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Digitally accelerating the circular economy

Standardizing data cost-effectively for small & medium-sized businesses globally

ABSTRACT

At present, there are no globally standardized tools for describing product characteristics relevant for the circular economy (CE). Data markets are fragmented into competing methods and siloed sectors. The Product Circularity Datasheet (PCDS) is an open source system being developed to enable standardized data-sharing. The PCDS system is summarised here based on a model and pilot projects developed in Luxembourg, and recommendations are made on how to use lessons learned to enable adoption of data gathering and sharing tools by small and medium-sized enterprises (SMEs), which as a group are the majority players in international supply chains.

INTRODUCTION

The optimal circular economy (CE) could be described as:

> *A system for products and processes that are restorative and regenerative by design.*

This system uses "Cradle to Cradle" biological and technical cycles as a basis for design and use.

By contrast, according to a more traditional view, a circular economy is:

> *An economic system that aims to minimise waste and maximise the use of resources by reusing, reducing and recycling.*

This interpretation is based more on conventional sustainability and waste management than on regenerative economics.

Many other variations sit between those two definitions, but a key aspect of all models is the need for data systems to ensure that materials and resources are tracked and managed consistently and reliably throughout their use cycles.

This paper examines the importance of standardized approaches to collecting and sharing data globally, across sectors, national borders, and economic zones in ways that are practical for SMEs. It describes the opportunities and challenges that may arise in creating globalised data systems in a circular economy context, using one example to demonstrate. The paper originated in the context of the workshop series "Digitalization and the Circular Economy" that was conducted between January and June 2023 with experts from politics, business and science. The question of international standardization was a recurring issue throughout the series and therefore warranted its own discussion.[1]

WHY IS CIRCULAR ECONOMY DATA A MATTER FOR INTERNATIONAL STANDARDIZATION?

Materials circulate globally across national borders and among different sectors, but the information about them is often organized by industrial sector. Data about those materials may thus be inconsistent between sectors, making it hard to share between them. The circular economy is intended to be a global system in which everybody uses portions of everybody else's materials at the beginning or end of product cycles. Thus there is a need for international standardization to ensure that data is consistent across sectors and economic zones. International data protocols are also essential to track and manage resources throughout their use, so they can circulate safely and continuously at high (and documented) levels of quality, regardless of their origins or final destination. Such consistency is also important for auditing data to ensure relia-

bility. It is also important for creating new value from circular economy activities, such as safe and dependable materials for use in supply chains.[2]

ESTABLISHING INTERNATIONAL STANDARDS VS IMPLEMENTING AND MANAGING THEM

Developing tools and systems based on international standards, and auditing such tools and systems against international standards is done through a complex web of mechanisms, which include:

1. **Self-regulation**: Organizations decide whether they will adopt and implement standards for their industry or field.

2. **Certification and auditing**: Third-party certification bodies conduct audits to verify that the processes and practices align with standards.

3. **Market and customer pressure**: Customers and partners often prefer to work with organizations that comply with recognized standards.

4. **Industry practices**: Adhering to recognized standards might be common practice in some industries.

5. **Legal and regulatory:** Regulatory bodies sometimes refer to or adopt standards.

As an example of standard setting in relation to the circular economy, the International Organization for Standardization (ISO) in July 2023 published draft circular economy standards for terminology, principles, business models, measurement, and guidance.[3] The published ISO draft standards are divided into:

- ISO/DIS 59004: Circular Economy – Terminology, Principles and Guidance for Implementation

- ISO/DIS 59010: Circular Economy – Guidance on the transition of business models and value networks

- ISO/DIS 59020: Circular economy – Measuring and assessing circularity.[4] As an example, here is an excerpt from the 59020 draft standard abstract:
  "The framework provides guidance on how the circularity performance of an economic system can be objectively, comprehensively and reliably measured and assessed using circularity indicators and complementary methods. The framework can be used to determine the effectiveness of circular actions executed by public and private organizations. The purpose of the standard is to assist organizations in the collection of necessary information to enable circular economic practices that minimize resource use and/or enable a circular flow of resources and contribute to sustainable development."

The public comment process on those draft standards has started. For further information, refer to the ISO publications referenced in the endnotes to this paper. These can be downloaded from the ISO website.

GLOBAL INTEROPERABILITY VS SECTOR SILOS

Outside of the ISO process, sectoral fragmentation has been recognized for years as a barrier to gathering and sharing climate data,[5] developing transnational legal frameworks,[6] and in agriculture and energy.[7] These issues occur between and within sectors. It is thus normal that a new paradigm such as the circular economy and its mechanisms also face these barriers.

Most resources pass through multi-tiered, complex supply chains before the final product reaches the users. These supply-and-use chains span industrial sectors. Base resources and components (including recycled materials) feed into multiple sectors, and products from those sectors are often mixed together at the end of use to be recycled or returned to the environment in biological cycles.

In that context, sector-specific approaches to data collection are essential within sectors, but can themselves create silos of information that hinder circular economy practices globally.[8] International standardization of data in the circular economy could ensure consistent data collection, management and sharing across different industries, countries and economic areas. This will help to prevent fragmentation and confusion in the market, and enable circular economy-oriented businesses to operate more efficiently and effectively.

Regions such as the EU and China have recognized many of these challenges. The EU has launched initiatives such as the EU Circular Economy Action Plan,[9] which aims to promote a more holistic approach to circular economy practices across different sectors. The EU Digital Product Passport initiative is part of this, and its developers are trying to reconcile two pressures: (i) the pressure to maintain business as usual in existing economic sectors, and (ii) the reality that materials in the circular economy move across sectors and cannot be siloed.[10] The outcome of this process will be crucial to the success of circular economy digitalization. Countries such as China have adopted circular economy legislation and policies,[11] but to what degree these include a passport-type approach was unclear at the time of writing. Sectors such as batteries[12] have also started passport initiatives, as have global certification companies such as Underwriters Laboratories (now UL Solutions), who govern the UL mark.[13] UL has named its passport a "Circularity Facts Report". Other product passports have different names.

HOW CAN DATA BE COLLECTED AND SHARED IN COMPLEX INTERNATIONAL SUPPLY CHAINS?

Collecting, sharing and tracking data across complex international supply chains presents significant challenges, as different countries and economic areas have different approaches. To deal with these, it is essential to establish international data-sharing tools and digital infrastructures that can be used across different regions. The ISO has started this process by publishing three previously described draft standards as a framework for such mechanisms. [14]

PRODUCT CIRCULARITY DATA SHEET (PCDS)[15] [16]

One standardized approach being developed within that framework goes under the name "Product Circularity Data Sheet" (PCDS). The PCDS initiative resulted from the need for a simpler data exchange mechanism than those developed in product passport initiatives such as the Horizon 2020 Buildings as Material Banks[17] project, and other initiatives identified through an inventory process[18] carried out by PCDS initiators (see below for more on passports). The Grand Duchy of Luxembourg has a policy of promoting data hubs for the circular economy and so the PCDS initiative was started in 2019 by Luxembourg's Ministry of the Economy to address the challenge. The public tender to support the initiative was awarded to the CE consultancy company PositiveImpaKT, located in Luxembourg. It is aimed at overcoming barriers such as trade secrets that hinder transparency, as well as segmented reporting standards that force suppliers and manufacturers to provide different data sets in diverse formats to customers and product platforms.[19] Several companies have joined the initiative to develop and test the PCDS. In parallel, the Ministry introduced the PCDS Initiative to the International Organization for Standardization (ISO), whose circular economy working group TC323-WG5 is currently developing a PCDS standard.[20] The PCDS standard is being drafted in the context of the published ISO draft standards referenced previously.

THE LUXEMBOURG PCDS

The draft PCDS developed in Luxembourg prior to the ISO process is, in terms of its widest scope, a system for collecting and sharing basic data on product circularity in a standardized way across national borders and economic areas in complex international supply chains. It is designed to provide a common language for describing products' circularity characteristics and to enable businesses to communicate this information across international supply chains. The PCDS is not a ranking or evaluation system. It is designed only to provide data for others to evaluate.

The PCDS being developed in Luxembourg is a threefold system:

1. A data template containing standardized and trustworthy statements on product circularity
2. A third-party verification process to validate the content of the PCDS (audit system)
3. A standardized data exchange protocol based on decentralized data storage (IT system)[21] [22]

In the template developed by Luxembourg and global partners, the main sections contain binary statements in a true/false format rather than detailed datasets. This is designed to simplify and standardize the process of providing and assembling data, as well as improve machine readability.

Status at the time of writing: A PCDS template was developed between 2019 and 2021 by Luxembourg's Ministry of the Economy and tested and modified with about 35 companies, as well as data platforms.[23] Further developments await publication of a draft ISO PCDS standard.

RELATIONSHIP TO PRODUCT PASSPORTS

In relation to product passports, the PCDS template developed between Luxembourg and partners is not a ranking or scoring mechanism, but only a provider of data. The completed PCDS is designed to provide high-level information to support those passports, both within and across sectors.[24] A completed PCDS is designed to stand on its own to provide data in the absence of a passport. By comparison, passports such as the battery passport contain more detailed data, including non-circular economy product performance data as well as post-manufacturing usage data. In other cases, a passport might contain ranking mechanisms to evaluate a product's circular economy suitability. In general, it will probably be more challenging to develop a globalized product passport for the circular economy because the level of detail will probably be greater than with a PCDS, so regional and sectoral variations will have to be considered. The PCDS and product passports are developing in tandem, except that no global passport was in development at the time of writing.

IMPLEMENTATION

Outside the ISO process and regardless of which methods or standards are established, fragmentation is increasing globally as more regions and industries start to implement circular economy data sharing methods. As described already, the problem is compounded by the nature of the circular economy itself. Most materials are not confined to specific industries, regions, or ecosystems, as witnessed by the widespread dispersal of microplastics into the global environment. This is precisely why international conventions and treaties have been developed for governing the release of such materials into the environment. However, no such treaty or convention is on the near-term horizon for the circular economy. In its absence, national and regional circularity initiatives are filling the gap, leading to further fragmentation.

In that context, implementing a PCDS globally may depend on who develops the most effective and easily adopted standardized data exchange protocol based on decentralized data storage (IT system), as already described. How could such protocols be piloted and scaled up?

Implementing standardized PCDS tools on a large scale is a significant undertaking and requires careful planning and testing. There are a number of ways of doing this that could be projected from the Luxembourg experience:

Cross-industry pilots: A PCDS template could be introduced in cross-industry pilots, in which multiple industries work together to test and refine the tool. For example, substances or product components that go into multiple products and derive their source materials from multiple sources could be piloted. This approach would allow for a more comprehensive understanding of the tool's strengths and weaknesses and could help to identify opportunities for further improvement. Packaging could be a candidate for this, as could base chemicals, base polymers, coatings, and connectors.

Regional pilots: The PCDS template could be introduced in a few countries in Europe or Asia, where there is already a strong interest in the circular economy. This would allow for testing and refinement of the PCDS in a more controlled environment before broader adoption.

Sector pilots. This approach might gain from past experience in several sectors, as well as new initiatives such as the Battery Passport initiative.[25] Candidates include the electronics, textiles and automotive industries. Some of these are beginning to pilot product passports that are more sophisticated and detailed than the Luxembourg PCDS template. In this way the PCDS and passports could be aligned. The downside risk is that being sector specific might reinforce silos inside a sector instead of a transition to a new cross-sector paradigm.

Piloting with passports. As soon as product passports come into effect more widely, the PCDS would be tested as a mechanism for feeding data into those passports.

Nonetheless, such pilots still leave open the question of how the resulting systems and tools rapidly gain widespread acceptance by millions of suppliers, manufacturers, recyclers, and retailers globally. Current global management regimes offer few clues to how this could be achieved to get ahead of the widespread fragmentation that is multiplying rapidly. In this respect, a solution may lie with new technologies themselves.

DEFINING ROLE OF AI

It is widely acknowledged that tools related to Artificial Intelligence (AI) have been sweeping across global markets and are having profound effects on data gathering and sharing. How could these be applied to data sharing in a circular economy?

Most of the world's manufacturing is done by small and medium-sized enterprises (SMEs),[26] which will have to provide data for the PCDS and for product passports, so cost is especially important for these stakeholders' acceptance. The main challenge in implementing the circular economy and the PCDS within such enterprises is the cost and time involved in developing and accessing the raw data, then verifying its accuracy and reliability.

The rapid emergence of practical AI tools will play a defining role in generating, acquiring and organizing circular economy data for PCDS tools. Already, environmental systems such as Environmental Product Declarations are using AI.[27] The era of Excel sheets and manual data entry is giving way to such automation. It is too early to say whether AI is already being applied to the PCDS, but the use of a binary format and standardized identifiers, if adopted, could make it easier for AI tools to organize the data.

There is widespread concern that AI still makes mistakes and could generate misleading data. This is a valid concern but should be taken in the context that humans make mistakes when entering data and interpreting it, and often these human mistakes are not traceable. Studies in, for example, pharmaceutical prescription dispensing have shown that AI makes fewer errors than humans, also in predicting reactions among drugs.[28]

There is concern that AI software is data-intensive, so also resource-intensive. While there is merit to this argument, the opposite is also true in the following cases:

- **Efficiency and optimization:** AI algorithms have made significant progress in optimizing various processes that increase efficiency and resource management in different industries. For example, in agriculture, AI can optimize water usage, reducing waste and environmental impacts.[29] In the case of the PCDS tools, AI systems could greatly improve the efficiency of labour- and resource-intensive data gathering and storage by preventing the kind of large-scale data duplications that occur at present.

- **Solving environmental challenges:** AI can be instrumental in finding innovative solutions to environmental challenges. By processing large datasets and identifying patterns, AI can help scientists and policymakers make informed decisions and devise effective strategies for mitigating environmental issues. One example related to PCDS tools is designing server systems that require far fewer resources and less energy, as well as further reducing the cost of renewable energy systems to power them.

It is also worth mentioning that global stock markets are being run largely with AI-type tools and so they have become inextricably linked to the world economy.

Resistance to embracing AI based on fear of errors or environmental impacts risks leaving the circular economy and tools such as the PCDS and passports behind in computing and might jeopardize the viability of their

business models. This is especially true in regions such as Asia, where much of the world's manufacturing occurs and AI is rapidly being embraced. Using AI for circular economy data, including safeguards to avoid massive errors and mechanisms that ensure environmental benefits, is a priority.

STAKEHOLDER ACCEPTANCE

It is essential to ensure that there is a clear understanding of the PCDS tools' purpose and benefits, as well as strong stakeholder engagement and support. By introducing and testing PCDS tools in increments, it is possible to build momentum for broader adoption and to ensure that the tools are effective in improving data governance in the circular economy.

SME NEEDS AND INTERESTS HAVE TO BE AT THE CORE OF DATA INITIATIVES

As already described, it is well established that SMEs are major players in manufacturing. According to the World Bank, 80–90 per cent of manufacturers are SMEs. Unfortunately, they don't have the resources to participate in developing standardized tools. Special attention needs to be paid to SMEs because of these resource constraints. Lack of access to resources and technical expertise can be a significant barrier to participation in circular economy initiatives.

Engaging with these types of SMEs, especially in Asia, is critical to the success of data management in the circular economy. Asia is a significant manufacturing hub and many products produced in this region are part of complex international supply chains.

To address this challenge, several potential strategies could be used to pilot PCDS tools for circular economy purposes. These strategies include the following. None of these approaches are confined to the circular economy, but rather reflect methods that have been used in the past.

1. Partnering with larger organizations: these companies and industry associations have more resources and technical expertise to support SMEs in data collection and analysis. These partners could provide guidance, training and support to help SMEs implement circular economy practices and collect the necessary data.

2. Providing financial and technical assistance: governments or other organizations could provide financial and technical assistance to SMEs to help them collect and analyse data related to circular economy practices. This could include funding for equipment or software, as well as technical assistance and training to help SMEs implement data collection processes.

3. Developing open-source data tools that are accessible to SMEs and other stakeholders. These tools could be designed to be user-friendly and require minimal technical expertise, making it easier for SMEs to participate in data collection and analysis initiatives. See also section on AI.

4. Start with pilot projects in specific sectors or regions in which SMEs are already engaged in the circular economy. These could be designed to test the feasibility of PCDS and other data tools and identify opportunities to scale up these initiatives over time.

By using a combination of these strategies, it may be possible to pilot data solutions for circular economy practices in a way that is accessible and beneficial to SMEs. This could help to overcome some of the resource constraints they face.

HOW CAN INTERNATIONAL PARTNERS BE WON OVER?

There are several initiatives in Asia and Europe that provide support to SMEs in collecting and reporting on data related to circular economy practices. It is important to learn from and be in contact with these initiatives to be able to build on previous experience and utilize existing mechanisms rather than trying to create new ones. Regional and global examples of these initiatives include:

1. The China Association for Small and Medium Business Enterprises provides a range of services for SMEs, including advice on policy, finance, taxation, certification and intellectual property.

2. The Small and Medium Enterprise Agency in Japan. A government agency to support Japan's large SME sector. Japan also has extensive experience involving SMEs in a standard approach to hazard identification and databases, which could provide valuable lessons for adopting the PCDS.

3. Small Business Standards (SBS) is a Belgian-based non-profit association (aisbl) operating in Europe and co-financed by the European Union and EFTA member states. Its goal is to represent and defend SME interests in the standardization process at European and international levels.

4. The Green Industry Platform (GIP): The GIP is a joint initiative of the United Nations Industrial Development Organization (UNIDO) and the Global Environment Facility (GEF) that aims to promote resource-efficient and low-carbon industrial production in developing countries. The GIP offers support to SMEs in the form of training, capacity-building and access to financing.

These initiatives demonstrate the range of support available to SMEs in Asia and Europe to collect and report on data related to circular economy practices. By providing training, mentorship and access to resources, these initiatives can help to overcome the resource constraints faced by many SMEs and promote the adoption of sustainable and circular practices.

It makes sense to directly involve those types of associations and agencies in piloting PCDS tools. This can be achieved by engaging in collaboration. One approach is to focus on shared priorities. For example, many Asian countries face significant environmental challenges, such as air pollution and water scarcity. By highlighting the role that the circular economy can play in addressing these challenges, it is possible to build support for international norm and standard setting.

Another approach is to focus on the economic benefits of the circular economy. The circular economy can generate new business opportunities and create jobs, and many countries in Asia are keen to develop new industries and technologies that can drive economic growth. By demonstrating the economic potential of the circular economy, it is possible to build support for standardized tools.

CONCLUSION AND RECOMMENDATIONS

International standardization of circular economy data, including piloting data collection and sharing in the circular economy is essential to ensure that resources are tracked and managed effectively throughout use cycles and across sectors. To achieve this, it is necessary to have standardized tools that can be used across different regions and sectors, while accommodating sectoral needs. This involves communication so that industries clearly understand the benefits.

SMEs account for most of the companies that will generate data for the circular economy. To win over international partners, especially SMEs in Asia, it is essential to highlight the circular economy's economic benefits for their business. First steps in engaging SMEs, which will be the major users of PCDS tools, could include involving SME associations and agencies and carrying out pilot projects (described above), with support from agencies that can subsidize SME pilot projects, with a special focus on AI tools that reduce costs and increase efficiency.

Foundations and government agencies in the policy-making arena could engage third parties to:

- describe and initiate an AI-enabled piloting mechanism for PCDS tools and possibly product passports in collaboration with SMEs, their representative associations, and facilitating organizations;

- prioritize which tools for circular economy data sharing are developed first, so that the transition from a linear economy is less chaotic;

- pilot AI-enabled circular economy data exchange tools and systems to assure practicality for SMEs;

- use AI to systematically track the development and implementation of these systems.

The product focuses of a pilot could include one technical cycle component, such as steel ingots used across sectors to manufacture product components, and one biological cycle component, such as biocompatible textiles used in blinds, clothing, flooring, and scrubbing cloths designed to degrade into the environment or be cascaded into other products. A pilot should include how to adapt the training component for SMEs, their customers. Because China is a major player in supplying components globally, such as steel and textiles, a pilot might include collaboration with, for example, the China Association for Small and Medium Business Enterprises, with a focus on industrial parks that provide enabling tools for SMEs. Similar agencies in India and Thailand are candidates, and the final choice depends on the willingness of agencies and SME associations to participate. This could be enhanced by involving an agency in Europe with ties to those countries and experience with the PCDS.

In summary, the PCDS is a beginning, not an end to the ongoing efforts to introduce a circular economy. It will continue evolving as different standards are put into place and the market begins to provide software solutions for implementation. Proactively involving SMEs for piloting and implementation could be central to the success of the initiative.

ENDNOTES

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