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Materials Passports: Optimising value recovery from materials

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To understand the circular value potential of materials, products and systems, one requires a reliable set of information. Materials Passports aim to provide this information. This paper explores the need for passports as well as their goals and functions. The types of information a Materials Passports should be able to contain are discussed, and how they relate to existing tools in the marketplace. The focus of Materials Passports on putting the Circular Economy into practice by value creation through recovery and how this encourages innovation is described.

1. Overview of buildings as material banks (BAMB)

Over 2 years ago, a consortium of partners across numerous EU countries came together to complete a proposal to the Horizon 2020 research programme, WASTE-1-2014. The objective of this research was integrating Materials Passports with Reversible Building Design to optimise Circular Industrial Value Chains. This successful proposal finally started in September 2015, led by Brussels Environment, with a budget of almost €10 million. Lasting 42 months, the project brings together 16 partners across eight EU countries. Other partners are EPEA Nederland, BRE, IBM, Ronneby Kommun, Vito, University of Twente, Zuyd Hogeschool, Vrije Universiteit Brussel, Sarajevo Green Design Foundation, University of Minho, Sundahus, Technical University of Munich, Aurubis, BAM Construct UK and Drees & Sommer.

The aims of BAMB are aptly described by the project title: the recovery of value from buildings, which are designed to facilitate that recovery. This includes a tracking mechanism for the value of materials, products and systems for reuse in a circular economy (CE) and implications on building design for reversibility. This will result in the prevention of construction and demolition waste, the reduction of virgin resource consumption and the development towards a CE. This builds on many years of resource efficiency in the construction sector, where high levels of recycling are now commonplace in many European countries. As is often the case with a linear use of resources, much of this recycling is not at high levels of application and the amount of reuse is minimal. BAMB, therefore, seeks to develop a circular approach to the use of building, systems, products and materials.

However, the challenges faced in achieving this paradigm shift are many, including the following.

- A complex and multifaceted supply chain, from commissioning to decommissioning.
- Buildings and infrastructure tend to last a long time, compared with other products, and can have multiple ownership and occupation profiles over their life cycle.
- There is a general lack of standardisation of design and component use compared with other sectors.
- There are many priorities in terms of delivering our built environment, including affordability, health and safety, and reducing energy consumption.

To deal with the complexities outlined above, research is underway on multiple fronts in the BAMB project, with crucial interaction between them.

Work package 1 elaborates the systemic nature of the BAMB ambition, since the envisioned circular value chains can only be realised if all the elements of the involved system are operational in a coherent and mutually reinforcing way.

Work package 2 is focused on making and implementing electronic Materials Passports to enable circular product design, material recovery and chain of possession partnerships, improving quality, value and security of material supplies, which together are integrated to eliminate waste. Materials Passports are presented in more detail in the following article ‘Materials Passports as a tool to optimise value recovery from materials’.

Work package 3 is developing the framework and protocols for an integrated design that facilities reversible building to promote reuse of components, and high transformation capacity to promote expanding and extending the use of buildings. This includes development of a virtual building simulator.

Work package 4 demonstrates new design, manufacturing, construction and maintenance approaches for buildings through pilots; testing business models for circular material value chains, organising supplier communities, to test waste reduction potential. Currently, the five demonstrators are being developed in the Netherlands, Germany, Belgium and Bosnia.

Work package 5 has a number of actions within it to enhance the application and exploitation of materials passports and reversible design. Action 1 will create and test an integrated, building level assessment for dynamic and circular building management. This will consider environmental and financial assessment, for new and existing buildings, and across the building life cycle. Action 2 develops new business models that enable a circular use of materials, building components and/or building elements as well as pragmatic operating models that support these business models. Action 3 defines a set of standards, policy propositions and regulations tackling the legal barriers on different levels that can ease the transition of the building and supply industry towards industrial symbiosis.

Other work packages are dedicated to project management and maximising the dissemination impact. This includes informing a growing stakeholder network and the special interest groups about the latest developments (see BAMB, 2016 to find out more). These stakeholders and many others working with specific work packages are also helping to shape the research as it proceeds. The BAMB consortium is keen to share as much information as possible throughout and at the conclusion of the work in Spring 2019, with articles in journals such as this being an important part of this process.

2. Introduction

This paper is on the subject of Materials Passports as they are being developed in the Horizon 2020 Buildings as Materials Banks (BAMB) project. Materials Passports is a tool to put the CE into practice. They are described in the article 'Resource Re-Pletion Role of Buildings'. Introducing Nutrient Certificates A.K.A Materials Passports as a Counterpart to Emissions Trading Schemes' (Hansen *et al.*, 2012). An earlier term coined for this concept by the authors, nutrient certificates, dates back to 2003. This paper serves as a foundational element in shaping Materials Passports in BAMB.

In this publication, Materials Passports is defined, using the term 'nutrient certificates', as follows

> Nutrient Certificates are sets of data describing defined characteristics of materials in products that give them value for recovery and reuse. The certificates are a marketplace mechanism to encourage product designs, material recovery systems, and chain of possession partnerships that improve the quality, value, and security of supply for materials so they can be reused in continuous loops or closed loops or beneficially returned to biological systems. This is done by adding a new value dimension to materials quality. This new dimension is based on the suitability of materials for recovery and reuse as resources in other products and processes. (Hansen *et al.*, 2012, p. 25)

Materials Passports is an active tool for value tracking and intended to be used to bring residual value to the market. Actions in every stage, from production to purchase to use to maintenance, have impacts on products and systems and their value recovery potential. Materials Passports makes information available relevant to all of these stages. Thus, they have the potential to drive innovation, for instance, by providing product design guidance or a way for manufacturers to transparently communicate the circular value of their products.

Materials Passports can be made for materials, products and systems. A single materials passport contains a set of information about that material, product or system. This can be either generic for the abstract product, when it concerns properties of a product, or it can apply to a specific product, when it concerns aspects that only apply to a single instance of a product such as its method of fixation in a building. For brevity, the group of materials, products and systems is referred to simply as 'products' throughout this paper.

The process of generating Materials Passports may involve more than one party. Materials Passports can thus contain data from different sources and provide information to different stakeholders (Figure 1). Not every stakeholder or context requires the same information. Part of the functionality of passports is to provide the necessary information specific to the users: A company maintaining Heating, ventilation and air conditioning (HVAC) systems requires information about different aspects of this than the user or the installer. Similarly, not all stakeholders require the information at the same point in time. An architect may be interested in this information before the building is built, while an end user of the building is interested in it at the operational phase of the building.

3. Materials Passports and existing tools

Several tools exist which have thematic connections to Materials Passports. These include among others tools to operationalise environmental indicators such as life cycle analysis (LCA) and environmental product declarations (EPD), tools to

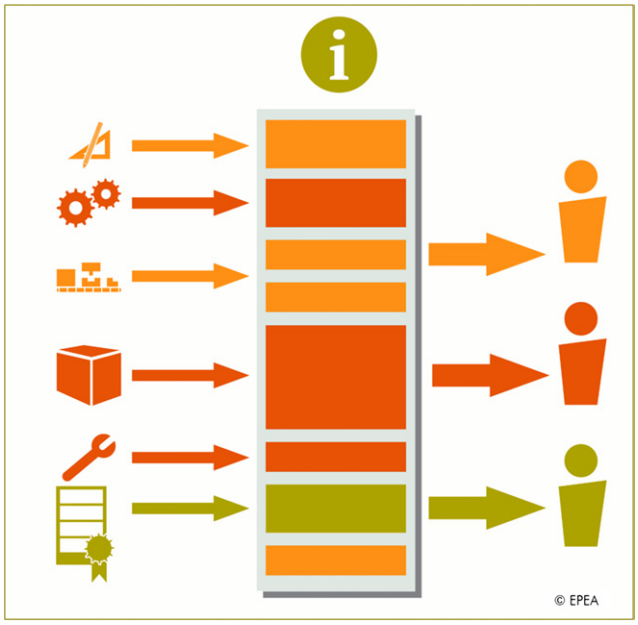

Figure 1. Schematic diagram of data collection from different sources, and the provision of information to different stakeholders. © EPEA

inventory composition such as bill of materials or bill of substances and tools to detail technical properties such as technical data sheets (TDS) or material safety data sheets (MSDS). There is also a set of tools sharing the passport analogy with Materials Passports. Among these are for instance Building Passports, Electronic Building Passports and Energy Passports. Building Passports is described as a tool to communicate a building's sustainability performance (Virta *et al.*, 2012). Building Passports is also described as a decision-making instrument using information on building quality as well as environmental properties and performance criteria (Blum, 2001). Electronic Building Passports (SSA, 2015, The research reported in this paper was funded by the Commonwealth, State and Territory Governments. The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the South Australian or other Governments.) is similar, but it emphasises the use phase. Energy Passports (Immotop.lu, 2016) focuses on energy-related impacts such as energy requirements and related emissions.

However, Materials Passports has a different scope than those passports initiatives. Materials Passports focuses on recovering value and maximising circular aspects, including material health. This means that impact-related performance is seen more as a consequence of action rather than as a measurement goal in itself. Still, the information in Materials Passports can be supported by measurements of impacts. Materials Passports are able to incorporate existing documents such as those mentioned above for this purpose as well. Additionally, based on Cradle to Cradle, passports describe beneficial impacts of products on their surroundings such as improved air quality, something which is currently not in the scope of (environmental) measurement tools.

4. More than an ingredients list

An appealing analogy for products and their compositions is the ingredients labels found on food items in the supermarket. As an extension of this analogy, EPDs have been described as the nutritional label counterpart (SGBC, 2016). Materials Passports, however, does more than provide this building equivalent of an ingredients list, and here is why:

- Products and their compositions are complex.

Value chains of products are often complex (Kaplinsky and Morris, 2001) and this is relevant in defining the composition of a product. Products are often made from parts or ingredients bought from suppliers, which can in turn be made from certain ingredients bought from (sub)suppliers and so forth. Eventually, the products' composition can (in many cases) be described by chemical identifiers (CAS numbers), of which more than 122 millions exist for substances (American Chemical Society, 2016). This complexity means that the ideal of a simple ingredients list analogous to that on a food item may not be a practical reality, and if it were, one might question if such a list would be useful to further circularity goals.

- The amount and types of materials in buildings, which are relevant for circularity, are huge.

This extends beyond construction elements including HVAC systems, lighting systems, furniture, flooring, ceiling systems, electronics, biological materials. As many of these materials can flow through shorter cycles than construction elements of a building, they represent a potentially high-value material stream for buildings. These products also impact human health. For instance, furniture (Andersen *et al.*, 2016), electronic office equipment (Cacho *et al.*, 2013) and interior products including flooring, paint, electronics and cleaning products, measurably impact air quality in buildings (Volland, 2014).

- Context of a product in its application is essential.

Knowing there are certain amounts of materials in a building is not practically useful if there is no knowledge of where these materials are located. It is also vital to understand if and how they can be extracted without losing their potential for reuse or recycling (e.g. through destruction or contamination with other materials). Context also defines impacts on, for instance, indoor air quality.

- Volatility and dependency of monetary value of materials.

Products and components are generally worth multiples of the value of their raw materials (3XN ADEPA, 2016). These values depend on actual market conditions. Having an ingredients list based on basic materials turns the focus to commodity prices. This ignores the potentially higher value of the products which the materials are contained in. Moreover, decision making on commodity price predictions is subject to their volatility, as demonstrated by the recent commodities crunch (IMF, 2016).

- Products change throughout the use of the building.

Throughout the building process from design to as-built to maintenance and adaptation to new owners or uses of the building, products used in a building frequently change. Tracking those changes is a key factor for having up-to-date information on the potential for value creation from products, components or systems.

Materials Passports places ingredients lists into context with data about material health, deinstallation, disassembly, positioning, location, reverse logistics and so on.

5. Conclusions

Materials Passports is a tool, which can be used by many stakeholders throughout the value chain of a building. Their goal is to document and track the full circular potential of materials, products and systems by supplying stakeholders with accurate information on diverse aspects related to the products' circular design including but not limited to their composition. As such, they provide a mechanism for innovation.

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