fact that a DPP **should link different sets of existing information** from different sources, but should not own the information. Accordingly, a DPP should be seen as a 'vehicle' for the information, but should not regulate it in isolation.

A common viewpoint among businesses is that all information included in a DPP should be **verifiable according to internationally recognised standards** to adequately enhance circularity in a product's operations and beyond, including the end-of-life treatment of components.

DPPs will **need to be more than just a reporting tool** if they are to be useful across the whole supply chain, for consumers and throughout the product life cycle. The exact goals, barriers and, therefore, the information to be covered in a DPP need to be clearly defined together with how the specific information will be used in practice to achieve the goals and tackle the identified issues.

The inclusion of a **unique product identifier (UPI)** is considered to be very important for businesses. UPIs should be applicable for cross-sectoral purposes in different product layers where data is traceable. Thus, it would have to be clarified to what extent one UPI applies for pallets storing packaging, primary product packaging, secondary product packaging and the content of the packaging. An example of this would be a shampoo product, which contains the shampoo itself, the bottle in which it is sold and also the secondary packaging such as a box.

Increased clarity on the governance aspect and targets of the data flow in DPPs could help to **balance the needs of transparency and confidentiality**, as some business data must be kept internal or only be disclosed under strict data protection rules to legitimate institutions that require the information. From a business perspective, an approach with layered access levels to DPP data could help to address the transparency versus confidentiality dilemma.

Some business stakeholders argue that the burden of proof lies with those wanting an exemption from transparency information requirements and that hold the information already, rather than the onus being on those requesting more detail. A solution could be that the data should, in principle, be made available to the public, with the caveat that it may be necessary to limit access in certain situations, such as for duly justified commercially sensitive and confidential information.

For the purposes of **better regulation**, requirements should not be duplicated across different regulations, as information requirements and obligations currently exist for certain product categories such as chemicals. Therefore, DPPs should automatically synchronise information from existing databases or replace it. Accordingly, it would be a potentially viable and efficient option for relevant business data to be stored on **cloud solutions** with different permission levels for different groups of stakeholders. Existing, company-initiated, pilot DPPs have already shown how simple consumer-related data allows them to make better informed decisions.

In some instances, there are no clear incentives for businesses to adopt circular practices, making it important to highlight the financial incentives in certain instances. **Sufficient financial incentives** are considered important to enable certain products to be recycled or returned to the producer (where producer responsibility is applicable).

Bearing in mind the complexity of products, it would be worthwhile during the first stage of the DPP development process to **start with less complex and clearly defined product groups**, and monitor how the DPPs are received by the market. Their impact can then be evaluated before adapting them for complex products such as cars and dishwashers, which contain numerous components. While some companies argue that social information should not be included in the initial phase of DPP development, as levels of complexity are high because of the persistent lack of supply chain information on some indicators, others argue for a step-by-step approach to include this information from the beginning.

DPPs should be product specific and different approaches might be needed in each case, in particular between industrial applications and consumer goods. DPPs should be introduced in cases where it is clear that they can add value towards sustainable production and consumption. The aim should be to compile meaningful and comparable information, primarily based on existing data.

As **consumer expectations** are likely to vary product by product, it is important to carry out consumer research at the outset of a DPP development process, and then further market research when the DPP is introduced. It will be important to maintain good stakeholder dialogue, governed by competent institutions.

4.4 Case studies

As part of the research conducted for this report, complementary interviews with companies were carried out to better understand how DPPs could work in practice and which issues should be considered for specific industries.

4.4.1 Construction industry

With regard to construction products, it would be important to know whether the aim of a DPP is for the products to have more recycling and recycled content, or whether compliance aspects should be addressed throughout the production process. Some **construction products have a very long lifespan** in buildings so the **recycling aspect and the future price** of used materials will not be known until **far in the future**. Therefore, there could be a need for DPPs, linked with BIM, to turn the concept of the building as a material bank into a reality.

Construction products are mostly used by **architects or designers**, who **already use BIM and EPDs** to obtain and manage environmental product information. Therefore, **interoperability, or data exchange**, between existing EPDs and a DPP would be considered as important, as would the ability to feed existing information digitally into a DPP instead of having to start from scratch. EPDs, for instance, already cover the majority of Scope 3 emissions and are publicly available in a PDF version. The main **added value** would be that a DPP could focus more on **circularity**, as EPDs already cover general environmental aspects.

Therefore, definitions on recyclability need to be clearly defined, alongside how recycling can occur at scale with clear incentives created. Also, information on material quality would be required. **Some construction products can be nearly continuously recycled**; thus, a **tool** that can **verify** this and ensure that certain quality standards are met would be helpful.

For **compliance management** purposes, it would be helpful to understand any potential barriers for recycling and the necessary information to overcome them. For example, in many countries, transport costs can make it more expensive to collect end-of-life construction products than sending them to landfill. Making sure that people know whether a product is hazardous or not is also an important aspect to consider. The need for unified, or sector-based, approaches depends on what elements are being addressed. For durability, it could be covered cross-sectorally, but certain elements, such as recycled content, might be very difficult to value across various sectors, as the price may vary significantly.

DPPs could also **tackle the challenge concerning verification**, data robustness and greenwashing. A verification process must be in place to ensure correct, and reasonable data, is included within DPPs. In the EPD process, third-party verifiers belong to a certain EPD programme operator, and different verifiers can deliver different results. Thus, there is a certain level of interpretation in the EPD world that must be tackled for a DPP to ensure comparability. Also, more social aspects could be useful in DPPs, as examining raw material suppliers should not be limited to environmental information.

DPPs could also support **future-oriented business models** with a focus on recycled construction materials. A business model already exists for taking back waste material. If the price for waste disposal in landfill is high enough, a viable business model would be to support clients to recycle their products. Thus, more ambitious requirements for waste disposal are needed to ensure that recyclable products are being recycled.

Some companies have already instigated pilot projects to convert traditional EPDs into digital versions that are machine readable and can be made compatible with BIM in the future. However, it is uncertain whether the EU's CPR will require a DPP, and whether this will be linked to the ESPR approach, which prevents construction companies from investing time and resources into further developing DPPs.

Industry example: ROCKWOOL's reclaim and recycling scheme Rockcycle®

Through Rockcycle®, ROCKWOOL has established a reclaim and recycling scheme for stone wool insulation offcuts from construction sites, as well as for stone wool insulation demolition waste. If not mixed or contaminated with other waste matter or materials, pure stone wool insulation products are continuously recyclable at end of life; this means that each time reclaimed materials are recycled into new products, their recyclability is not reduced, making it an almost infinite closed-loop system. ROCKWOOL has dedicated facilities, where costs remain very low, to recycle construction and demolition waste that is typically sent to landfill. By recycling waste and transforming it into new products, the demand for primary raw materials could be reduced, which would in turn help to reduce the life cycle environmental impact of the built environment. This could also help to reduce the construction industry's dependence on landfill. By 2021, ROCKWOOL was offering the Rockcycle® reclaimed materials service to customers in 17 countries, and aims to offer the service to 30 countries by 2030.⁵⁵

A DPP would be beneficial as it could help to ensure that materials are collected and returned to the recycler without impurities or having been mixed with other waste materials by improving tracking and data collection. Without a DPP, such high-value recycling would not be possible because of a lack of knowledge about the materials' purity.

4.4.2 Furniture manufacturing

Carpets, mattresses and furniture panels are amongst the top global waste categories. If a product is to be recycled, it needs to be returned to the manufacturer at the end of each use cycle, and to be truly circular it needs to be reused, which is why it is necessary to distinguish specific products.

Due to a **lack of common standards** to deal with such products, some companies developed their own standards for component transparency. However, some of the relevant information is not currently available in the supply chain because of an absence of regulations. Thus, some companies conduct their own material analyses, with every supplier adding their information. In one example, a company that designed mattresses made of polyester encountered a problem with recycling, as minute traces of cotton in the core material hindered the recycling of the polyester. The company discussed the issue with its suppliers who then removed the cotton. This example illustrates why details on the product composition is important and shows the need for the entire supply chain to be transparent. Currently, each piece of information needs to be thoroughly checked to ascertain whether the available product information is from self-declared or third-party verified data.

Industry example: Niaga® tag

Niaga® is a provider of circular product redesigns and material solutions.^{56,57} The company's mission is to completely phase out waste and design products that can be used again and again, by bringing reuse, repair and recyclability, and also clean and safe materials, from theory to practice. However, a recyclable product that is not returned will not actually be recycled. That is why Niaga® developed the Niaga® tag and circularity platform,⁵⁸ to provide a digital approach for an infrastructure that enables transparency and return options.

Products from Niaga®'s partners are marked with a scannable Niaga® tag that includes a QR code to grant access to a unique DPP that shows what a given product is made of, and how it can be returned after use. As future policy developments remain uncertain, the landing page is future-proof and compatible with the forthcoming DPP. The DPP of the Niaga® tag is product specific, objective and fact based, and can include aggregated features (eg percentage recycled content, recyclability, repairability), which are substantiated by information in the DPP. Furthermore, IPR-sensitive information can be protected with different access levels for different user types (eg verifiers or recyclers versus suppliers or consumers).

Through this approach, Niaga® aims for full product transparency. This is considered as vital because the precise public disclosure of a product's components is seen as the only way to assess its recyclability and its impact on personal and environmental health. Today, the Niaga® tag can be found on the carpets, mattresses and furniture panels of sustainable-oriented businesses in the sector, and helping to transform waste streams into material streams.

As there is still a lack of general awareness and knowledge regarding product composition in the sector, the DPP could provide a major step forward in collating the most relevant information across the whole value chain. However, it should be noted that many DPPs in the industry are merely certificates presented in the form of DPPs. Although there is interest amongst innovative industries, the problem lies in the absence of general regulation and the uncertainty as to the direction of upcoming policies with regard to the harmonisation and standardisation of DPPs.

The EU's ESPR proposal and the increasing support for the 'sustainability by design' approach could be a good basis for further discussions. Within the furniture industry, there are only reputational incentives, especially for premium businesses, to offer transparency to their customers. If products do not contain hazardous substances and are designed for recycling, then there is already a clear incentive for such approaches that show the benefits. If they do contain hazardous substances, then there are currently no incentives for engagement.

4.4.3 Metal industry

For commodity providers and the metal industry, one specific challenge is to have information at an 'atom level' as various materials are mixed and melted. Therefore, information on origin, or provenance, and also energy consumption and emissions is important. It is also a challenge to follow up product data as, for instance, smelters ship 20,000 tons of their product, which is then used in many different products. Thus, it is hard to draw up a common set of data points to develop a DPP that can provide trustworthy data at the end of the product life cycle.

It may also be challenging to monitor recycling as aluminium, and other metals, can have a typical product lifespan of 35–50 years before they are recycled. One specific question centres on how to break down data granularity and move it across complex and long-term value chains such as the metal industry and further downstream. Hence, it would be beneficial if all DPPs could have a similar general structure. Most companies can already provide the most relevant data but there is a question over who will decide which specific data is required for a DPP and how it is consistently reported across the process chain.

Traditionally regulated environmental data sets in metal industries such as energy consumption and water usage are readily available, yet the collection of comparable data on the **CO₂ footprint of products remains difficult**. Companies are already providing a lot of production data for their clients' own product passports, which is in many cases a legal obligation for product liability reasons. Today, companies frequently provide such data to clients in paper-based formats as regulated by law and contracts. What clients do with that data is not under the control of the delivering company, as it only has to ensure that the provided data is accurate. To present the comprehensive environmental footprint of products, **EPDs** are currently widespread in metal industries and are therefore considered a very useful tool for future DPPs.

Industry example:
DPP for outdoor furniture made with Hydro CIRCAL recycled aluminium

Together with a customer (a furniture producer), the aluminium producer Hydro has set up its own blockchain-based DPP pilot. Hydro's two green aluminium brands, Hydro CIRCAL (recycled aluminium) and Hydro REDUXA (low carbon aluminium), are certified by an independent third-party. The certificates are stored on a blockchain and provide selected, trustworthy sustainability data, which can feed into DPPs. The passport validates information such as manufacturing date and location, composition of materials and environmental footprint.

The furniture producer intends to use this DPP approach as part of its product-related storytelling for a bench manufactured from aluminium recycled from post-consumer scrap and wood. Consumers can access selected information related to the production to understand how, and where, the product and the materials, such as the aluminium, have been sourced and produced.⁵⁹

Starting with a primary focus on GHG emission reduction and the respective reporting or certification schemes is considered critical to the future success of the European steel industry as it invests billions of Euros in breakthrough technology to become climate neutral before 2050. Therefore, it is seen as crucial, by business representatives, for the future competitiveness of European steel industries that if a DPP is implemented it should build as far as possible on existing standards and not include complex, new reporting duties. Since steel is one of the most traded and competitive global commodities, DPPs should also give specific attention to transparency on social and labour standards to prevent the relocation of production to regions with less stringent environmental and social standards and to support a just transition of the industry.

Based on this, the **role of public procurement** could be important for steel products because, as for the construction sector, state-induced investments are highly relevant. If institutional buyers require data to be presented within a DPP, this could form a central part of the decision-making process.

In steel production, companies already comply with multiple mandatory, voluntary or market-based reporting obligations. Their specific challenge is to harmonise and combine these existing schemes without creating additional ones with excessive administrative burdens. Steel companies would consider it important to decide on the information that should be provided based on the main sustainability impact categories of steel production, such as climate, circularity, labour standards and just transition. In these areas, international product and performance standards have been developed across several high-level, multi-stakeholder processes, including governments, industry, labour unions and civil society organisations. Examples include ResponsibleSteel™, the Carbon Disclosure Project and the International Energy Agency (IEA) green steel definition process on behalf of G7 (see Annex for more information). These existing initiatives should be considered for all developments around DPPs concerning steel products. Similar schemes and approaches exist or are under development for other materials.

5. Conclusions and recommendations



iStock.com/Khanchit Khirisutchalual

5.1 Overall conclusions from industry perspectives

DPPs are a great opportunity to modernise and digitalise product information to support industry transformation towards carbon neutrality and increased circularity. There is a strong belief that a DPP can be an important instrument to help consumers make better informed choices and create incentives for producers to make their products more sustainable. Rather than being 'just another tool' to collate a lot of information, DPPs will provide real added value to improve products by making up-to-date and relevant information accessible for all stakeholders in the value chain.

Several **preconditions have to be met** for the wider acceptance of DPPs. A clear set of definitions need to be agreed so that all stakeholders in the value chain have a shared understanding of what 'circularity' means and the data required for its delivery. Once a common baseline has been set, DPPs could enable a more circular approach for basic material industries, manufacturing and other sectors. DPPs could address some of the key challenges to more circular practices, such as the lack of **transparency, standardisation and data reliability**.

Data transparency is a critical issue for businesses. Information and data should be shared in a balanced manner without compromising business confidentiality. This implies that each product component needs to be linked with a piece of reliable data, which is available under different access levels, according to the stakeholder roles.

DPP implementation should start small and soon with testing and pilots, rather than with a target to develop everything perfectly from the beginning. The importance of developing flexible and future-proof systems **must be considered**.

It is also important to **harmonise data requirements and develop standards** based upon existing EU regulations to avoid duplication. Otherwise, a DPP could quickly become more of a bureaucratic burden than a benefit. Building on existing data would negate the **need for** a lengthy, step-by-step implementation approach. There is also a need for common methodology to share information and **internationally recognised standards** for its technical implementation. These efforts could benefit from **existing international initiatives**, approaches and stakeholders active in the harmonisation of product data and standards, as outlined in this report.

Creating new circular offers for customers and companies further down the supply chain requires the **ability to verify claims through consistent, reliable information**. This is another key condition for all stakeholders if they are to reach an understanding of how durability and recyclability data can be captured to ensure a DPP is effective across the entire value chain. Reliable information was considered to be especially important for consumer engagement instead of creating yet another mandatory reporting tool.

Overall, DPPs could be a big step forward for sustainability, boosting material and energy efficiency, and enabling new business models and circular value creation based on digital data sharing. However, given the urgent need of such a tool and the complexity of some of the tasks to be delivered to harness the full potential of DPPs, it would be logical to start simple and fast with some basic information about the product composition, and then increase the scope of the embedded data in subsequent iterations of the instrument.

The aspects identified over the course of this study provide an evidence base for further discussion on how the EU should approach the piloting and implementation of DPPs from business perspectives, and how businesses can best prepare to implement them successfully. Future research and stakeholder discussions concerning the DPP should seek to gather more insights and experience on its exact design, technical implementation and data governance, and also information on sustainability and social aspects that could potentially be included.

5.2 Recommendations

5.2.1 Implementation principles

Overall, the specific recommendations from business perspectives for the design and implementation of a DPP can be classified under the following principles:

Coherence and consistency:

- **All forthcoming EU regulations and initiatives for which DPPs are discussed should be closely aligned and linked with the approach proposed for the ESPR** and experiences from the EU Battery Passport.
- **The digital infrastructure and software for IT implementation of DPPs should be interoperable and compatible** as far as possible with other systems.
- **The EU should manage the overall governance for implementing a DPP** through setting clear guidelines for use. The EU should also create an enabling environment through common standards, access rights management and an interoperability framework.
- **Existing international initiatives, approaches and stakeholders present in the harmonisation of product data and standards should be used** to avoid redundancies or duplication of efforts.
- **DPPs should be used to set criteria for green public procurement** and as a substantiation tool for ecolabels.
- **DPPs should enable a common framework for additional voluntary product information sharing**, by setting a standardised approach to exchange information such as recycled content or carbon and product footprints in complex supply chains.

Flexibility and exploration:

- **Start small and modestly but promptly with DPP testing and pilots**, based on a phased approach with the possibility for continuous extension and further development to enable iterative learnings.
- **Start with a variety of clearly defined products and sectors as pilots**, to test the general approach and identify what commonalities exist between different product groups.
- **All detailed data included in DPPs should be product group specific** to be reliable and comparable rather than a one-size-fits-all approach.
- **A decentralised DPP approach** to product information storage is favoured by most businesses over a centralised approach.

Transparency and accountability:

- **Sufficient data should be provided for consumers, businesses and investors**, so that they can make more informed purchasing decisions that take sustainability criteria into consideration.
- **All information requirements for a DPP should be relevant and fit for purpose**; hence, each piece of information should be based on a clear scope and a concrete user benefit along the product life cycle.
- **Mandatory product information in DPPs should balance different levels of data access and data protection needs**, so that transparency is ensured as default along the value chain without infringing legitimate confidentiality concerns.
- **The operational implementation of DPPs should be carried out via trusted intermediaries** to ensure strong governance principles that have both technical expertise along with an understanding of the wider policy aims of DPPs to support a circular economy.

5.2.2 Guiding questions for further design

This report demonstrates that further work will be needed to understand how DPPs will work in practice. Work on their further design, implementation and adoption will be supported by considering the following guiding questions:

- Which DPP approaches could realistically be implemented in the near future? Should this lean towards a one-size-fits-all approach, or should there be different requirements for more complex products?
- What are the benefits and disadvantages of each DPP approach, and how are business, and other stakeholders, affected?
- Which product groups and materials should be covered and prioritised by DPPs in the initial phase of the ESPR and other regulations such as the CPR, and why?
- What are the key opportunities and barriers to product-specific DPP implementation, and how could these be addressed?
- What are the perspectives of businesses and other stakeholders on product-specific DPPs?
- What information would material producers and manufacturers need to share with each other?
- What are the key barriers to effective information sharing, and how could these be addressed by digital solutions?
- How can transparency be made the norm?
- What are the long-term benefits for businesses?
- What role should a DPP play with regards to the environmental claims of products?
- What role should a DPP play in storing data for wider issues such as social data?

Annex: Stakeholder support for DPP adoption, and further initiatives with links to DPP stakeholder support

The transition towards a circular economy, GHG reductions, and environmental, social and governance (ESG) reporting has demonstrated the need for more data provision and information transfer across value creation networks. Hence, an increasing demand for information from businesses, policymakers, environmental non-governmental organisations and consumer protection organisations supports the introduction of information approaches like a DPP. Consumers will require reliable, easy-to-understand product information in order to engage them with DPPs, which in turn will help them to make informed decisions.

Overall, numerous private and public initiatives exist that support the adoption and implementation of DPPs. This report has been conducted on behalf of the Taskforce for climate neutral and circular materials and products, a group of progressive businesses pushing for the realisation of an EU circular economy with a DPP as a key tool. The EC created several strategies (see Section 3) that either conceptualise a DPP (ESPR) or announces its introduction to a specific sector or to support consumers. Standard-setting institutions such as the German Institute for Standardisation, and research projects and associations such as the European Circular Economy Research Alliance⁶⁰ are currently developing projects linked to DPP creation. Moreover, the EC and national governments, such as in Germany, have initiated, or support, various industry initiatives to pave the way for more sophisticated digital product data applications. Also, a multitude of information and communication technology companies and start-ups have established themselves in the field around DPP systems.

Regarding technological development, the data for DPPs will have to be obtained with the help of an underlying infrastructure of DPP-enabling systems including data spaces. In this regard, activities and projects have emerged that support the creation of a DPP's technological basis. International Data Spaces Association (IDSA), Gaia-X and its offspring Catena-X represent three major European associations, whose main focus is on scalable and standardised data infrastructures, including data spaces and DPPs. They provide reference architectures⁶¹ that can be used for future data spaces.

IDSA aims to build the future of the global digital economy with International Data Spaces. In contrast, Gaia-X is a European-initiated project for Europe and beyond that involves a multitude of stakeholders from government, academia and business working together to establish a secure and federated data infrastructure. Catena-X is an exemplary data space with a special focus on the automotive sector. Among other projects, multiple stakeholders from academia and industry, within the Catena-X project, are exploring solutions to implement the upcoming EU Battery Passport. The reference architecture of IDSA, Gaia-X and Catena-X may therefore represent important guidelines for the creation of future DPP systems.

Further initiatives

Former Carbon Disclosure Project (CDP)

Founded in 2000, CDP is an international non-profit organisation that operates the global disclosure system for investors, companies, cities, states and regions, to manage their environmental impacts. At the request of investors, purchasers and city stakeholders, CDP seeks to measure and manage risks and opportunities on climate change, water security and deforestation. By this means, CDP was amongst the first initiatives to leverage investor pressure to influence corporate disclosure on environmental impacts. Today it is considered by many stakeholders to be the gold standard of environmental reporting with one of the world's largest and most comprehensive data sets on environmental action on both corporate and city level.⁶²

Circularity Dataset Initiative

The Circularity Dataset Initiative was launched by the Ministry of the Economy of Luxembourg, working with multinational and regional manufacturers and platforms, to create the Product Circularity Data Sheet. The Circularity Dataset Initiative seeks to address the challenge for industry and consumers to access reliable data on the circular properties of a product because trade secrets are hindering transparency and reporting standards are poor. Accordingly, manufacturers are forced to send out different data sets in diverse formats to customers and product platforms. Unfortunately, a lot of circularity information goes missing, as its generation and handling require considerable human and financial resources. Therefore, the Product Circularity Data Sheet is seeking to establish a standardised way of presenting data so that all interested stakeholders can adapt it to their own needs and avoid creating "just another bureaucratic standard".⁶³ The initiative intends to make basic circularity data widely available in a decentralised way so that relying on a centralised platform or database is not necessary to avoid loss of confidence.⁶⁴

Environmental Product Declarations (EPDs)

EPDs are aimed at manufacturers in the supply chain and trade and commerce sectors, rather than consumers. They are based on a life cycle assessment, according to ISO 14040, in which all material flows, from raw material extraction to disposal, are systematically recorded. Key declaration figures centre on global warming potential in CO₂ equivalents, water consumption, waste production, ozone depletion and acidification potential.⁶⁵ They provide extensive quantitative and verified information, present environmental impacts without evaluating them, allow data aggregation along a value chain and require independent third-party verification.⁶⁶ While the product is not tested by laboratories for concrete properties, the EPD verification process checks whether the information provided by the manufacturer complies with applicable standards and rules, and is plausible and complete.⁶⁷ In practice, EPDs have been used especially for the description of the environmental performance of construction products.

However, the EU frequently takes a critical position on EPDs and rejects such voluntary schemes as a basis for EU regulations because a large range of methods and initiatives already exist. Different approaches for defining the environmental performance of products may lead to differing results and extensive costs for companies and also confusion amongst consumers. As an example, there are at least six competing EPD systems around the world relating to particular areas, although they are all based on ISO 14025.⁶⁸ Their results can vary within the same system between different third-party verifiers, according to industry feedback.⁶⁹

Global Battery Alliance (GBA)

The GBA is a fusion of 90 organisations with the goal to create a “circular, responsible and sustainable battery value chain”. Founded in 2017, GBA has designed a Digital Battery Passport (DBP), a product-specific DPP that is intended to be a digital twin of physical batteries. The cornerstones of the passport are a digital platform and a selective information output. There are plans to create a DBP for every battery, enabled by the DBP platform, to allow information to be uploaded and accessed as needed. Stakeholders will receive specific data, while governments and the public will receive only necessary information. Overall, the programme consists of a global reporting framework with rules to measure, audit and report ESG parameters. The DBP is a digital ID for batteries with data and descriptions about the ESG performance, manufacturing history and provenance as well as advancing battery life extension and enabling recycling. The DBP also seeks to harmonise digital systems to input data into the battery passport and a digital platform to collect and exchange information in order to inform policymaking for governments and civil society and to develop performance benchmarks.

The DBP is designed to trace the origin of the used materials and log their carbon footprint. Furthermore, it monitors the battery during its entire life cycle in order to enable and improve transparency. To achieve this goal, each company involved in different stages of a battery’s life cycle is obligated to provide specific information on the battery. Amongst other things, this information includes mining and refining, material, cell, battery and vehicle production, electric vehicle utilisation and end-of-life recycling. During these process steps, the DBP is based on standardised information regarding quality and environmental aspects to enable comparability. The GBA passport can therefore be seen as a voluntary extension of the planned mandatory European Battery Passport, focusing on ESG compliance issues.

European Battery Alliance (EBA)

The EBA was founded in 2017 by the EC, EU Member States, industry and the scientific community. The EBA’s main goal is to develop an innovative, competitive and sustainable battery value chain to build capacity for battery technology and production that matches demand in the EU. The EBA considers the development of a DBP as an important enabler for a transparent battery market and the traceability of large batteries throughout their life cycle to create innovative products and services. In combination with supply chain due diligence, a DBP

is considered to be a powerful tool for addressing the social and environmental risks of extraction, processing and trading of raw materials for battery manufacturing purposes. Thus, a DBP could be used to ensure transparency and high ethical standards for raw materials.

Global Alliance for Buildings and Construction (GlobalABC) Building Passport Practical Guidelines

Released on 17 September 2021 by the GlobalABC, the Building Passport Practical Guidelines⁷⁰ aim to promote transparency, consistency and information exchange in the building sector. To overcome current data gaps and barriers, holistic and multidimensional Building Passports should focus on capturing, administering and managing building-related data and information throughout the life cycle of buildings, such as construction, modernisation and dismantling. Thus, the Building Passport is intended as an information management tool, and the guidelines provide information on how to make it work in practice, by drawing on the experiences of stakeholders and similar existing or emerging initiatives. The guidelines explain the approach of the Building Passport for market transformation through the digitalisation of building-related data and information in order to create sectoral transparency and opportunities for new business models.

Greenhouse Gas (GHG) Protocol

The GHG Protocol was developed by the World Resources Institute and the WBCSD. The first version of the Corporate Standard was published in 2001, and has since been regularly updated. It aims to develop, and promote, internationally accepted GHG accounting and reporting standards and tools. Based on the main aspects of the GHG Protocol, the Product Life Cycle Standard and the Corporate Value Chain Standard have been created. Companies can use the Product Life Cycle Standard to provide an overview of the GHG emissions associated with their product. This includes raw materials, manufacturing, transportation, storage, use and disposal. The GHG Protocol is considered to be the most widely used standard for preparing GHG reports.⁷¹ Numerous other public or corporate standards are based on it, including ISO 14064 to quantify, monitor, report and verify GHG emissions. It could also be a widespread option to provide essential GHG-related input data for a DPP.

IEA green steel definition process on behalf of G7

Following the priority areas for Germany’s 2022 G7 Presidency, the IEA presented a new report entitled ‘Achieving Net Zero Heavy Industry Sectors in G7 Members’.⁷² It focuses on the implementation of policies to drastically reduce CO₂ emissions from heavy industries in the G7 and beyond. First, it covers a toolbox of policies and financing mechanisms to initiate and sustain a whole industry transition. Second, it contains a series of common definitions of ‘near zero emission’ steel and cement production, a precondition to establish future policies independently of the exact transformation pathways or specific technologies chosen. The report was intended to inform policymakers, manufacturers, consumers, investors, leading sectoral initiatives and the research community in preparation for the G7 Climate and Energy Ministerial in May 2022 and beyond.

Industrial Deep Decarbonisation Initiative (IDDI)

The Clean Energy Ministerial (circular economyM)⁷³ IDDI, co-ordinated by the United Nations Industrial Development Organization (UNIDO), is a coalition of public and private organisations creating a market for low carbon industrial materials such as steel and cement. The IDDI seeks to standardise GHG assessments, throughout the product life cycle, define what low carbon steel, cement and concrete are, establish public and private sector procurement targets, and increase investments into the development of low carbon products and the design of industry guidelines for industries such as construction and automotive.

The sourcing and sharing of reliable data for the development of common standards for GHG reporting and targets are therefore essential. However, data systems often lack the value chains of global basic materials industries. Accordingly, the IDDI also seeks to establish key definitions, tools, guidelines and publicly accessible data to enable reporting and benchmarking comparisons for the industry. For example, the IDDI recommends the introduction of consistent minimum standards for low carbon steel and cement products to encourage best production and manufacturing practices. The proposed data submission could take the form of EPDs or voluntary ecolabels. An open-access database will support product evaluations and comparisons to increase transparency along supply chains.⁷⁴ A global framework will be set up to ensure data is publicly accessible, including software tools for evaluation purposes.⁷⁵ Although not mentioned specifically, this implies potentially strong links to DPP approaches.

Substances of Concern In articles as such or in complex objects (Products) (SCIP)

The Waste Framework Directive sets out measures for addressing the adverse impacts of the generation and management of waste on the environment and human health, and for improving the efficient use of resources that are crucial for the transition to a circular economy.⁷⁶

The Waste Framework Directive established the SCIP database. Within this database, the European Chemicals Agency has set up a 'Candidate List' of substances that are of very high concern.

Companies that supply articles containing substances that are on the Candidate List in a concentration above 0.1 per cent weight by weight (w/w) on the EU market must submit information on these articles to the European Chemicals Agency. The SCIP database ensures that the information on articles containing Candidate List substances is available throughout the whole life cycle of products and materials, including at the waste stage. The information in the database is then made available to waste operators and consumers.⁷⁷

Product Environmental Footprint (PEF)

Even before the idea of the DPP gained traction, in 2013 the EC had started working on a standardised method for the environmental performance of products, including goods and services.^{78,79} The objective of the PEF was to substantiate the environmental claims of companies to enable sustainable purchasing decisions based on comprehensive, comparable and trustworthy data.^{80,81} In the PEF, the potential environmental impacts of material or energy flows, and also the resulting emission and waste flows, can be recorded in 16 categories. In the interim, the EC has attempted to advance the PEF through pilot projects for specific product groups. Thus, the PEF could be a potential starting point for discussions on the information to be included in the DPP. In order to calculate the environmental performance of products, the EC incentivises industries to apply methodological insights gained through the PEF's development phase, and recommends access for other stakeholders including public administrations, non-governmental organisations and business partners.⁸² However, industry representatives have argued that the PEF is not ready for application as its reporting standard has, so far, been unavailable for carbon-intensive basic materials, except metal sheets⁸³ and several other product groups with significant GHG footprints. According to environmental associations, further impacts including loss of biodiversity, noise levels and animal welfare are not sufficiently covered by this method.

ResponsibleSteel™

Founded as a not-for-profit organisation, ResponsibleSteel™⁸⁴ sees its mission to be the steel industry's first global multi-stakeholder standard and certification initiative. It seeks to provide a forum for a multi-stakeholder approach to facilitate co-operation and mutual commitment from companies at all levels of the steel supply chain, representatives from civil society and other stakeholders. Its organisational members are from all stages of the supply chain, civil society and downstream users, and its goal is to create a certification standard that aligns with the ISEAL Codes of Good Practice.⁸⁵ The standard intends to drive good management of air, water and biodiversity issues, asks for strategies to reduce GHG emissions, and demands human rights and health and safety criteria for workers in order to support responsible patterns of production and consumption.

Science Based Targets Initiative (SBTi)

The SBTi, founded in 2015, is a partnership between CDP, the UN Global Compact, the World Resources Institute and the World Wide Fund for Nature. Its main goal is to normalise science-based target settings for companies. In this context, they are actions that ultimately help to meet the goals set by the Paris Agreement (limiting global warming to well below 2°C – and preferably below 1.5°C).⁸⁶ In 2021, the initiative published the first version of the SBTi Corporate Net-Zero Standard. The SBTi claims it is the first global science-based standard that supports companies to reach the net zero target, which is defined as reducing Scope 1, 2 and 3 emissions to zero.

WBCSD Circular Transition Indicators

The members of the WBCSD have developed a universal framework to measure the circularity of material and water flows. The Circular Transition Indicators (CTI)⁸⁷ are intended to create a transparent and objective framework that can be applied to businesses of all industries, sizes, value chain positions and geographies. The CTI framework provides insights into opportunities to close loops and optimise overall resource use, and links a company's circular performance with its business performance. The latest version of the CTI framework (CTI v3.0) allows companies to measure the impact of recycling measures on GHG emissions reductions, and provides new indicators on product lifespan.

WBCSD Partnership for Carbon Transparency (PACT)

The PACT, which includes companies, standard-setting bodies and industry initiatives, was launched on 9 November 2021, and aims to support companies to calculate and exchange product carbon emissions data across value chains.⁸⁸ Because of a lack of transparency across value chains, Scope 3 GHG emissions are very hard to address. Therefore, the PACT seeks to increase transparency with more detailed methodological guidelines to consistently calculate and account for verified primary data-based product carbon footprints. It also seeks to create an infrastructure for the digital exchange of verified and reliable data on product carbon footprints across value chains. Regarding the underlying methodologies, the two basic approaches are product- or sector-specific rules and overarching, cross-sectoral protocols and standards, such as the GHG Protocol Product Life Cycle Accounting and Reporting Standard and the GHG Protocol Corporate Value Chain (Scope 3) Standard or ISO standards (14044/40, 14067, 14025).

The PACT is intended to provide an infrastructure system to enable interoperability between digital solutions for sharing comparable, consistent, verified data across the value chain and accounting for product GHG emissions. Furthermore, the business confidentiality of sensitive product data will be ensured to solve the data-sharing dilemma for companies intending to decarbonise their supply chains. Although the PACT does not directly mention a DPP, some core intentions are very similar; thus, alignment with a DPP approach would be highly beneficial for the definition of common methods and standards and also digital infrastructure systems.

References

1. OECD. (2018). *Global Material Resources Outlook to 2060*. <https://www.oecd.org/env/global-material-resources-outlook-to-2060-9789264307452-en.htm>
2. World Bank. (2018). *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. <https://openknowledge.worldbank.org/handle/10986/30317>
3. European Commission. (2020, March 10). *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. A New Industrial Strategy for Europe*. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=circular-economyLEX:52020DC0102&from=EN>
4. European Commission, Directorate-General for Energy, Directorate-General for Enterprise and Industry. (2014). *Ecodesign your future: How ecodesign can help the environment by making products smarter*. <https://data.europa.eu/doi/10.2769/38512>
5. University of Cambridge Institute for Sustainability Leadership (CISL); Agora Energiewende. (2021, May 11). *Tomorrow's Markets Today: Scaling up Demand for Climate Neutral Basic Materials and Products*. CLG Europe. https://www.corporateleadersgroup.com/files/cisl-clg-agera_tomorrows_markets_today_report_0.pdf
6. European Commission. (2021, February 18). *An Open, Sustainable and Assertive Trade Policy*. https://trade.ec.europa.eu/doclib/docs/2021/february/tradoc_159434.pdf
7. European Commission. (2021, July 14). *Proposal for a Regulation of the European Parliament and of the Council, Establishing a Carbon Border Adjustment Mechanism*. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021PC0564&from=EN>
8. University of Cambridge Institute for Sustainability Leadership (CISL). (2020, November 17). *Developing the EU's 'Competitive Sustainability' for a Resilient Recovery and Dynamic Growth*. Cambridge, UK: the Cambridge Institute for Sustainability Leadership. <https://www.cisl.cam.ac.uk/system/files/documents/cisl-competitive-sustainability-report.pdf>
9. Kristoffersen, E.; Blomsma, F.; Mikalef, P.; Li, J. (2020, November). The Smart Circular Economy: A Digital-Enabled Circular Strategies Framework for Manufacturing Companies. *Journal of Business Research*, 120, 241–261. <https://www.sciencedirect.com/science/article/pii/S0148296320304987>
10. European Commission. (2020, March 10). *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Region. Long Term Action Plan for Better Implementation and Enforcement of Single Market Rules*. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2020%3A94%3AFIN>
11. Berg, H.; Bendix, P.; Jansen, M.; Le Blévenec, K.; Bottermann, P.; Magnus-Melgar, M.; Pohjalainen, E.; Wahlström, M. (2021, July 13). *Unlocking the Potential of Industry 4.0 to Reduce the Environmental Impact of Production*. European Environment Agency, European Topic Centre on Waste and Materials in a Green Economy. <https://www.eionet.europa.eu/etcs/etc-wmge/products/etc-wmge-reports/unlocking-the-potential-of-industry-4-0-to-reduce-the-environmental-impact-of-production>
12. Wilts, H.; Berg, H. (2017, December 21). The Digital Circular Economy: Can the Digital Transformation Pave the Way for Resource-Efficient Materials Cycles? *Wuppertal Institut für Klima, Umwelt, Energie*, 17. https://www.researchgate.net/publication/331631088_The_Digital_Circular_Economy_Can_the_Digital_Transformation_Pave_the_Way_for_Resource-Efficient_Materials_Cycles
13. Mulhall, D.; Ayed, A.-C.; Schroeder, J.; Hansen, K.; Wautelet, T. (2022, May 6). The Product Circularity Data Sheet—A Standardized Digital Fingerprint for Circular Economy Data about Products. *Energies*, 15, 3397. <https://www.mdpi.com/1996-1073/15/9/3397/htm>
14. Mulhall, D.; Ayed, A.-C.; Schroeder, J.; Hansen, K.; Wautelet, T. (2022, May 6). The Product Circularity Data Sheet—A Standardized Digital Fingerprint for Circular Economy Data about Products. *Energies*, 15, 3397. <https://www.mdpi.com/1996-1073/15/9/3397/htm>
15. Berg, H.; Le Blévenec, K.; Kristoffersen, E.; Strée, B.; Witomski, A.; Stein, N.; Bastein, T.; Ramesohl, S.; Vrancken, K. (2020, October 20). Digital Circular Economy: A Cornerstone of a Sustainable European Industry Transformation. *Ecircular economyRA European Circular Economy Research Alliance*. https://www.era-min.eu/sites/default/files/publications/201023_ecera_white_paper_on_digital_circular_economy.pdf

16. Berg, H.; Le Blévenec, K.; Kristoffersen, E.; Strée, B.; Witomski, A.; Stein, N.; Bastein, T.; Ramesohl, S.; Vrancken, K. (2020, October 20). Digital Circular Economy: A Cornerstone of a Sustainable European Industry Transformation. *Ecircular economyRA European Circular Economy Research Alliance*. https://www.era-min.eu/sites/default/files/publications/201023_ecera_white_paper_on_digital_circular_economy.pdf
17. Adisorn, T.; Tholen, L.; Götz, T. (2021, April 19). Towards a Digital Product Passport Fit for Contributing to a Circular Economy. *Energies*, 14, 2289. <https://www.mdpi.com/1996-1073/14/8/2289/htm>
18. Walden, J.; Steinbrecher, A.; Marinkovic, M. (2021). Digital Product Passports as Enabler of the Circular Economy. *Chemie Ingenieur Technik*, 93, 1717–1727. <https://onlinelibrary.wiley.com/doi/abs/10.1002/cite.202100121>
19. Greenhouse Gas Protocol. FAQ. https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf
20. University of Cambridge Institute for Sustainability Leadership (CISL); Agora Energiewende. (2021, May 11). *Tomorrow's Markets Today: Scaling up Demand for Climate Neutral Basic Materials and Products*. CLG Europe. https://www.corporateleadersgroup.com/files/cisl-clg-agera_tomorrows_markets_today_report_0.pdf
21. European Commission. (2020, December 10). *Proposal for a Regulation of the European Parliament and of the Council Concerning Batteries and Waste Batteries, Repealing Directive 2006/66/EC and Amending Regulation (EU) No 2019/1020*. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020PC0798&from=EN>
22. European Commission. (2022, March 30). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Region. EU Strategy for Sustainable and Circular Textiles*. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0141&from=EN>
23. EPEA. *Cradle to Cradle® Buildings*. <https://epea.com/en/services/buildings>
24. Eastman, C.; Teicholz, P.; Sacks, R.; Liston, K. (2008). *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors* (2nd ed.). New Jersey, Wiley.
25. Catena-X. <https://catena-x.net/en/>
26. European Commission. (2022, March 30). *Proposal for a Regulation of the European Parliament and of the Council Establishing a Framework for Setting Ecodesign Requirements for Sustainable Products and Repealing Directive*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=circular_economyLEX:52022PC0142
27. Wilts, H; Berg, H. (2017, December). The Digital Circular Economy: Can the Digital Transformation Pave the Way for Resource-Efficient Materials Cycles? *International Journal on Environmental Sciences*, 7(5). <https://nbn-resolving.org/urn:nbn:de:bsz:wup4-opus-69785>
28. Greenhouse Gas Protocol. FAQ. https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf
29. See for example: <https://ec.europa.eu/eurostat/web/waste/data/database>
30. See for example the definition provided by the German Federal Ministry for the Environment and Consumer Protection: <https://www.bmu.de/en/cluster/bmu-digital-policy-agenda-for-the-environment-digital-product-passport>
31. Kristoffersen, E; Blomsma, F; Mikalef, P; Li, J. (2020). The Smart Circular Economy: A Digital-Enabled Circular Strategies Framework for Manufacturing Companies. *Journal of Business Research*, 120, 241–261. <https://doi.org/10.1016/j.jbusres.2020.07.044>
32. University of Cambridge Institute for Sustainability Leadership (CISL); Agora Energiewende. (2021, May 11). *Tomorrow's Markets Today: Scaling up Demand for Climate Neutral Basic Materials and Products*. CLG Europe. https://www.corporateleadersgroup.com/files/cisl-clg-agera_tomorrows_markets_today_report_0.pdf
33. International Data Spaces e. V. <https://internationaldataspaces.org/use/reference-architecture/>
34. Adisorn, T.; Tholen, L.; Götz, T. (2021). Towards a Digital Product Passport Fit for Contributing to a Circular Economy. *Energies*, 14(8), 2289. doi: doi.org/10.3390/en14082289
35. Donetskaya, J. V.; Gatchin, Y. A. (2021) Development of Requirements for The Content of a Digital Passport and Design Solutions. *Journal of Physics*, 1828. doi: [doi:10.1088/1742-6596/1828/1/012102](https://doi.org/10.1088/1742-6596/1828/1/012102)
36. Pagoropoulos, A.; Pigosso, D.; McAloone, T. (2017). *The Emergent Role of Digital Technologies in the Circular Economy: A Review*. *Procedia CIRP*, 64, 19-24. <https://www.sciencedirect.com/science/article/pii/S2212827117301452>

37. European Resource Efficiency Platform (EREP). (2012). *Manifesto & Policy Recommendations*. https://ec.europa.eu/environment/resource_efficiency/documents/erep_manifesto_and_policy_recommendations_31-03-2014.pdf
38. European Commission. (2020, March 10). *Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Region. Long Term Action Plan for Better Implementation and Enforcement of Single Market Rules*. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2020%3A94%3AFIN>
39. European Commission. (2021, May 5). *Updating the 2020 Industrial Strategy: Towards a Stronger Single Market for Europe's Recovery*. https://ec.europa.eu/commission/presscorner/detail/en/IP_21_1884
40. European Commission. (2020, November 13). *Communication from the Commission to the European Parliament and the Council. New Consumer Agenda Strengthening Consumer Resilience for Sustainable Recovery*. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0696>
41. European Commission. (2020, December 10). *Proposal for a Regulation of the European Parliament and of the Council Concerning Batteries and Waste Batteries, Repealing Directive 2006/66/EC and Amending Regulation (EU) No 2019/1020*. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020PC0798&from=EN>
42. European Parliamentary Research Service. (2022) *New EU Regulatory Framework for Batteries*; p 10. [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/689337/EPRS_BRI\(2021\)689337_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/689337/EPRS_BRI(2021)689337_EN.pdf)
43. European Commission. (2022). *Annexes to the Proposal for a Regulation of the European Parliament and of the Council Concerning Batteries and Waste Batteries*; Annexes pp. 1–14. <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52020PC0798>
44. University of Cambridge Institute for Sustainability Leadership (CISL). (2021, December 16). *Accelerating the Transition to a Climate Neutral and Circular Economy: How the EU Can Deliver through the Sustainable Products Initiative*. Cambridge, UK: Taskforce for climate neutral and circular materials and products - CLG Europe. https://www.corporateleadersgroup.com/files/cisl_clg_eu_spi_policy_briefing_0.pdf
45. University of Cambridge Institute for Sustainability Leadership (CISL). (2022, March 30). *CLG Europe Materials & Products Taskforce's rapid reaction to the March Circular Economy Package*. https://www.corporateleadersgroup.com/files/materials_and_products_taskforce_circular_economy_package_i_rapid_reaction_30_march.pdf
46. European Commission. (2022, March 30). *Proposal for Ecodesign for Sustainable Products Regulation*. https://environment.ec.europa.eu/publications/proposal-ecodesign-sustainable-products-regulation_en
47. Malgaj, M. (2022, April 29) *Regulation on Ecodesign for Sustainable Products*, Public Hearing. <https://www.eesc.europa.eu/en/agenda/our-events/events/sustainable-products-initiative-including-ecodesign-directive/presentations>
48. European Commission. (2022, March 30). *Proposal for Ecodesign for Sustainable Products Regulation*. https://environment.ec.europa.eu/publications/proposal-ecodesign-sustainable-products-regulation_en
49. European Commission. (2022, March 30). *Proposal for Ecodesign for Sustainable Products Regulation*. https://environment.ec.europa.eu/publications/proposal-ecodesign-sustainable-products-regulation_en
50. European Commission (2022, March 30) *Proposal for a Regulation laying down harmonised conditions for the marketing of construction products, amending Regulation (EU) 2019/1020 and repealing Regulation (EU) 305/2011*. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022PC0144&from=EN>
51. European Commission (2022, March 30). *Proposal for a Regulation laying down harmonised conditions for the marketing of construction products, amending Regulation (EU) 2019/1020 and repealing Regulation (EU) 305/2011*. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022PC0144&from=EN>
52. European Commission. (2021, July 14). *Carbon Border Adjustment Mechanism: Questions and Answers*. https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661
53. European Commission. (2021, July 14). *Proposal for a Regulation of the European Parliament and of the Council, Establishing a Carbon Border Adjustment Mechanism*. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021PC0564&from=EN>
54. Further literature on a decentralised implementation approach can be found [here](#) and [here](#).
55. ROCKWOOL. (2021). *Resilient by Nature - Sustainability Report 2021*, pp. 20–21. https://www.rockwool.com/globalassets/sustainability/sustainability-report/rockwool-sustainability-report-2021_final.pdf

56. Niaga®. <https://www.niaga.world/en>
57. Niaga® - Check your tag. <https://www.niaga.world/en/check-your-tag>
58. European Union. *Niaga® designs out waste, completely*. European Circular Economy Stakeholder Platform. <https://circulareconomy.europa.eu/platform/en/good-practices/niagar-designs-out-waste-completely>
59. Norsk Hydro. *The certificates of Hydro's greener brands feed into digital product passports*. <https://www.hydro.com/fr-CH/a-propos-dhydro/les-articles-dhydro/the-certificates-of-hydros-greener-brands-feed-into-digital-product-passports/>
60. Berg, H.; Le Blévenec, K.; Kristoffersen, E.; Strée, B.; Witomski, A.; Stein, N.; Bastein, T.; Ramesohl, S.; Vrancken, K. (2020, October 20). Digital Circular Economy: A Cornerstone of a Sustainable European Industry Transformation. *Ecircular economyRA European Circular Economy Research Alliance*. https://www.era-min.eu/sites/default/files/publications/201023_ecera_white_paper_on_digital_circular_economy.pdf
61. *International Data Spaces e. V.* <https://internationaldataspaces.org/use/reference-architecture/>
62. CDP Worldwide. <https://www.cdp.net/en/>
63. Circularity Dataset Initiative. *The Product Circularity Data Sheet*. <https://pcds.lu/>
64. Circularity Dataset Initiative. *The Product Circularity Data Sheet*. <https://pcds.lu/>
65. Kietzmann, A. *EPD Programm*. IBU - Institut Bauen und Umwelt e.V. <https://ibu-epd.com/epd-programm/>
66. BMU. (2019). *Umweltinformationen Für Produkte Und Dienstleistungen*. https://www.bmu.de/fileadmin/Daten_BMU/Pool/Broschueren/umweltinformationen_produkte_dienstleistungen.pdf
67. Kietzmann, A. *EPD Programm*. IBU - Institut Bauen und Umwelt e.V. <https://ibu-epd.com/epd-programm/>
68. European Commission. *Single Market for Green Products Initiative*. <https://ec.europa.eu/environment/eussd/smgp/index.htm>
69. * Personal feedback from industry representatives in the course of interviews conducted for the purposes of this report.
70. UN Environment Programme (UNEP). (2021, September 17). Global Alliance for Buildings and Construction. (2021) *New report: the building passport practical guidelines*. <https://globalabc.org/news/new-report-building-passport-practical-guidelines>
71. Kauffmann, C.; Tébar Less, C.; Teichmann, D. (2012). *Corporate Greenhouse Gas Emission Reporting: A Stocktaking of Government Schemes*. OECD Working Papers on International Investment, No. 2012/01. https://www.oecd.org/daf/inv/investment-policy/WP-2012_1.pdf
72. International Energy Agency. (IEA). (2022, May 19). *Achieving Net Zero Heavy Industry Sectors in G7 Members. G7 members can lead the world in reducing emissions from heavy industry* - IEA <https://www.iea.org/news/g7-members-can-lead-the-world-in-reducing-emissions-from-heavy-industry>
73. Clean Energy Ministerial (circular economyM). *Clean energy future*. <https://www.cleanenergyministerial.org/>
74. United Nations Industrial Development Organization (UNIDO). *Industrial Deep Decarbonisation Initiative*. <https://www.unido.org/IDDI>
75. Industrial Deep Decarbonisation Initiative (IDDI). *Industrial Deep Decarbonisation: An initiative of the Clean Energy Ministerial*. <https://www.cleanenergyministerial.org/initiatives-campaigns/industrial-deep-decarbonisation-initiative/>
76. European Chemicals Agency (ECHA). *Understanding WFD*. <https://echa.europa.eu/understanding-wfd>
77. European Chemicals Agency (ECHA). *SCIP*. <https://echa.europa.eu/scip>
78. European Commission. (2021, December 16). *Understanding Product Environmental Footprint and Organisation Environmental Footprint Methods*. https://ec.europa.eu/environment/eussd/smgp/pdf/EF%20simple%20guide_v7_clen.pdf
79. University of Cambridge Institute for Sustainability Leadership (CISL); Agora Energiewende. (2021, May 11). *Tomorrow's Markets Today: Scaling up Demand for Climate Neutral Basic Materials and Products*. CLG Europe. https://www.corporateleadersgroup.com/files/cisl-clg-agera_tomorrows_markets_today_report_0.pdf
80. European Commission. (2020). *Initiative on substantiating green claims - Environment - European Commission*. https://ec.europa.eu/environment/eussd/smgp/initiative_on_green_claims.htm
81. European Commission, Directorate-General for Justice and Consumers; GfK, Time.lex, Milieu Ltd., BIO IS, Ecologic Institute. (2015). *Consumer Market Study on Environmental Claims for Non-Food Products: Final Report*; Publications Office: LU. <https://op.europa.eu/en/publication-detail/-/publication/ae7f9aa1-bdea-4ad2-82d1-835549c3ce2a/language-en>

-
82. European Commission. (2021, December 16). *Environmental Footprint Methods*. [news article]. https://environment.ec.europa.eu/news/environmental-footprint-methods-2021-12-16_en#:~:text=The%20Environmental%20Footprint%20methods%20measure,methods%20agreed%20at%20international%20level
 83. European Commission. Results and Deliverables of the Environmental Footprint Pilot Phase. https://ec.europa.eu/environment/eusssd/smgp/PEFCR_OEFSR_en.htm
 84. *Responsible Steel*. <https://www.responsiblesteel.org/>
 85. *ISEAL*. <https://www.isealliance.org/>
 86. Science Based Targets initiative. *Ambitious corporate climate action*. <https://sciencebasedtargets.org/>
 87. Damen, M.; Martinetti, I.; Edgerton, B.; Van Brunschot, C.; Kupier, S. (2022, May). *Circular Transition Indicators v3.0 – Metrics for Business, by Business*. WBCSD. <https://www.wbcsd.org/content/wbc/download/14172/204337/1>
 88. WBCSD. (2021). *Pathfinder Framework - Guidance for the Accounting and Exchange of Product Life Cycle Emissions*. <https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/SOS-1.5/Resources/Pathfinder-Framework-Guidance-for-the-Accounting-and-Exchange-of-Product-Life-Cycle-Emissions>



**Wuppertal Institute for Climate,
Environment and Energy**

Döppersberg 19,
42103 Wuppertal, Germany
T: +49 202 2492-0
info@wupperinst.org



**University of Cambridge Institute
for Sustainability Leadership**

Head Office

The Entopia Building,
1 Regent Street,
Cambridge, CB2 1GG
UK +44(0)1223 768850
info@cisl.cam.ac.uk

EU Office

The Periclès Building
Rue de la Science 23
B-1040 Brussels, Belgium
+32(0)2 894 93 19
Info.eu@cisl.cam.ac.uk

South Africa

PO Box 313
Cape Town 8000, South Africa
+27 (0)82 829 6852
info.sa@cisl.cam.ac.uk