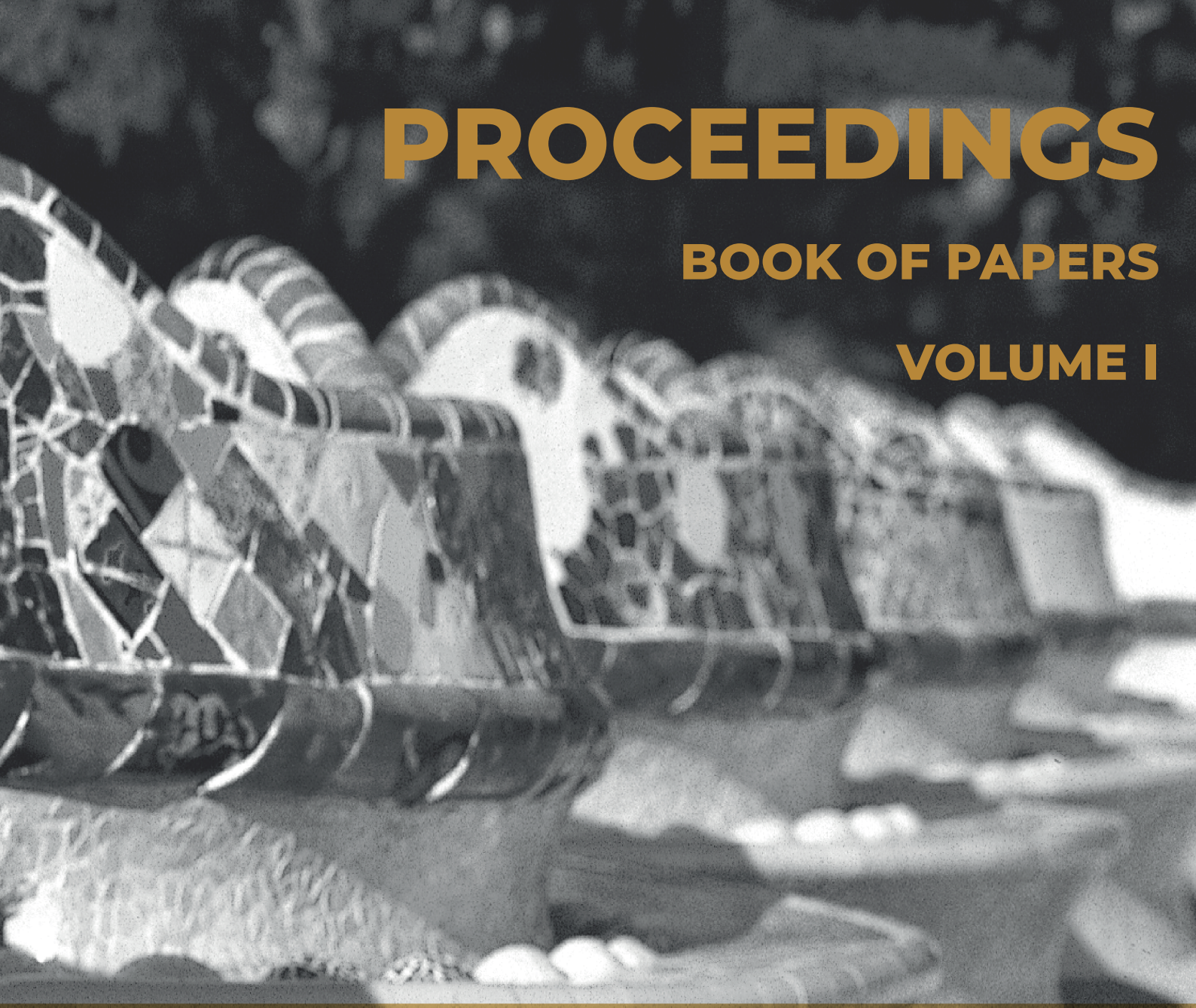

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ERSCP 2019 BARCELONA

15-18 October 2019, Barcelona

19th European Roundtable on Sustainable Consumption and Production

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Circular and sustainable products. From theory into practice.

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Abstract

Circular economy is seen as an innovative path with the potential to achieve a more sustainable society. In this context, and, facing high pressure and motivation from governments, many research projects and initiatives are being developed all over the world. However, we still have a long road ahead in translating the theory and research outputs into practice. For example, in the recently launched report "The circularity Gap report" published by Circular economy in January 2019, our society is only 9% circular and the trend is still negative, the circularity gap is not closing and the upward trend in resource extraction and greenhouse gas emissions has continued in the past 12 months (Circle economy, 2019).

In the circular approach to product and service development, which entails fundamental changes in production and consumption systems, where it is necessary to go beyond resource efficiency and recycling (European Environment Agency, 2017), it's clear the importance of design as an integrating agent in the process. Design professionals, through a redesigned approach to the design practice, applying efficient tools and comprehensive life cycle methods, have the challenge and the potential to transform products, services, and business models.

The work presented in the current paper is part of a research project (Camocho, Ferreira, & Vicente, 2018) which aims to support the transition to circular and sustainable economy through design where the authors will explore the current practice, methods, tools and communication elements applied in the development and placement in the market of products claiming to be sustainable and/or circular. The pilot study presented in the paper aims to demonstrate and validate the procedure for the analysis of the process that underlays a representative sample of Portuguese products. The research aims to identify which are the real needs, drivers and barriers faced by designers and product developers in the circular design and development process. The results of the work will underpin a holistic approach, sparking critical thinking and supporting a more efficient design practice for a circular production and consumption.

Keywords: Design, Circular Economy, Life Cycle Assessment, Sustainable Products, Sustainability

 ISBN: 978-84-09-16892-7

1. Introduction

The paper presents part of the research currently under development which aims to support the transition to a more sustainable and circular economy through design. The design practice has a crucial role in defining the characteristics of the products and services that fulfil the needs of society and most of their impacts on the life cycle are defined in the design and development phase through the designers and developer's choices.
In order to promote a sustainable and innovative design and its practice, it is important to understand how circular and sustainable products and services are developed and placed on the market, how they communicate to users their sustainability profile, how consumers understand the information available on the product; and which are the user perceptions about the circularity and sustainability profile of products and services.

The successful integration of circular economy in the design practice requires a new, or at least, an adapted set of principles, strategies, and methods (den Hollander, Bakker, & Hultink, 2017), in a holistic approach, considering all aspects of production to consumption, covering the entire life cycle of the product or service, is fundamental. However, despite the developments towards a circular economy, there is still a gap between what is developed at the research level and what is applied in practice by designers and companies, particularly in Portugal.

In this paper, the authors look to a specific part of the process related to the development of products in order to understand how designers and product developers translate the user and business needs in product design development. The identification of which methodologies and tools are applied in practice by designers and which are the needs, barriers and drivers in their practice in product/service development will promote the development of efficient resources to support the transition to a circular economy through design which is the goal of the research under development (Camocho, Vicente, Ferreira 2019a).

2. Background

The economic model in Europe is still linear which implies a huge pressure on the environment, human health and inefficient production and consumption of natural resources leading to an over-dependence of resources from outside Europe (European Environment Agency, 2017).

According to the recently released, Circularity Gap report, our world is only 9% circular and the trend is negative. The majority of materials used in our economy, which are not cycled, are not recovered and are either dispersed in the form of emissions or unrecoverable waste. (de Wit, Verstraeten-Jochemsen, Hoogzaad, & Kubbinga, 2019). The majority of products are still developed and placed in the market without a circularity perspective and at the end of their functional life, the majority are discarded and their value and materials are wasted, including the loss of critical raw materials (European Commission, 2015).
The linear economy, based on a take-make-use-waste system, has to change. The way resources are managed, how products are developed, produced and consumed and what happens after the functional life of products have to change in line with the boundaries of our planet (Ellen Macarthur Foundation) and the needs of society. The goal and challenges we face today are not to go backwards in the evolution of civilization but in redesigning our society and the way of meeting our needs in an innovative, sustainable and circular way, attaining benefits for businesses, companies, and people such as

- innovative and efficient ways of production and consumption;
- protection for businesses against scarcity of resources and volatile prices;
- opportunities for jobs and social integration;
- optimization of waste management boosting recycling and reducing landfill;
- energy savings as fewer production processes require less energy;
- benefits for the environment in terms of climate and biodiversity, air, soil and water pollution (European Commission b).

The transition to a circular economy approach its seen as a potential way to alleviate the sustainability pressures and concerns and deliver economic, social and environmental benefits (European Environment Agency, 2017) and the design practice has a huge role in the process. The way we design, produce, use, distribute and discard products has strong impacts and most products developed and used today are not optimized, resulting in premature obsolescence. In this regard, designers have the responsibility of defining the product characteristics and its circularity potential: i.e., their reparability, durability, selection of materials, proportion of recycled and renewable materials, their suitability for refurbishment, remanufacture, etc (European Environment Agency, 2017; European Commission, 2019), and also by establishing the link to new business models and services which are required such as maintenance, repairing, reuse and reverse logistics and other services like sharing, leasing and renting services, as well as services that deliver performance (Bocken et al., 2016; BEUC, 2015), to increase the circularity potential of the proposed solutions.

Designers have the role of meet people's needs and develop technically and economically feasible products and services and in this new approach to improve the economy these professionals are challenged by new environmental, social and economic needs and must adopt a holistic approach to problem-solving (Bocken et al., 2016), supported by new knowledge and competences.

In order to promote a more effective design practice to circular product development, by supporting designers with improved tools and knowledge, the research under development is mapping the maturity of the design practice for circular economy in Portugal through the analysis the current procedures, drivers, needs, methods and tools adopted by the design professionals and companies. In the next section, the research method is explained.

3. Method

The activities under development are based on field research as a primary source of information aiming to identify and map the design practice for circular economy and sustainability. At this stage, the research team is identifying industrial products that are produced in Portugal and placed in the market (national or international) as being more sustainable. In this step, products that are placed in the market and communicated with allegations such as "circular products", "sustainable products", "eco products", "green products", etc, are being identified through literature, internet, magazines, social media, specialized shops (physical or online), exhibitions and fairs, by conducting workshops with relevant stakeholder and the creation and management of forums or discussion groups on social media platforms. The collection of products and all the relevant data is being gathered in a database of "sustainable" products that will be used to support the research.

In the second phase, the analysis of the tools and methods applied in the product development through direct contact with the designers and producers of a representative selection of products through questionnaires, phone and face-to-face interviews, workshops and other events will result in the understanding of how sustainable

 ISBN: 978-84-09-16892-7

products are developed in Portugal and which tools and methods are applied in practice. This task will also allow the identification of the main drivers, challenges and the needs faced by practitioners.

Those professionals motivated to develop innovative and sustainable products are the ones that have been facing all the challenges and barriers required by enrolling in this development path, and by comparing what is available in terms of sustainability and circularity methods and tools with what is really applied in practice, the study aims to provide a clear idea on the extension of this gap and which are the real needs to support an effective and successful transition to more circular and sustainable economy**.**

The third phase will consist of measuring the effectiveness of the current practice trough a qualitative and/or quantitative evaluation of the sustainability profile of a group of identified products. The assessment will be based on the information available and will be performed by the application of life cycle assessment and circularity tools available. This analysis will be useful to perform an overview of the application of sustainability in the products available and how deep the concepts are rooted in the development process and communication of sustainability profile of products in Portugal.

Database of sustainable products in Portugal

Several platforms such as the ECO.NOMIA portal from the Portuguese Ministry of environment (www.eco.nomia.pt) and other commercial platforms such as the Planetiers (https://planetiers.com), Puro Verde (www.puroverde-ecostore.com) and many others have a collection of examples of sustainable products, however, these include examples from several origins, being difficult to understand which are developed in Portugal, and there is lack information on the criteria used as the basis to select them. Most of the examples rely on the allegations communicated by the producers, which in some cases can be misleading or even greenwashing (Camocho, Vicente, Ferreira 2019b).

The information and availability of Portuguese products are difficult to identify and even for the professional retailers of sustainable products, the access and availability is considered a problem. From a short consultation to these commercial stores, the main conclusions are that there are several products available on the global international market, but there is a lack of national products, and most of the products available with sustainability allegations do not have any form of validation or certification.

Within the research, several products are being collected in a database developed with a structure aiming to organize a wide sample and all relevant data. The initial version for research purpose was developed in excel, however, the goal in the future is to upgrade it into a user-friendly database that could be made available online to the public.

The structure was developed according to the needs of the research and it's based on the variables and information needed to support the planned research.

The structure of the database is divided into three main groups, "Background information", "Product and company information" and "Development process". In each group, several variables were identified as shown in table 1.

Table 1. *Variables in the sustainable products database.*

Background information	Product/company information	Development process
-Product name -Images and /or illustrations -Short description of the product -Company name -Source of information -The designer responsible for t development of the product - Sector - Contacts	-Allegations of sustainabili provided by the companies th place the products in the market - Certifications, labels, etc	-Criteria/type of strateg implemented in the developme process - Methodology applied -Tools applied (related to the desig practice) -Barriers for development a implementation -Drivers for development a implementation - Suggestions

Questionnaires and guidelines for interviews with designers and professionals

As mentioned before, in the second phase of this process, the research aims to analyse which design and sustainability tools and methods were applied in product development by the designers and producers of a set of selected products to understand and map how sustainable products are developed in Portugal, which tools and methods are applied in practice, which are the main drivers, challenges and the needs faced by practitioners and other information which was considered relevant.

The questionnaires composed by a set of 20 questions were structured according to the needs of the research. Besides the general information of the company and the interviewee, the second section of the questionnaire aimed to collect data related to the sustainability profile and characteristics of the product, such as: the sustainability allegations used in the communication of the product; certification, which label does the product have and which is the opinion regarding certification and labelling schemes. Within section three, data related to the product development is collected. Which criteria and sustainability strategies were implemented, which methodology was applied, does the approach adopted have a life cycle perspective and which life cycle stages are considered, which design and sustainability tools does the professional knows and which of them are being applied in the process, which are the reasons for not applying tools, which are the main drivers for develop sustainable and circular products and which are the main barriers to integrate sustainability and circularity aspects in the development process.

In order to validate the structure of the questionnaire and the approach developed, a pre-test was performed with the designers and developers of three industrial companies with different characteristics from different sectors and maturity levels. In the next chapters, the authors present the preliminary results and conclusions of the test.

4. Results of the pilot test

In the preliminary test, the authors tested the procedure and structure with three distinct companies. In table 2, a short overview of the results is presented in order to demonstrate the adequacy and the potential data to be collected

Table 2. *Variables in the sustainable products database.*

 ISBN: 978-84-09-16892-7

Designer/product developer	**Product developer A**	**Designer B**	**Designer C**
Type of products	Fashion products	Cork Products	Leather goods
Percentage of sustainab products in the company	100%	100% - All products ha sustainability considerati in the development proces	100%
The dimension of the compar	Small company	Large company	Small company
How the product is considere by the company	Eco-products Sustainab Circular	Circular products	Vegan Sustainable Ecological
Sustainability and circulari allegation used in t communication of the produ	Sustainable producti Reduced environment impacts Environmental goals Use sustainable materials Reuse of produ components and material the end of life	Sustainable material 100 recyclable Use of recycled materia from the company and fro external sources Circular products	Vegan and sustainab design Handcraft process Vegetable and Nickel free Versatile and timeless
Is the product or the compar certified?	No	Yes (at company level and product level)	No
Certification schemes ar labels implemented	n.a	The company has sever certifications and labe according to the wide ran of products developed distinct sectors	n.a
Personal opinion abo certification and labels	Environmental certificati is not required by the users	Important to communica the product performance	Important, but t consumers are not aware
If available, could a specif label to demonstrate t circularity of nation products is important?	Yes, very important	Yes, it's important for t communication and to t awareness of Portugue consumers	Yes, it could be interesting it has a good relationsh between the effort ar relevance of the label
Criteria and strategi implemented in t development process	Use of sustainable material Vegan products Recovery products at the end of life f refurbishing or recycling	Use of sustainable material Reuse and recycling materials Material selection accordi to the function	Use of vegan materials A sustainable and manu process Durability and high quality
The methodology applied the design and process	Ad-hoc environment thinking in the process. No systematic approa used in the process	Product is developed wi sustainable principle however without systematic approach	The products are develop with sustainabili considerations following the criteria and objectives of t company

Does the methodology used the company integrate a li cycle approach?	There are concerns about tl life cycle, but not in systematized way	Yes. But not in a ve systematic way	Not in a systematic way
Which phases of the Life cyc are considered	All (according to t interviewee)	All (according to t interviewee)	All (according to t interviewee)
Tools to support the proce known by the deviser/produ developer	None	None	None
Does the company app sustainability tools in t design process?	No	No	No
Identification of tools used the process	Not applicable	Not applicable	Not applicable
Reasons to not apply tools the development process	Lack of knowledge about t availability and potential these tools	Lack of knowledge abo tools by the designers and t the company	Lack of knowledge abo tools
Main motivations to develo sustainable and circul products?	Environmental awarene Personal goals to develop sustainable produc Concern about anim welfare and biodiversi New lifestyles	The company is high engaged in the developme of sustainable products. The main material used is sustainable material wi high potential.	The company and t designer is very engaged the development sustainable and vega products following the lo tradition of the company the development of leath products
Main barriers to t integration of sustainabili and circularity aspects in t development process?	Difficult collaboration wi suppliers In the subcontracting some parts and componer is difficult to enga suppliers Lack of trust in t suppliers In some cases, t recognition of sustainab materials is difficult or n perceived by the users La of consumers awareness Fashion is perceived main as handicraft and no industrial process Lack of long ter perspective by users	Cost. The material has higher cost and son consumers do not percei the benefits of the use of th material Lack of training of designe in sustainability too methodologies and process Data and releva information about t sustainability and circulari profile of materials that c be used in the design practi are not easily available designers	Awareness of the consum about the potential sustainability Higher cost of the material Availability of raw materia with good properties Higher cost of the producti

 ISBN: 978-84-09-16892-7

5. Conclusions

The research activities are being developed to understand how sustainable products are developed in Portugal and which are the main needs and barriers of the design professionals in adopting and implementing sustainability and circular economy measures in the design process. The research methodology foresees that this survey has a starting point in the identification and analysis of national products that are placed on the market as being sustainable and/or circular. From the products collected in a database created for the project, the team is analysing how companies are communicating the product profiles to consumers, how the information reaches the consumer, and how the products are developed in practice within the industry. Through direct contact with the professionals responsible for its development, it is intended to understand which are the real motivations and needs of the designers.

In the context of the analysis required, a questionnaire was developed as a guideline for the interviews and its structure reflects the data needed to understand how sustainable products are designed in Portugal. The majority of the questions are open questions, which usually promotes the discussion and exchange of ideas between the interviewer and the interviewee, which is a positive approach in this case because it not limits the perspective of the interviewees and allows a broader collection of useful data that need to be analysed and synthesized by the project team.

Based on pilot interviews carried out to test and validate the structure and the approach defined, and the examples and information included in the products database, a preliminary analysis can be performed. In this context, it is clear that all the professionals that are dealing in a daily basis with the development of sustainable and circular products are very much engaged and motivated to develop and place in the market innovative and efficient products that contribute for a reduction on the impact of the production, consumption and use of products. In most of the companies, when there is the goal of sustainability, the approach is extended to all products and activities and this is also reflected in the allegations that are used to promote the products and the companies. In general, the principles like use of recycled materials, reuse of products and materials, reduction of material and energy consumption, use of low impact materials and processes are the most common allegations, however, it was identified that, despite the fact that there are some life cycle aspects in the development process, the design practice and product development do not have a systematic life cycle approach. Which is also reflected in the absence of certified products in Portugal. Regarding certification, the general knowledge and perception about certifications and labels by the users are very low (Camocho 2019) and companies do not have in general the motivation to enrol in certification processes. The relation between the cost and the benefits of certification is very low and the majority of the companies tend to adopt self-declarations and allegations without any kind of verification and validation and, without any life cycle assessment and validation process.

Most products and services are placed in the market and promoted based on the assumptions of sustainability that result in some cases of the adoption of measures that have the potential to lead to sustainable or circular products, but, without a proper methodology, life cycle thinking and a verification procedure, these products and their allegations can be misleading for the consumer or even considered as greenwashing. A good example of this aspect is the generalized use of cork in Portugal. Cork is a very good and sustainable material but there is a general perception that all products made from cork are sustainable. Most of these products are placed in the market as sustainable products, however, in some cases that it's not true because there are other impacts related to other

aspects of the products that are not accounted.

Within the design and development process, the integration of sustainability and circularity aspects is applied based on a non-systematized approach related with personal knowledge and motivation and in most of the cases, the design practice does not have the support of proper methodologies and tools that help the professionals in integration of sustainability and circularity principles and criteria in all stages of the life cycle. Currently, there are several tools available that can support the design process, however, the designers and the companies are not aware of their availability and the benefits of their application.

Despite the efforts and wide promotion of circular economy and sustainability, there are still several barriers in the transition to circular economy and sustainability; the design professionals, in general, still don't have enough competences, knowledge and skills to integrate these aspects in an efficient way; the engagement of stakeholders in the value chain is difficult; the costs linked to the production of these products can also act as a barrier and the consumer awareness, which is increasing, is still marginal and related usually to niche markets.

An important consideration that was verified in the research is that the designers and companies that are in the market with the goals of sustainability and circular economy are highly engaged in the process, and despite all the barriers faced in their daily activities, these professionals want to have a role in this transition in the society with a long term perspective.

Based on the research project and the activities under development, the authors supported by mapping the maturity of the design practice for circular economy and sustainability and through the analysis of the practical experiences, motivations, barriers and needs of the design professionals which are dealing with the challenges of the process, will develop an updated methodology, guidelines, tools and other resources to support the design process for the circular economy.

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