DOUTORAMENTO EM
DESIGN

Faculdade de Design,
Tecnologia e Comunicação
Universidade Europeia

David João Geraldes Camocho

Transition to Circular and Sustainable Economy through Design: Annexes

Orientadores: Ana Margarida Ferreira & José Vicente

IADE - UE - FACULDADE DE DESIGN, TECNOLOGIA E COMUNICAÇÃO

Faculdade de Design, Tecnologia e Comunicação
Universidade Europeia

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David João Geraldes Camocho

Transition to Circular and Sustainable Economy through Design

Annexes

Tese apresentada ao IADE – Faculdade de Design, Tecnologia e Comunicação da Universidade Europeia, para cumprimento dos requisitos necessários à obtenção do grau de Doutor em Design realizada sob a orientação científica da Doutora Ana Margarida Ferreira, Professora Associada com Agregação do IADE – Universidade Europeia e do Doutor José Manuel Andrade Nunes Vicente, Professor Auxiliar da Escola de Artes – Universidade de Évora.

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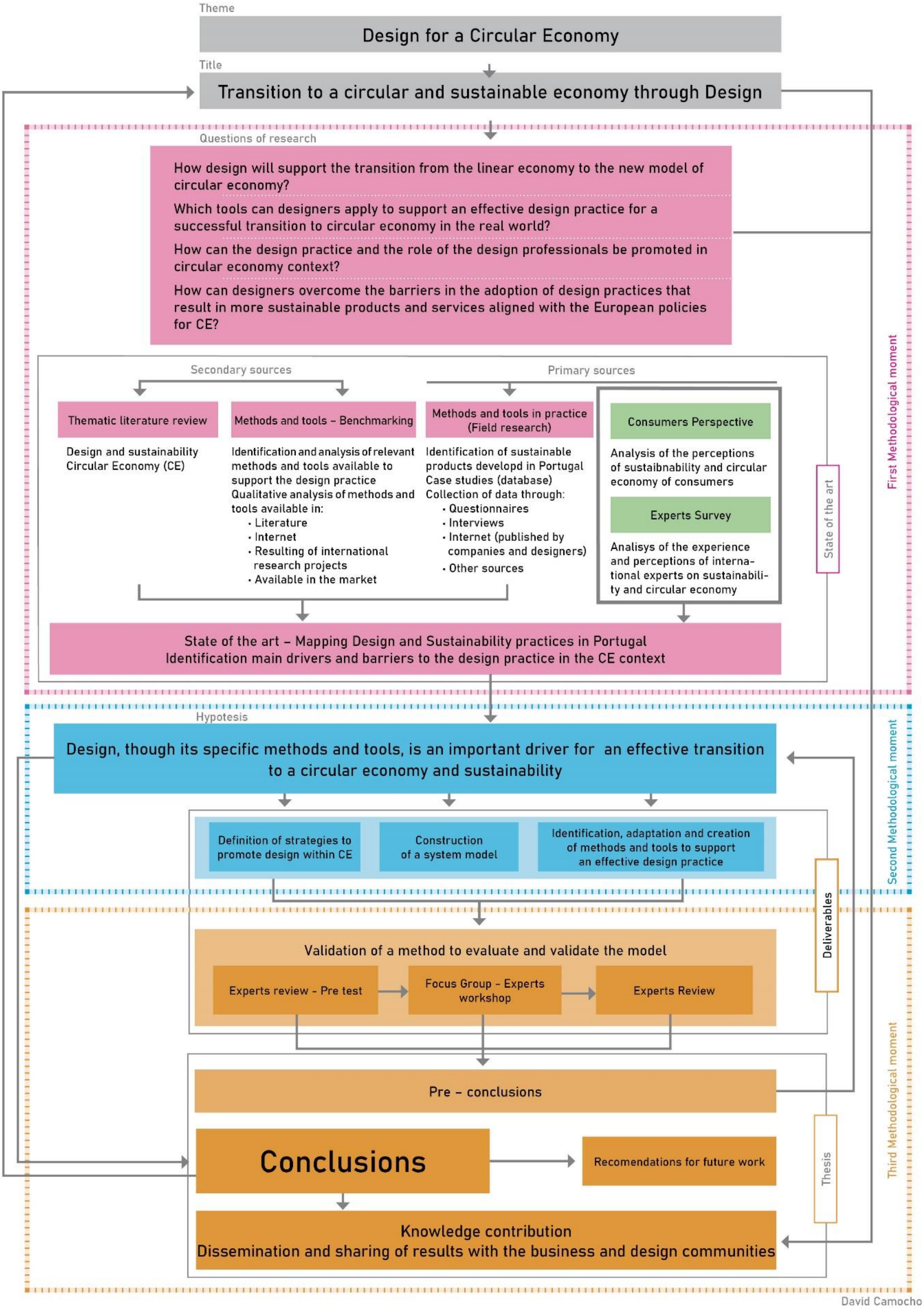
Annex 1 – Research Design


Theme
Design for a Circular Economy
Title
Transition to a circular and sustainable economy through Design
Questions of research
How design will support the transition from the linear economy to the new model of circular economy?
Which tools can designers apply to support an effective design practice for a successful transition to circular economy in the real world?
How can the design practice and the role of the design professionals be promoted in circular economy context?
How can designers overcome the barriers in the adoption of design practices that result in more sustainable products and services aligned with the European policies for CE?
Secondary sources
Primary sources
Thematic literature review
Design and sustainability
Circular Economy (CE)
Methods and tools – Benchmarking
Identification and analysis of relevant methods and tools available to support the design practice
Qualitative analysis of methods and tools available in:
• Literature
• Internet
• Resulting of international research projects
• Available in the market
Methods and tools in practice (Field research)
Identification of sustainable products developd in Portugal
Case studies (database)
Collection of data through:
• Questionnaires
• Interviews
• Internet (published by companies and designers)
• Other sources
Consumers Perspective
Analysis of the perceptions of sustaibnability and circular economy of consumers
Experts Survey
Analisys of the experience and perceptions of international experts on sustainability and circular economy
State of the art
State of the art – Mapping Design and Sustainability practices in Portugal
Identification main drivers and barriers to the design practice in the CE context
First Methodological moment
Hypotesis
Design, though its specific methods and tools, is an important driver for an effective transition to a circular economy and sustainability
Definition of strategies to promote design within CE
Construction of a system model
Identification, adaptation and creation of methods and tools to support an effective design practice
Second Methodological moment
Deliverables
Validation of a method to evaluate and validate the model
Experts review - Pre test
Focus Group - Experts workshop
Experts Review
Pre – conclusions
Conclusions
Recomendations for future work
Thesis
Knowledge contribution
Dissemination and sharing of results with the business and design communities
Third Methodological moment
David Camocho

Annex 2 – Questionnaire Designers Practice

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Questionário para Designers – Guião entrevista

OBJETIVO DO QUESTIONÁRIO

Este questionário faz parte da investigação no âmbito de uma Tese de Doutoramento em Design, em desenvolvimento no IADE – Universidade Europeia e tem como objetivo reunir informação que permita identificar a prática, motivações e barreiras do design sustentável, ecológico, circular, etc através da análise da perceção e da experiência dos designers e responsáveis pelo desenvolvimento de produtos de produção industrial criados e produzidos em Portugal.

Esta investigação deverá permitir a identificação de necessidades e requisitos para o desenvolvimento e colocação no mercado de produtos desenvolvidos com citérios de sustentabilidade e de economia circular e suportar o desenvolvimento de metodologias, ferramentas ou *guidelines* para o apoio à prática do design em Portugal.

CONFIDENCIALIDADE

Todas as informações prestadas no âmbito deste questionário serão utilizadas única e exclusivamente para fins académicos e serão tratadas de forma confidencial.

Todos os dados recolhidos serão usados e apresentados de forma agregada, não sendo possível reconhecer e/ou identificar os indivíduos ou empresas que participam neste estudo.

Autorização para registo de entrevista: Sim ☐ Não ☒ Ass: ______________________________

A QUEM SE DESTINA O QUESTIONÁRIO

O questionário destina-se a designers e responsáveis pelo desenvolvimento de produtos de produção industrial.

PREENCHIMENTO DO QUESTIONÁRIO

Neste questionário, não há respostas certas ou erradas. O importante é avaliar a perceção e experiência no desenvolvimento de produtos.

Obrigado pela sua colaboração.
Para qualquer questão ou sugestão, contacte através do email david.camocho@gmail.com

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Secção 1 – Dados gerais

01 Nome (facultativo): ___________

02 Atividade profissional: ____

03 Empresa: ____

04 Produto(s): ____

05 Na empresa, o desenvolvimento de produtos sustentáveis representa:

100% ☐ >75% ☒ >50% ☐ >25% ☐ <25% ☒

06 Dimensão da empresa:

Micro (<10) ☐ Pequena (<50) ☐ Média (<250) ☐ Grande (>250) ☐

Secção 2 – Critérios de sustentabilidade

07 Como categoriza o seu produto?

Ecológico ☐ Sustentável ☐ Circular ☐ Outro ☐ ______________________

08 Que alegações de sustentabilidade utiliza na comunicação do seu produto?

____
____
____
____
____

09 O produto tem alguma certificação ambiental?

Sim ☐ Não ☐

Se respondeu "Sim", por favor refira as certificações do produto.

____
____

Se respondeu "Não" indique qual a sua opinião relativamente à certificação do produto.

____
____
____
____

Secção 3 – Desenvolvimento do produto

10 Que critérios ou estratégias foram implementadas no produto desenvolvido?

____
____
____
____

11 Qual a metodologia aplicada no desenvolvimento do produto?

____
____
____
____

12 A metodologia integra uma abordagem de ciclo de vida?

Sim ☐ Não ☐

13 Que fases do ciclo de vida são consideradas no desenvolvimento do produto?

____
____
____

14 Que ferramentas de apoio ao desenvolvimento de produtos sustentáveis conhece?

____
____
____

15 No processo de design aplica ferramentas de sustentabilidade?

Sim ☐ Não ☐

Se respondeu "Sim" Que ferramentas efetivamente são aplicadas no processo de desenvolvimento?

____
____
____
____

Se respondeu “Não”, qual a razão para não aplicar ferramentas de sustentabilidade no processo?

16 Quais são as motivações para o desenvolvimento de produtos mais sustentáveis?

17 Quais são as principais barreiras à integração de considerações de sustentabilidade no desenvolvimento de produtos?

18 – Observações

Neste campo pode colocar observações que considere relevantes para o desenvolvimento da investigação

19 – Outras questões

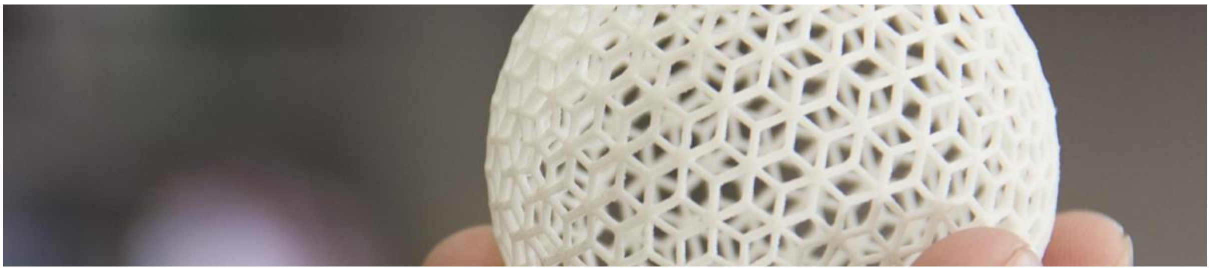
Lembra-se de alguma questão que deveria ter sido colocada no âmbito deste trabalho?

19 – Acompanhamento da investigação.

Se tiver interesse em acompanhar o desenvolvimento da investigação, insira o seu email no campo seguinte.

Muito obrigado pela sua colaboração

Annex 3a – Questionnaire international experts Survey – Paper version



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Transition to circular and sustainable economy through design

International experts review - Survey

This questionnaire is part of a research project within the scope of a Doctoral Thesis in Design under development at IADE - European University in Portugal and aims to collect the views and perceptions of a group of international experts on the fields of circular economy, sustainability and design.

The collected information will allow the identification of an international overview of the practice, motivations and barriers in the transition to circular economy through design, and will support the research and development of methods, tools and guidelines to promote an improved design practice.

david.camocho@gmail.com (not shared) Switch account

Filling in the questionnaire

In this questionnaire, there are no right or wrong answers. The importance is to identify and explore the perceptions and experiences related to the circular economy, sustainability and design.

It will take you around 10 minutes to complete the survey.

Thank you in advance for your cooperation!

Consent to process personal data

By agreeing to participate in this survey you give your consent to have your relevant data collected and processed by the authors for the purpose of the current PhD research project.

Your answers to this survey will be treated and presented in aggregated form and it will not be possible to recognize and/or identify the answers and opinions expressed in the questionnaire

Next

Clear form

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Transition to circular and sustainable economy through design

International experts review - Survey

david.camocho@gmail.com (not shared) Switch account

* Required

Section 1 – General data

01 - Name

Your answer

02 - Institution/afilliation

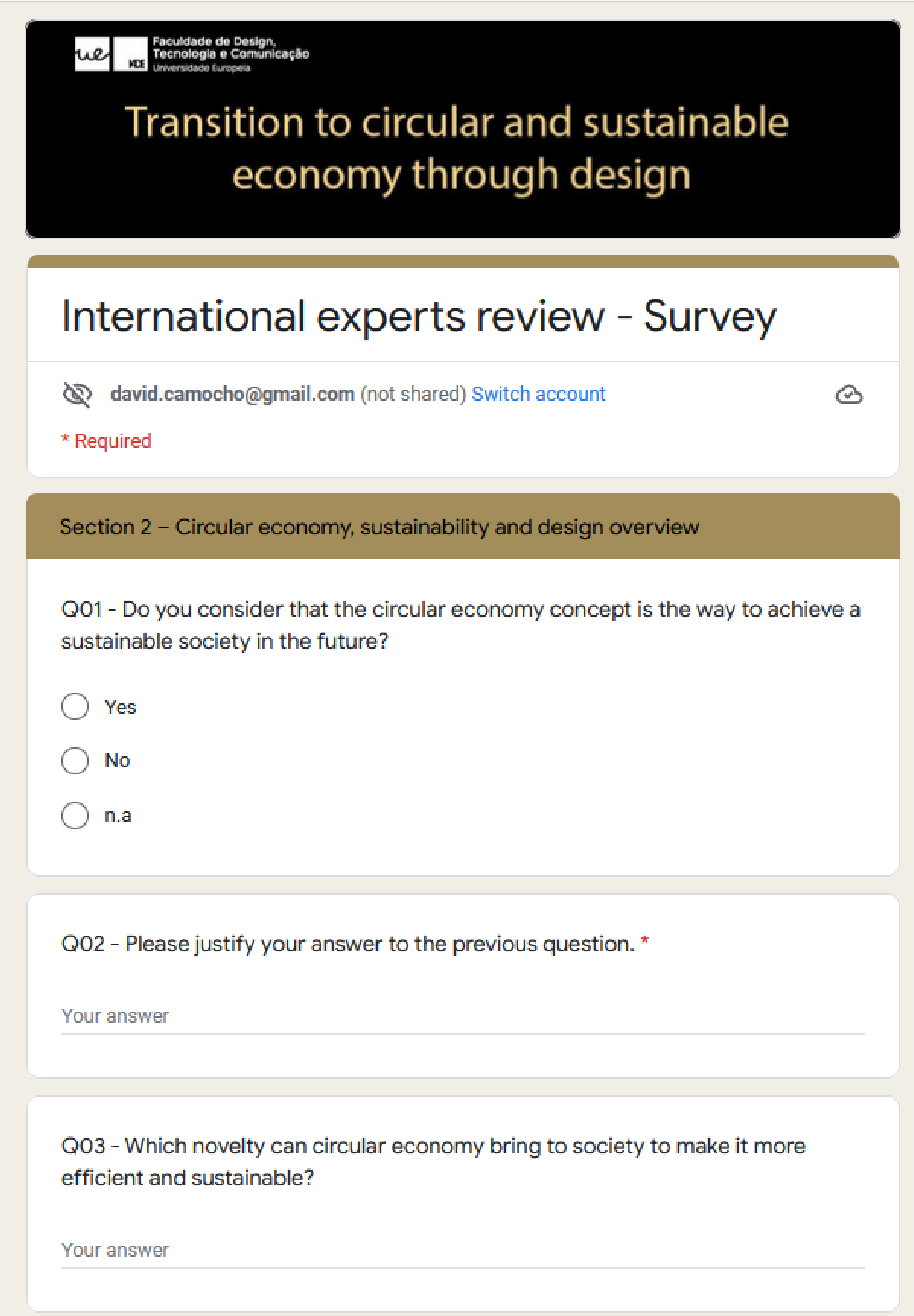
Your answer

03 - Country

Your answer

04 - Expert profile *

- Academia
- Research
- Business
- Public authority
- Other:



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Transition to circular and sustainable economy through design

International experts review - Survey

david.camocho@gmail.com (not shared) Switch account

* Required

Section 2 – Circular economy, sustainability and design overview

Q01 - Do you consider that the circular economy concept is the way to achieve a sustainable society in the future?

- Yes
- No
- n.a

Q02 - Please justify your answer to the previous question. *

Your answer

Q03 - Which novelty can circular economy bring to society to make it more efficient and sustainable?

Your answer

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Transition to circular and sustainable economy through design

International experts review - Survey

david.camocho@gmail.com (not shared) Switch account

* Required

Section 2 – Circular economy, sustainability and design overview

Q01 - Do you consider that the circular economy concept is the way to achieve a sustainable society in the future?

- ◯ Yes
- ◯ No
- ◯ n.a

Q02 - Please justify your answer to the previous question. *

Your answer

Q03 - Which novelty can circular economy bring to society to make it more efficient and sustainable?

Your answer

Q04- In your opinion and experience, which are the main drivers and motivation to adopt circular economy in practice?

Your answer

Q05 - Which are the main barriers to implement circular economy in practice?

Your answer

Q06 - How should we overcome the current obstacles and promote the design practice towards innovative and sustainable solutions?

Your answer

Q07 – In your perspective, what are we doing wrong in translating the circular economy approach in practice?

Your answer

Q08 - Do you have other ideas, comments or suggestions on how to promote an effective design practice towards circular economy, sustainability and innovation?

Your answer

Back Submit Clear form

Never submit passwords through Google Forms.

Annex 3b – Questionnaire international experts Survey – Online

Faculdade de Design, Tecnologia e Comunicação
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International experts review - Survey

Purpose of the survey

This questionnaire is part of a research project within the scope of a Doctoral Thesis in Design under development at IADE - European University in Portugal and aims to collect the views and perceptions of a group of international experts on the fields of circular economy, sustainability and design.

The collected information will allow the identification of an international overview of the practice, motivations and barriers in the transition to circular economy through design, and will support the research and development of methods, tools and guidelines to promote an improved design practice.

Consent to process personal data

By agreeing to participate in this survey you give your consent to have your relevant personal data collected and processed by the authors for the purpose of the current PhD research project.

Your answers to this survey, including any personal data collected, will be treated and presented in aggregated form and it will not be possible to recognize and/or identify the answers and opinions expressed in the questionnaire.

For whom the questionnaire is intended

The questionnaire is intended for international experts in the field of Circular economy, sustainability and design.

Filling in the questionnaire

In this questionnaire, there are no right or wrong answers. The importance is to identify and explore the perceptions and experiences related to the circular economy, sustainability and design.

It will take you around 10 minutes to complete the survey.

Thank you in advance for your cooperation!

For any questions or suggestions, please contact via email to: david.camocho@gmail.com

Section 1 – General data

01 Name: ____

02 Institution/affiliation : ____

03 Country: ____

04 Expert profile:

Academia ☐ Research ☐ Business ☐ Public Authority ☐ Other ☐ ______________

Section 2 – Circular economy and design overview

Q01- Do you consider that the circular economy concept, methodologies and tools are the means to achieve a sustainable society in the future?

Yes ☐ No ☐ n.a ☐

Q02 - Please justify your answer.

____

____

____

Q03 - Which novelty can circular economy bring to society to make it more efficient and sustainable?

____

____

Q04- In your opinion and experience, which are the main drivers and motivation to adopt circular economy in practice?

____

____

Q05 - Which are the main barriers to implement circular economy in practice?

____

____

____

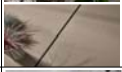
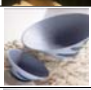
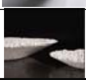
Q07 - How should we overcome the current obstacles and promote the design practice towards innovative and sustainable solutions?

Q08 – In your perspective, what are we doing wrong in translating the circular economy approach in practice?

Q09 - Do you have other ideas, comments or suggestions on how to promote an effective design practice towards circular economy, sustainability and innovation?

Thank you for your cooperation!

Annex 4 – Products database_structure and examples

backgrounf information								product/company information		Development		
product name	image	discription	company	source	designer/responsável desenvolvimento	Contacto	sector	alegations of sustainability	certifications	criteria/type of strategy implemented	methodology applied	tools applied
Ecotiles Revigres - Saturno - Ecompact - Ecotech - Ecompact Estruturado		Gama de paviementos eco	Revigres	http://revigres.pt/wp-content/uploads/2018/02/CAT_REVIGRES_ESSENTIALS_2018.pdf			Cerâmica	A valorização de 99,54% dos resíduos do processo e sua incorporação na produção; • A opção pelo ECODESIGN: um plano e processo produtivo mais eficiente que permite uma redução nos impactos ambientais; • A reutilização da totalidade das águas residuais industriais; • A gestão das emissões de CO2 e implementação de medidas para a sua redução; • A utilização de matérias-primas inertes e consequente redução de resíduos perigosos; • A implementação de um plano de racionalização energética dos processos e equipamentos; • A utilização de embalagens recicladas na sua totalidade e paletes tratadas	BREEAM E LEED e EPD Ciclo de Vida (pré-produção, produção, e pós-produção) e devidamente validadas por uma entidade independente e internacional: o sistema IBU da organização alemã The Institut Bauen und Umwelt e.V.	ecodesign		
Reviconfort		Pavimento desmontável reutilizável e aplicado sem colas	Revigres	http://eco.nomia.pt/pt/exemplos/385-revigres			Cerâmica	Não necessita de colas, nem de cimentos, nem de mão-de-obra especializada e pode ser imediatamente utilizado após aplicação		ecodesign		
NAZ-		Roupa Sustentávels	NAZ	https://naz.pt	Cristiana Costa	wecare@naz.pt	Textil	A Näz é uma marca de moda sustentável que é inspirada no quotidiano das mulheres modernas,		ecodesign		
EPAL Fill Forever		Garrafa PET reutilizável	EPAL	https://www.epal.pt/EPAL/docs/default-source/produtos-e-servi%C3%A7os/site_fillforever.pdf?sfvrsn=8			Aguas	garrafa 100% nacional, inovadora, elegante, discreta, reutilizável, ecológica, ultra leve e funcional O gargalo e a tampa foram optimizados com uma redução de cerca de 40% do material Pesa somente 27.5g, é de material 100% reciclável e permite utilizar um processo de produção com um consumo de energia muito baixo				
SunCook		Forno Solar	SUNOK	https://planetiers.com/collections/mercado-online-sustentavel-todos-os-produtos/products/forno-solar-suntaste	Nuno Martins	nom@sunok.eu		Forno a energia solar produzido com cortiça				
Jindo Burel		Tenis sutentáveis	Berg	http://eco.nomia.pt/pt/exemplos/berg-burel			Texti e calçado	Ténis 100% nacionais e 100% recicláveis. produção é feita com materiais exclusivamente portugueses, com uma preocupação ecológica de forma a garantir que todos os materiais são recicláveis. Feitos de cortiça e burel, os ténis Jindo Burel são 100% recicláveis, desde do forro em pele até aos atacadores de algodão. O próximo passo, segundo os criadores, é considerar e estudar a hipótese de devolução das sapatilhas aquando do seu fim de uso por parte do utilizador. Desta forma, os designers ganham informação importante acerca do desgaste dos materiais, e ainda podem proceder ao seu reaproveitamento para outros produtos.	Em 2017 esta inovação foi premiada na feira internacional alemã dedicada ao desporto IPSO Munique na categoria de inovação em Outdoor – Footwear Lifestyle,			
MO.CA		Mobiliario em cartão	MOCA	http://eco.nomia.pt/pt/exemplos/moca			Mobiliário	onstrução de mobiliário de interior, sustentável, inspirado nos princípios de construção da Lego, modulares, práticos, mas resistentes e principalmente amigos do ambiente. Utilizando como matéria-prima desperdícios de cartão (recolhidos em indústrias e empresas) este é um exemplo de upcycling de materiais que, de outra forma, teriam como destino a reciclagem.		Valorização de subprodutos e resíduos , Extensão do ciclo de vida: reutilização, remanufatura, recondicionamento		
Garbags		produtos da Garbags são feitos a partir de resíduos	Garbags	http://eco.nomia.pt/pt/exemplos/garbags			Moda	Os produtos da Garbags são feitos a partir de resíduos das mais heterogéneas proveniências desde embalagens de café, de alimentos para animais, de leite, batatas fritas, sumo, escovas de dentes, revista		Extensão do ciclo de vida: reutilização, remanufatura, recondicionamento , Valorização de subprodutos e resíduos		
CUSCUZ		òculos de sol de madeira		http://www.cuscuzdesign.com	Ana mendes	HELLO@CUSCUZDESIGN.COM +351 915 233 65	acessórios moda	CUSCUZ is a sustainable fashion accessory and design brand. Handmade sunglasses with natural, long-lasting upcycled materials. Design a better tomorrow.		Social design Sustainability Slow design Upcycling		
Atitude		Peças de cerâmica decorativas desenvolvidad para o consurso Remade in Portugal 2007	SPAL	https://www.spal.pt/index.php/design-spal/ecodesign	Spal Studio		Cerâmica	Conjunto de peças decorativas produzidas apartir do reaproveitamento de lamas da ETARI da fabrica. O material é composto por porcelana, gesso e vidrados, e a textura interior é feita manualmente com compressão de plático de bolhas				
RESTART		Peças de cerâmica decorativas desenvolvidad para o consurso Remade in Portugal 2008	SPAL	https://www.spal.pt/index.php/design-spal/ecodesign	Spal Studio		Cerâmica	Produto decorativo produzido a partir de reaproveitamento de peças moídas ecom a adição de resina epoxy.				
PARTICLES		Peças de cerâmica decorativas desenvolvidad para o consurso Remade in Portugal 2009	SPAL	https://www.spal.pt/index.php/design-spal/ecodesign	Spal Studio		Cerâmica	Peças decorativas produzidas aprtir do refugo da produção moído ligado por fritas incolores				
WAKE		Peças de cerâmica decorativas desenvolvidad para o consurso Remade in Portugal 2010	SPAL	https://www.spal.pt/index.php/design-spal/ecodesign	Spal Studio		Cerâmica	Peças decorativas obtidas atraveés do reaproveitamento de peças moídas com adição de resina e corante				
UNICA		Peças de cerâmica decorativas desenvolvidad para o consurso Remade in Portugal 2010	SPAL	https://www.spal.pt/index.php/design-spal/ecodesign	Spal Studio		Cerâmica	Conjunto de peças decorativas produzidas apartir do reaproveitamento de lamas da ETARI da fabrica. O material é composto por porcelana, gesso e vidrados. A peças são ainda vidradas exteriormente para permitir uso alimentar				
REMADE2.0		Peças de cerâmica decorativas desenvolvidad para o consurso Remade in Portugal 2012	SPAL	https://www.spal.pt/index.php/design-spal/ecodesign	Spal Studio		Cerâmica	Produto decorativo produzido a partir de reaproveitamento de peças moídas ecom a adição de resina epoxy.				
Laura Bag		Malas e acessórios Vegan	AnTÓNIO	www.antonio-handmadestory.com	Ana e Sara Mateus	customer@antonio-handmadestory.com	Moda	brand with a clean and sustainable design handcrafter's process, focused on each detail, and assuring the quality work with a vegetable tanned leather and nickel free accessories, which assure a product in harmony with our environment as well as a new consumption conscience versatile, elegant and timeless, under an ethical and sustainable philosophy				
Balluta shoes		Luxurious footwear	Balluta	https://balluta-shoes.com/about-us/	Catarina Pedroso		Moda	técnicas tradicionais e materiais ecológicos couro vegan– feito de poliamida reciclada – e entrançado à mão ou os saltos feitos de cortiça revestida a folha de madeira. shoes are made from high-quality sustainable materials - animal-free				
MURICEA		Calçado produzido a partir de platico reciclado do Oceano	ZOURI	https://www.zouri-shoes.com/		info@zouri-shoes.com	Calçado	Sustainable sneakers crafted in 100% eco-vegan materials and with plastic from the Ocean. Upper and lining made with Organic Cotton (Gots and Fair Trade certified), a natural rubber outsole with plastic trash from the ocean and EVA midsole with 15% recycled material Each pair reuses the equivalent to 6 bottles of plastic from the Ocean. These series collected in Esposende, Portugal.				
Delta Q		~C]apsula café 100% organixa e biodegradável	Delta Q	https://www.noticiasaominuto.com/economia/1253275/sustentabilidade-delta-q-apresenta-capsula-de-cafe-	centro de inovação do Grupo Nabeiro, a Diverge		Alimentas	BioPBS, ou seja, de um material de base biológica e vegetal, constituído por cana-de-açúcar, mandioca e milho. É uma cápsula com 0% plásticos, 0% micro-plásticos e 0% alumínio.	Rainforest Alliance; UTZ; Green leaf			
película biodegradável		película biodegradável	Silvex	https://www.silvex.pt/pt/fleximagination/case-studies_24.html		fleximagination@silvex.pt	Alimentar	película aderente 100% biodegradável e compostável fabricada com matéria-prima designada Mater-Bi®, um material com origem em recursos renováveis, de origem agrícola europeia, sem organismos geneticamente modificados e polímeros biodegradáveis. Para além de permitir reduzir a emissão de CO2, ao usar esta matéria-prima, é possível reduzir o consumo de energia e de recursos não renováveis (derivados de petróleo).				
Ruby water blue		eco-luxury fashion	Najha	https://najha.com/	Daniela Sá	najhafashionbags@gmail.com 22 099 1569	Moda	eco-luxury fashion brand with vegan concept which main material is cork, which range of products that goes from bags, shoes, accessories and clothing. Alongside with all fashion and vegan concept part of the brand, there is a strong connection with our environmental impact. Cork as sustainable material and its recycling potentiality. So at the end life of the product you can return it for recycling you earn a 10% discount coupon for your next Najha and the product gains a new life, transformed in granulated cork for home designs.				

Rutz Shoes		Eco freindly shoes	Rutz	https://rutz.pt		Rutz LX Factory Store Rua Rodrigues Faria, 103 Ed. I, 0.01D Loja 3 1300-501 Lisboa Phone: (+351) 210 966 422 | 915 067 849 E-Mail: rutz@rutz.pt	Calçado	the eco-friendly choice of material and the concern with lightness and comfort				
Joplins		wooden sunglasses, bamboo sunglasses and vegetal acetate sunglasses	Joplins	www.wearjoplins.com				ECO-FRIENDLY , SUSTAINABLE , HANDMADE Joplins' main purpose is to promote a healthier and more ecologically sustainable lifestyle. For this we have created frames made of sustainable materials such as bamboo, recycled wood, recycled wood with cotton and vegetal acetate.				
Escovas Babu		Escovas de dentes	Babu	http://www.babueco.com		Zona industrial lote 11 2550-171 Cadaval, Portugal info@babueco.com	Higiene	produtos já utilizados por nós mas fabricados com materiais que não coloquem em causa a biodiversidade e preservação do ecossistema. BIODEGRADÁVEL - O bambu é totalmente biodegradável, ao contrário das tradicionais que demoram mais de 400 anos anos a decompor-se! Para além de amigo do ambiente, está a utilizar um produto vindo da natureza.				
Furnitue and acessories		furniture and accessories for the home	Ghome	www.ghome.pt		email ghome@ghome.pt phone +351 211 351 676	Mobiliário e decoração	As a brand it will claim to itself the right to intervene on the very basis of the pyramid – together with others on the level of decision making, actively contributing to responsible forms of production and consequently be of help towards a more responsible consumption.				
IKIMOBILE		smartphones e acessórios	IKIMOBILE	https://ikimobile.com		Rua Gaivotas em Terra nº 2 - S4 Parque das Nações 1990-196, Lisboa - Portugal info@ikimobile.com		A ikimobile acredita que é necessário desenvolver a sustentabilidade a nível global sendo necessário garantir harmonia com o que a rodeia defendendo valores como responsabilidade, respeito pela comunidade onde está inserida e com todos aqueles com que lida diariamente. Pesquisa constante de no desenvolvimento de energias limpas; Redução dos resíduos criados resultantes da actividade da empresa; Reciclagem e recolha selectiva dos resíduos; Elaboração de projetos que visam o uso sustentável de água e energia eléctrica e ainda consumos responsáveis com o objectivo de diminuir o impacto da sua actividade no meio ambiente; Planos de consciencialização junto de colaboradores, clientes, fornecedores e parceiros para que se transformem atitudes sustentáveis em permanentes; Consciencialização junto da comunidade para despertar a utilização de comportamentos amigos do ambiente; Participação em projectos da sociedade de responsabilidade social e ambiental.				
BOA SAFRA		Moliliário	Boa Safra	https://boasafra.pt		917 469 078	Mobiliário	The pieces are conceived by Portuguese designers and made locally, with time and dedication. Boa Safra products are defined by aesthetic simplicity, timeless design and the use of both natural materials and finishes. At Boa Safra headquarters we are developing a pole for sustainable living that we call ECO LIFE DESIGN. We have several parteners and projects going on with practical proposals of local impact for the development of a more sustainable life.				
UM-Renovar		Conjunto de telhas e acessório sustentáveis	UMBELINO MONTEIRO	https://www.csustentavel.com/um-renovar/ http://www.umbelino.pt			Construção	solução UM-Renovar, uma solução fácil, completa e integrada para a renovação de telhados, que resulta da combinação de três produtos com a assinatura Umbelino Monteiro: telhas cerâmicas, placas de fibrocimento e telhas fotovoltaicas.				
argila expandida Argex		AGREGADO ECOLÓGICO	Argex	www.argex.pt		argex@argex.pt Zona Industrial de Bustos, Azurveira 3770-011 Bustos - Portugal	Construção	Este produto 100% natural não sobrecarrega a estrutura, ajuda a regular ahumidade e melhora a eficiência térmica e acústica dos edifícios, o que permite uma redução dos consumos energéticos. Oferece ainda, uma proteção natural ao sistema e aumenta a vida útil dos materiais utilizados na impermeabilização e isolamento. ARGEX® é um produto natural, ecológico, duradouro, incombustível e inerte, não se decompõe ou apodrece é leve e capaz de armazenar uma determinada quantidade de humidade, que vai libertando lentamente.				
DOOP				https://www.indiegogo.com/projects/doop-toothbrush#/		Pedro Alves https://www.linkedin.com/in/pedro-alves-a8b3423b/		Made from recycled plastics, and with removable heads: Doop is the last toothbrush you'll ever buy.				

Annex 5a – Questionnaire consumers perceptions – Online version

Questionário PhD - Perceção dos consumidores sobre aspetos de Sustentabilidade nos produtos

Este questionário faz parte da investigação no âmbito de uma Tese de Doutoramento em Design em desenvolvimento no IADE – Universidade Europeia e tem como objetivo reunir informação que permita estudar a perceção dos consumidores sobre o perfil de sustentabilidade dos produtos colocados no mercado e a comunicação veiculada pelos produtores/vendedores.

Esta investigação deverá permitir a identificação dos benefícios e requisitos para uma comunicação eficaz do perfil de sustentabilidade e como os produtos desenvolvidos com critérios de sustentabilidade e de economia circular devem ser comunicados e colocados no mercado

Todas as informações prestadas no âmbito deste questionário serão utilizadas única e exclusivamente para fins académicos e serão tratadas de forma confidencial.

Todos os dados recolhidos serão usados apenas para fins estatísticos e apresentados de forma agregada, não sendo possível reconhecer e/ou identificar os indivíduos ou empresas que participam neste estudo.

O questionário deve ser preenchido por indivíduos/consumidores em geral, com e sem, conhecimentos e hábitos de consumo mais sustentáveis.

PREENCHIMENTO DO QUESTIONÁRIO
Neste questionário, não há respostas certas ou erradas. O importante é avaliar a perceção e experiência individual.

Este questionário foi concebido para ser preenchido de forma simples e breve. O seu preenchimento deverá demorar cerca de 5 minutos.

Obrigado pela sua colaboração.
Qualquer questão, contacte através do email david.camocho@gmail.com

david.camocho@gmail.com (not shared) Switch account

00 - Nome (Opcional)

Your answer

01- Idade

Your answer

02 - Sexo

- ◯ Masculino
- ◯ Feminino

03 - Habilitações literárias

- ◯ Inferior a 12º Ano
- ◯ 12º Ano
- ◯ Licenciatura
- ◯ Mestrado ou superior
- ◯ Other: ____

04 - Atividade profissional

Your answer

05 - Indique o seu nível de conhecimento nas seguintes áreas

	Não sei o que é	Já ouvi falar	Sei o que é - Noções básicas	Conhecimento elevado	Especialista na área
Design	○	○	○	○	○
Ecodesign	○	○	○	○	○
Sustentabilidade	○	○	○	○	○
Economia Circular	○	○	○	○	○

06 - Considera ter uma atitude sustentável no seu dia-a-dia?

○ Sim

○ Não

07 - Atitudes e práticas de sustentabilidade

	Não aplica	Medidas pontuais	Aplicação moderada	Aplicação regular	Nível elevado de aplicação
Separação de resíduos para reciclagem	○	○	○	○	○
Medidas para poupança de água	○	○	○	○	○
Medidas para poupança de energia	○	○	○	○	○
Compra de produtos alimentares biológicos	○	○	○	○	○
Compra de produtos mais sustentáveis/ecológicos	○	○	○	○	○

08 - Qual a influência de fatores ecológicos e de sustentabilidade na aquisição dos seguintes tipos de produtos:

	Nenhuma influencia	Baixa	Moderada	Elevado	Nível muito elevado de influência
Produtos alimentares	○	○	○	○	○
Detergentes e produtos de limpeza	○	○	○	○	○
Eletrodomésticos	○	○	○	○	○
Mobiliário	○	○	○	○	○
Veículos	○	○	○	○	○
Produtos de decoração	○	○	○	○	○
Brinquedos	○	○	○	○	○
Têxtil, vestuário e acessórios	○	○	○	○	○
Utilitários do dia-a-dia	○	○	○	○	○

09: A presença de rótulos e certificação ambiental na comunicação do produto tem influencia na sua decisão de compra?

- ○ Sim
- ○ Não
- ○ Nunca tinha pensado no assunto

10 - Qual o seu nível de confiança nas alegações de sustentabilidade comunicadas nos produtos?

- ◯ Não confia
- ◯ Baixo nível de confiança
- ◯ Nível médio de confiança
- ◯ Alta confiança
- ◯ Total confiança

A B C D E

11 - Conhece os seguintes elementos de rotulagem/comunicação da imagem anterior?

	Não conheço	Reconheço a imagem, mas não sei o que significa	Conheço a imagem e sei o seu significado
Imagem A	◯	◯	◯
Imagem B	◯	◯	◯
Imagem C	◯	◯	◯
Imagem D	◯	◯	◯
Imagem E	◯	◯	◯

11 b - Conhece os seguintes elementos de rotulagem/comunicação da imagem anterior?

	Não conheço	Reconheço a imagem, mas não sei o que significa	Conheço a imagem e sei o seu significado
Imagem F	○	○	○
Imagem G	○	○	○
Imagem H	○	○	○
Imagem I	○	○	○
Imagem J	○	○	○

12 - No exemplo seguinte são apresentados 3 produtos para beber café. Indique qual a sua perceção relativamente ao perfil de sustentabilidade destes produtos. Qual considera o mais ecológico e qual considera menos ecológico/Sustentável?

Indique qual o produto MAIS e MENOS ecológico/sustentável

	Copo de papel	Copo de plástico (Poliestireno expandido)	Chávena de cerâmica
MAIS ecológico/sustentável	◯	◯	◯
MENOS ecológico/Sustentável	◯	◯	◯

13 - Na figura seguinte são apresentadas 6 imagens de lápis de carvão. Por favor, com base a sua percepção ordene os lápis de acordo com o seu perfil ecológico/sustentabilidade

1
2
3
4
5
6

Por favor indique a ordem, do mais ecológico para o menos ecológico

Your answer

Por favor indique a ordem, do mais ecológico para o menos ecológico

Your answer

14 – Observações

Neste campo pode colocar observações que considere relevantes para o desenvolvimento da investigação

Your answer

15 – Acompanhamento da investigação.

Se tiver interesse em acompanhar o desenvolvimento da investigação, insira o seu email no campo seguinte.

Your answer

Submit **Clear form**

Never submit passwords through Google Forms.

Annex 5b – Questionnaire consumers perceptions – Paper version

QUESTIONÁRIO

OBJETIVO DO QUESTIONÁRIO

Este questionário faz parte da investigação no âmbito de uma Tese de Doutoramento em Design, em desenvolvimento no IADE – Universidade Europeia e tem como objetivo reunir informação que permita estudar a perceção dos consumidores sobre o perfil de sustentabilidade dos produtos colocados no mercado e a comunicação veiculada pelos produtores/vendedores.

Esta investigação deverá permitir a identificação dos benefícios e requisitos para uma comunicação eficaz do perfil de sustentabilidade e como os produtos desenvolvidos com citérios de sustentabilidade e de economia circular devem ser comunicados e colocados no mercado.

CONFIDENCIALIDADE

Todas as informações prestadas no âmbito deste questionário serão utilizadas única e exclusivamente para fins académicos e serão tratadas de forma confidencial.

Todos os dados recolhidos serão usados apenas para fins estatísticos e apresentados de forma agregada, não sendo possível reconhecer e/ou identificar os indivíduos ou empresas que participam neste estudo.

A QUEM SE DESTINA O QUESTIONÁRIO

O questionário deve ser preenchido por indivíduos/consumidores em geral com e sem conhecimentos e hábitos de consumo mais sustentáveis.

PREENCHIMENTO DO QUESTIONÁRIO

1. Neste questionário, não há respostas certas ou erradas. O importante é avaliar a perceção e experiência individual.
2. O questionário está estruturado em 5 secções:
   - Secção 1 – Dados gerais sobre o inquirido
   - Secção 2 – Conhecimentos gerais
   - Secção 3 – Hábitos de consumos e influencia da rotulagem ambiental
   - Secção 4 – Perceção do perfil de sustentabilidade dos produtos
   - Secção 5 – Observações e acompanhamento do projeto
3. Este questionário foi concebido para ser preenchido de forma simples e breve. O seu preenchimento deverá demorar cerca de 10 minutos.

Obrigado pela sua colaboração.

Qualquer questão, contacte através do email david.camocho@gmail.com

SECÇÃO 1 – DADOS GERAIS

01 Idade: ___________

02 Sexo: Masculino [ ] Feminino [ ]

03 Habilitações literárias:
Inferior a 12º ano [ ] 12º ano [ ] Licenciatura [ ] Mestrado ou superior [ ] Outro [ ] ____________________

04 Atividade profissional: ____

SECÇÃO 2 – CONHECIMENTOS GERAIS

05 **Indique o seu nível de conhecimento nas seguintes áreas:**

	1 Não sei o que é	2 Já ouvi falar	3 Sei o que é – Noções básicas	4 Conhecimento elevado	5 Especialista na área
Design	○	○	○	○	○
Ecodesign	○	○	○	○	○
Sustentabilidade	○	○	○	○	○
Economia circular	○	○	○	○	○

SECÇÃO 3 – HÁBITOS DE CONSUMOS E INFLUÊNCIA DA ROTULAGEM AMBIENTAL

06 Considera ter uma atitude sustentável no seu dia-a-dia?

Sim [ ] Não [ ]

07 Atitudes e práticas de sustentabilidade

	1 Não aplica	2 Medidas pontuais	3 Aplicação moderada	4 Aplicação regular	5 Aplicação elevada
Separação de resíduos para reciclagem	○	○	○	○	○
Medidas para poupança de água	○	○	○	○	○
Medidas para poupança de energia	○	○	○	○	○
Compra de produtos alimentares biológicos	○	○	○	○	○
Compra de produtos mais sustentáveis /ecológicos	○	○	○	○	○

08 Qual a influência de fatores ecológicos e de sustentabilidade na aquisição dos seguintes tipos de produtos:

	1 Nenhuma influência	2 Baixa	3 Moderada	4 Elevada	5 Muito elevada
Produtos alimentares	○	○	○	○	○
Detergentes e produtos de limpeza	○	○	○	○	○
Eletrodomésticos	○	○	○	○	○
Mobiliário	○	○	○	○	○
Veículos	○	○	○	○	○
Produtos de decoração	○	○	○	○	○
Brinquedos	○	○	○	○	○
Têxtil, vestuário e acessórios	○	○	○	○	○
Utilitários do dia-a-dia	○	○	○	○	○
Outros: (especifique) ____________________	○	○	○	○	○

09 **A presença de rótulos e certificação ambiental na comunicação do produto tem influencia na sua decisão de compra?**

Sim [ ]   Não [ ]   Nunca tinha pensado no assunto [ ]

10 **Qual o seu nível de confiança nas alegações de sustentabilidade comunicadas nos produtos?**

Não confia [ ]   Baixo nível de confiança [ ]   Nível médio de confiança [ ]   Alta confiança [ ]   Total confiança [ ]

11 **Conhece os seguintes elementos de rotulagem/comunicação?**

1 Não conheço	○	○	○	○	○
2 Reconheço a imagem mas não sei o que significa	○	○	○	○	○
3 Conheço e sei o seu significado	○	○	○	○	○

1 Não conheço	○	○	○	○	○
2 Reconheço a imagem mas não sei o que significa	○	○	○	○	○
3 Conheço e sei o seu significado	○	○	○	○	○

SECÇÃO 4 – PERCEÇÃO DO PERFIL DE SUSTENTABILIDADE DOS PRODUTOS

12 No exemplo seguinte são apresentados 3 produtos para beber café. Indique qual a sua perceção relativamente ao perfil de sustentabilidade destes produtos. **Qual considera o mais ecológico e qual considera menos ecológico?** (1 – mais ecológico, 3 – menos ecológico)

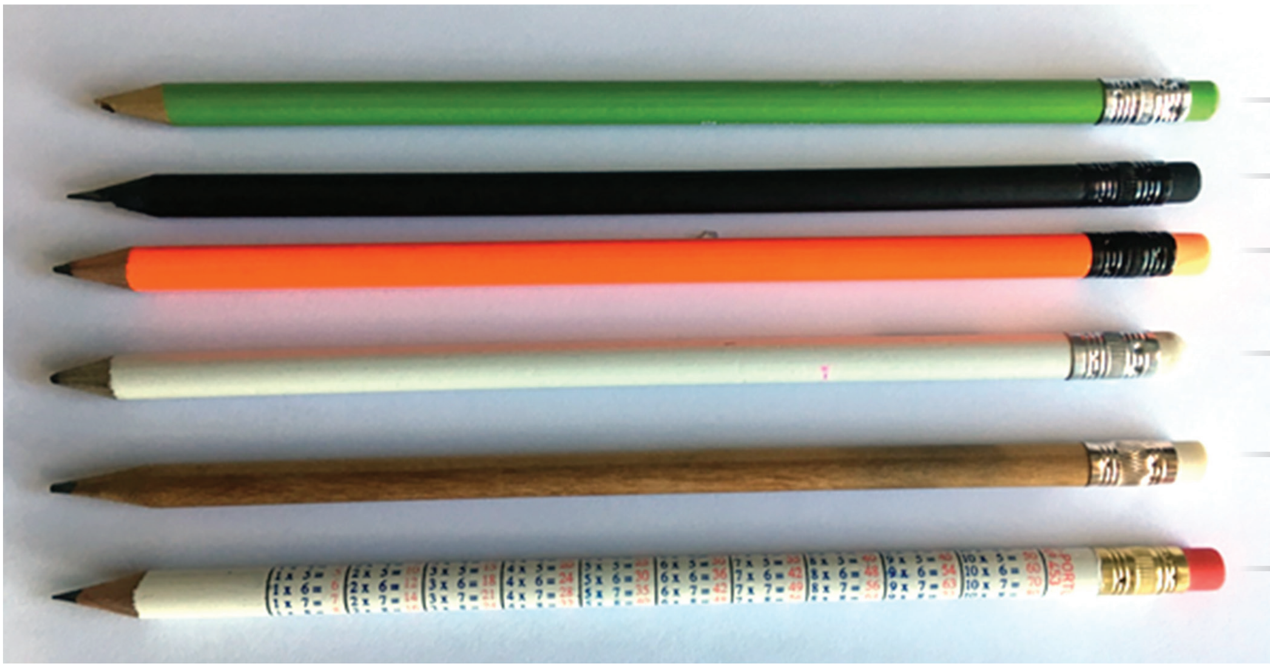
○ Copo de poliestireno descartável (esferovite)

○ Copo de papel

○ Chávena de cerâmica

13 Exemplo 2:

Ordene os seguintes produtos de acordo com a sua perceção de sustentabilidade. (1 mais ecológico, 6 – menos ecológico)



SECÇÃO 5 – OBSERVAÇÕES E ACOMPANHAMENTO DO PROJETO

14 **Observações**

Neste campo pode colocar observações que considere relevantes para o desenvolvimento da investigação

15 **Acompanhamento da investigação.**

Se tiver interesse em acompanhar o desenvolvimento da investigação, insira o seu email no campo seguinte.

Muito obrigado pela sua colaboração!

Annex 6 – Rounding the Vertices_ Strategies review

Rounding the vertices - Principles for circular and sustainable design

Trough Design, improve the circularity profile of you process in 21,4%

Direct impact	Indirect impact	No impact

	Guidelines	description		Key indicators	Influence of the strategyes in the four axis Functional Dimension	Physical resources	Social dimension	Economic Resources
1	Design with a life cycle perspective		- Consider all life cycle phases - Analise the impacts in each phase - avoid the tranference of impacts for other phases - Conduct LCA studies					
2	Design the function/Rethink the system		- Question the function Develop new concepts - Alternative value proposition - Innovate on the ways to fulfil the functions and the needs - inclusive solutions					
3	Design with Synergies and co-creation		- Collaborate - Synergies - Co-creation - Industrial Symbiosis					
4	Design durable products		- Quality of materials - Reparablility - Upgradability - Maintenance - Wear resistant design solutions - Product-user relation - Simplicity principle					
5	Design with Sustainable materials and energy		- Low impact materials - Low embodied energy materials - Renewable materials - Non toxic materials - Renewable energy - Cost effective materials - Use fair materials					
6	Design Product-service systems		- Rethink the business model - innovate and create newbusiness models '- Sharing - Leasing - Virtualize - Servicityze/ Increase service component -					
7	Design for an Efficient and sustainable production		- Reduce consumprion of materials and energy - Modularity - Best avaliable tehcnics - Standartization					
8	Design for optimal use		- Reduce consumables - Sinplicity principle - Inclusive design					
9	Design for Recirculation and zero waste		- Re-use - Recycle - Remanufacture - Renew - Repair - Eliminate waste					
10	Design Circular Business models		- Rethink the business model - innovate and create newbusiness models					

Rounding the vertices -

Trough Design, improve the circularity profile of you process in 21,4%

New concepts	Durability	Life cycle perspective
Optimize resources	Services & Virtualization	Closing the loop
Process	New B. models	Other
Improve use phase	Collaboration	

	Katch_e	Sinndesign	PAEC	Circle economy	Bocken	Moreno	Resolve	CD guide	BS8001	Eberhardt	ECPRACTGuide	10GR	The 9 R's	10 Good design principles Dieter Rams	NIKE	CIRCit	Gap Report 21
1	Design of long-life products	Principle @: Develop new concepts	Refuse	DESIGN FOR THE FUTURE	Designing long-life products. "Designing	Design for energy conservation	REGENERATE	Understand circular Flows	Alternative value proposition/business model development	Assembly/ disassembly	Biomimicry	Don't use toxic substances and arrange closed loops for necessary but toxic ones.	Refuse	Good design is innovative	MATERIAL CHOICES	Rethink & Reconfigure	Design For the Future:
2	Design for product-life extension (Repair, upgrade, etc.)	Principle 1: Improve the sustainability performance of input materials	Rethink	INCORPORATE DIGITAL TECHNOLOGY	Design for product-life extension	Design for material conservation and eliminate waste	SHARE	Regenerative Thinking	Identify alternative design solutions to solve the problem, root cause, system and life cycle perspective	Material selection/ substitution	Cradle to Cradle	Minimise energy and resource consumption in production and transport through HOUSEKEEPING	Rethink	Good design makes a product useful	CYCLABILITY	Reinvent	Design For the Future:
3	Design of product-oriented services	Principle 2: Reduce the use of materials	Reduce	PRESERVE & EXTEND WHAT'S ALREADY MADE	Design for a technological cycle.	Design for optimising/extend product life	OPTIMISE	Service Flip	Consider the product, service opportunity in context of the organization's brand, vision, mission, values	Adaptability/ flexibility	Design for disassembly/deconstruction	MINIMISE energy and resource consumption in the usage phase, especially for products with most significant environmental aspects in the usage phase.	reduce	Good design is aesthetic	WASTE AVOIDANCE	Restore, reduce and avoid	Sustain & Preserve What's Already There:
4	Design of use- or result-oriented services (Selling the function instead of the product)	Principle 3: Improve the sustainability performance of production	Re-use	PRIORITISE REGENERATIVE RESOURCES	Design for a biological cycle	Design for multiple life cycles	LOOP	Insides Out	Optimize ease of reuse, disassembly and recycling	Modularity	Design for flexibility	Promote repair and upgrading, especially for SYSTEM dependent products.	Reuse	Good design makes a product understandable	DISASSEMBLY	Logistics and packaging	Rethink the Business Model:
5	Design for recycling (Material circularity)	Principle 4: Improve the sustainability performance of packaging and logistics	Repair	USE WASTE AS A RESOURCE	Design for Disassembly and reassembly	Design for sustainability	VIRTUALISE	Inspiration: Digital Systems	Optimize product lifetime by designing for ease of maintenance, repair and upgradability	Prefabrication	Design for maintainability/reparability	Promote LONG LIFE, especially for products with most significant environmental aspects OUT of usage phase.	Repair	Good design is unobtrusive	GREEN CHEMISTRY	Upgrade	Use Waste as a Resource:
6	Design for remanufacturing	Principle 5: Improve the sustainability performance in the use phase	Refurbish	RETHINK THE BUSINESS MODEL	Access and performance model	Design for users	EXCHANGE	Learn from Nature	Optimize product lifetime by designing for durability and reliability	Secondary materials	Design for recoverability/recyclability	Use structural features and high quality materials to minimise WEIGHT not interfering with necessary flexibility, impact strength or functional priorities	refurbish	Good design is honest	REFURBISH-MENT	Repair and maintenance	Prioritise Regenerative Resources:
7	Design for materials sustainability	Principle 6: Increase product durability	Remanufacture	COLLABORATE TO CREATE JOINT VALUE	Extending product value	Design for the present towards the future		Define Your Challenge	Consider modular product structure	Durability	Design for the environment (eco-design)		remanufacture	Good design is long-lasting	VERSATILITY	Reuse	Team Up to Create Joint Value:
8	Design for energy sustainability	Principle 7: Optimize the end-of-life system	Repurpose		Classic long- life model			Find Circular Opportunities	Consider open design and greater transparency	Standardisation	Green chemistry	PREARRANGE upgrading, repair and recycling through access ability, labelling, modules, breaking points, manuals	Repurpose	Good design is thorough down to the last detail	DURABILITY	Refurbish	
9			Recycle		Encourage sufficiency Solutions			Building Teams	Consider building stronger product-user attachment or classic design	Component and material optimisation	Integrated design process	Promote upgrading, repair and recycling by using few, SIMPLE, recycled, not blended materials and no alloys	Recycle	Good design is environmentally friendly	PACKAGING	Remanufacture	
10			Recover		Extending resource value			Circular Buy-In	Consider encouraging reduced need for ownership and consumption, e.g. through shared use of the product	Reusing existing building/ components/ materials	Life cycle thinking	Use as FEW joining elements as possible and use screws, adhesives, welding, snap fits, geometric locking etc. according to the life cycle scenario.		Good design is as little design as possible	NEW MODELS	Repurpose	
11					Industrial Symbiosis			Circular Business Model	Reduce impact during use: energy and water consumption, consumables	Optimised shapes/ dimensions	Lifetime extension & durability					Recycle	
12								Create Brand Promise	Consider end-of-life strategies, e.g. reuse of product, remanufacturing/refurbishing, recycling of materials, waste-to-energy	Accessibility	Regenerative design					Cascade	
13								User-Centred Research	Reduce energy used in disassembly and recycling	Layer independence	Standardization					Recover	
14								Circular Brainstorming	Optimize product size, weight, volume	Material storage	Systems thinking						
15								Embed Feedback Mechanisms	Avoid design aspects detrimental to reuse and recycling, e.g. composites/mixtures of materials	Short use							
16								Smart Material Choices	Select lower impact materials – cleaner/sustainable/renewable/lower energy/recycled content/recyclable	Symbiosis/sharing							
17								Concept Selection	Eliminate substances which are or could be potentially hazardous to human health or the environment that can or might bereleased during use								
18								Rapid Prototyping	Restrict or eliminate substances which are or could be potentially hazardous to human health or the environment whichremain present in the product or part								
19								Product Journey Mapping	Reduce the use of materials with resource security risks								
20								Launch to Learn	Reduce number of parts								
21								Imagine New Partnerships	Increase incorporation of used components								
22								Create Your Narrative	Include similar considerations for packaging and consider role within distribution								
23								Align Your Organisation	Optimize resource efficiency in production techniques								
24								Continuous Learning Loops	Reduce energy consumption								
25								Materials Journey Mapping	Reduce water consumption								
26								Product Redesign Workshop	Reduce process waste								
27								Material Selection	Use internally reclaimed or recycled materials from process waste								
28								Moving Forward with Materials	Reduce emissions to air, water and soil during manufacture								
29									Optimize shape and volume for efficient packing density								
30									Optimize transport/distribution in relation to fuel use and emissions								

DISRUPT: KEY ELEMENTS OF THE CIRCULAR ECONOMY

	The Circularity Gap Report 2021. (2021), 71.
Design For the Future:	Adopt a systemic perspective during the design process, to employ the right materials for appropriate lifetime and extended future use
Design For the Future:	Adopt a systemic perspective during the design process, to employ the right materials for appropriate lifetime and extended future use. Incorporate Digital Technology: Track and optimise resource use and strengthen connections between supply-chain actors through digital, online platforms and technologies.
Sustain & Preserve What's Already There:	Maintain, repair and upgrade resources in use to maximise their lifetime and give them a second life through take-back strategies, where applicable
Rethink the Business Model:	Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services.
Use Waste as a Resource:	Utilise waste streams as a sou
Prioritise Regenerative Resources:	Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way
Team Up to Create Joint Value:	Work together throughout the supply chain, internally within organisations and with the public sector to increase transparency and create shared value.

Source https://www.katche.eu/knowledge-platform/tools-and-training-materials/katch_e-tools/ce-designer/

Strategy/Principle	Description	Criteria									
Design of long-life products	Designing long-life products is concerned with ensuring a long utilization period of products through features that enable products to serve their originally planned functions over a longer period of time without loss of performance. This is the counter strategy to the implanted programmed obsolescence, in which the products are designed to lose part or all of their performance elements after a specific period.	Strong product-user relation	Durable and wear resistant materials and components	Timeless and customized design	Reliability	Lifespan information to clients/consumers	User-friendliness				
Design for product-life extension (Repair, upgrade, etc.)	Product life extension is concerned with an increase in the use period of products, which results in a slowdown of the flow of materials through the economy. It has to do with maintenance, repair and upgrading or a combination of these and is related to product characteristics that can be defined at the design stage.	Easy replacement of components	Aesthetic and/or technical upgradeability	Durable and wear resistant materials and components	Use of modular solutions	Simplified product architecture	Choice of tools needed for dis- and reassembly	Minimize connecting elements	Facilitate access and detection of connecting elements	Standard connection elements	
Design of product-oriented services	In order to ensure that products that were designed for product-life extension actually have their lifetime prolonged, services such as maintenance, repair, refurbishment, upgrading, advice, consulting and training are often necessary. These services concern consumer products as well as business-to-business situations.	Geographic accessibility	Variety of offers in therms of available services	Customer satisfaction	Added-value (for customers)	Employment creation	Transportation sustainability	Involvement and promotion of local communities			
Design of use- or result-oriented services (Selling the function instead of the product)	In this strategy, the keyword is "ownership". The provider retains the ownership of the product and makes it accessible to the clients (individuals or organizations) through different business models like leasing, renting, sharing, pooling, etc. (access-oriented services). Alternatively, the provider makes a result available to the user and in this case the relationship with a pre-determined product is weaker (result-oriented services). Here, the client and provider agree on a result – the way of achieving such result is more open than in the product-or use-oriented services and therefore the potential of finding radically new and more sustainable solutions is higher.	Accessibility	Influence in product design	Impact of the services in resources use intensity	Existence of easy and affordable information and communication technologies	Customer satisfaction	Added-value (for customers)	Transportation sustainability	Involvement and promotion of local communities	**Employment creation**	
Design for recycling (Material circularity)	The objective of this strategy is to develop products in such a way that the materials ("technical nutrients") can be continuously and safely recycled into new materials and products. Designers must understand the process and the conditions for an efficient and quality recycling, resulting in quality materials that can be used as valuable input material in the product cycle.	Use of recyclable materials	Choice and variety of materials for easy recycling	Marking materials for recycling	Easy separation of technical from biological materials	Minimize connecting elements	Facilitate access and detection of connecting elements	Standard connection elements	Avoid the use of dangerous tools and processes	Employment creation and good working conditions	
Design for remanufacturing	Design for remanufacturing is a combination of design strategies whereby a product is designed to facilitate remanufacture. Remanufacture returns a used product to a "like-new condition"; it is a process of recapturing the value of the material when a product was first manufactured. Remanufacture results in the reduction of energy and material consumption, and production cost reductions, allowing the manufacturer to increase the productivity as well as the profitability in the business.	Technology integration/stable technologies over lifetime	Use of modular solutions	Existence of a take back programme	Optimize reverse logistics (RL) network design and involve the supply chain in RL planning	Durable and wear resistant materials and components	Simplified product architecture	Minimize connecting elements	Facilitate access and detection of connecting elements	Standard connecting elements	Employment creation
Design for materials sustainability	Resource efficiency means using the Earth's limited resources in a sustainable manner while minimizing impacts on the environment. It allows us to create more with less and to deliver greater value with less input. A reduction of the quantity of materials used in a product or service is possible by implementing efficient strategies in product design. The selection of materials and components is a key element in the definition of the potential impact of a product or a service. In the design phase, the design teams can choose materials and components with lower impact.	Optimize products' design to reduce material consumption	Avoid consumable materials in the use phase	Use of recycled materials	Eliminate the use of hazardous materials in the product	Avoid the use of non-renewable materials in the product	Use of locally produced raw materials and components	Avoid the use of scarce and/or critical materials	Use of raw materials and components from suppliers with good social responsibility (SR) practices	Information on product sustainability to consumers	Influence sustainable consumer behaviour regarding materials consumption
Design for energy sustainability	Product design should take into account the energy that the product will need to meet user needs, taking the whole life cycle into account. For energy-using products (e.g. electronics, cars, lighting), the use phase may be the most important one; however, for many other non-energy consuming products (such as furniture or packaging), the manufacturing phase can represent a significant portion of energy consumption. In service design, on the other hand, the transportation activities may take a very significant role when it comes to energy, since many services require a lot of transport. This strategy thus encompasses energy efficiency, the use of solutions that incorporate renewable energy and also the consumption of energy related to transport.	Reduce energy consumption in production	Reduce energy consumption in use	Reduce energy consumption in transport	Energy plus	Replace non-renewable by renewable energy	Use low embodied energy materials	Information on energy consumption to clients/consumers	Influence sustainable consumer behaviour regarding energy consumption		

Strategy/Principle	Description	Criteria									
Principle @: Develop new concepts	The first principle is symbolized with @ because it is the most far-reaching principle and may lead to discovering alternative and innovative ways to fulfill the needs of users. In this sense, it is not connected to any particular life cycle stage as it questions the product and its function as a whole. It is a complex principle, and perhaps the reader should go through all the principles and then come back to this one: it will make more sense and will be easier to apprehend. In a brainstorming session, though, it is recommended to start by thinking "out of the box" and this is what principle @ is about.	Consumer needs and expectations	Integration of functions	Dematerialization: From products to services	Product system						
Principle 1: Improve the sustainability performance of input materials	The sustainability issues at stake are the input materials and components that constitute the product or are necessary to provide it. Are materials hazardous, non-renewable or scarce? Are they virgin or recycled? Can they be recycled? Do the suppliers have good environmental and social practices? Are the materials and components local, or do they have to travel long distances and do not support the local or regional communities' economies? On the basis of the materials and components used in the reference product or product-service, and the processes necessary to manufacture them, the possibility of using alternative ones with better environmental, social and economic performance is analyzed.	Avoid hazardous substances in the product	Use of renewable resources	Use of locally produced raw materials and components	Minimize the use of scarce materials	Use of low embodied energy material	Use of recycled materials from external sources (outside the manufacturing company)	Use of recyclable materials	Adequate quality of raw materials	Use of raw materials and components from suppliers with good social responsibility (SR) practices	
Principle 2: Reduce the use of materials	Reduction of the amount of materials used is possible by developing lean but strong product designs. This includes also the improvement of efficiency of materials' use having in mind subsequent purposes, such as resource cascading; or reducing the use of virgin materials through recycling.	Optimizing the products' design (shape, size, weight, etc.) to reduce material consumption	Resource cascading	Use of in-house (internal) recycled materials	Encourage remanufacturing						
Principle 3: Improve the sustainability performance of production	This principle focuses on adopting design measures that improve the production stage by reducing the consumption of energy, water and materials per unit of output (i.e., increasing resources productivity), preventing / minimizing the generation of waste and emissions at source and improving the working conditions.	Reducing the energy consumption of production processes	Reducing air and water emissions from production	Waste prevention	Reducing water consumptions	Use of best production technologies	Avoiding hazardous ancillary materials to promote health and safety at the workplace	Avoiding hazardous processes or tools to promote health and safety at the workplace			
Principle 4: Improve the sustainability performance of packaging and logistics	This principle is about designing the product and packaging in such way that the product is stored and transported from the factory to the retailer and end user in the most sustainable manner. If the packaging is a core element in a design project, then the packaging itself should be regarded as a product, and all eight checklists apply.	Avoid or minimize packaging	Returnable packaging system	Reusable packaging	Avoid the use of hazardous substances in packaging	Use of recyclable materials in packaging	Use of recycled materials in packaging	Use of biodegradable materials in packaging	Optimizing transport of products	Information on packaging for a proper waste management	Design of product and packaging to avoid product damage during transport
Principle 5: Improve the sustainability performance in the use phase	This principle relates to the use phase of products. The goal is to reduce the negative and enhance the positive environmental and social impacts associated with their use through design options. This ranges from strategies related to minimizing water, energy and materials during use, to influencing a more sustainable behaviour of consumers and combating discrimination of, e.g., handicaped people.	Reducing energy consumption	Reducing water consumption	Reducing the environmental impact of cleaning and washing	Provide information on the proper use of the product	Reduce the consumption of consumables and/or maintenance materials	Inclusive or universal design	Fair marketing, factual and unbiased information (regarding the environmental and social profile of the product)	Design for consumer's health and safety		
Principle 6: Increase product durability	The objective of this principle is to extend the technical, aesthetic and emotional lifetime of the product, so that it will be used for as long as possible. While this strategy may seem unattractive for companies because they would "sell less", it can be interesting and competitive for certain types of products and market segments where high quality and durability are a strong sales argument.	Reducing wear and any other loss of properties	Easy replacement of components	Use of modular systems	Timeless design	Strong product-user relation					
Principle 7: Optimize the end-of-life system	This principle addresses design options that facilitate material recycling at the end of the product's life time (design for recycling) as well as the sustainable disposal of non-recyclable materials.	Choice and variety of materials for easy recycling	Easy disassembly	Marking of materials for recycling	Provide information for the adequate end of life process	Minimizing connecting elements	Facilitate access and detection of connecting elements	Adapting the structure for reuse	Facilitate safe removal of hazardous substances		

http://circitnord.com/tools/guidelines-for-circular-product-development/
http://circitnord.com/wp-content/uploads/2020/04/Guidelines-for-circular-product-design-and-development.pdf

Design guidelines for circular strategies

1 Rethink & Reconfigure
2 Reinvent
3 Restore, reduce and avoid
4 Logistics and packaging
5 Upgrade
6 Repair and maintenance
7 Reuse
8 Refurbish
9 Remanufacture
10 Repurpose
11 Recycle
12 Cascade
13 Recover

10 PRINCIPLES OF CIRCULAR DESIGN

https://www.nikecirculardesign.com/guides/MiniGuide.pdf

MATERIAL CHOICES
CYCLABILITY
WASTE AVOIDANCE
DISASSEMBLY
GREEN CHEMISTRY
REFURBISH-MENT
VERSATILITY
DURABILITY
PACKAGING
NEW MODELS

Leading the transition
[Action plan for circular economy in Portugal: 2017-2020

Source

	Strategy/Principle	Description	
Smarter product use and manufacture	Refuse	Make product redundant by abandoning it function or by offering the same function with a radically different product	
	Rethink	Make product use mores intensive (e.g. through sharing produccts, or by putting multi-fiunctional products in the market=	
	Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials	
Estended lifespan of products na its parts	Re-use	Re-use by another consumer of discarded product which is still in good conditions and fulfils its original function	
	Repair	Repair and maintenance of defective product so it can be used with its original function	
	Refurbish	Restore na old product and bring it up to date	
	Remanufacture	Use parts of discarded product in a new product with the same function	
	Repurpose	use discarded product or its parts in a new product with a diferent function	
Useful application of materials	Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality	
	Recover	Incineration of materials with energy recovery	

Circle Economy

Source https://www.circle-economy.com/circular-economy/7-key-elements

Strategy/Principle	Description	Criteria	
DESIGN FOR THE FUTURE	Account for the systems perspective during the design process, to use the right materials, to design for appropriate lifetime and to design for extended future use.		
INCORPORATE DIGITAL TECHNOLOGY	Track and optimise resource use and strengthen connections between supply chain actors through digital, online platforms and technologies that provide insights.		
PRESERVE & EXTEND WHAT'S ALREADY MADE	While resources are in-use, maintain, repair and upgrade them to maximise their lifetime and give them a second life through take back strategies when applicable.		
PRIORITISE REGENERATIVE RESOURCES	Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way.		
USE WASTE AS A RESOURCE	Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.		
RETHINK THE BUSINESS MODEL	Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services.		
COLLABORATE TO CREATE JOINT VALUE	Work together throughout the supply chain, internally within organisations and with the public sector to increase transparency and create joint value.		

Product design and business model strategies for a circular economy

Nancy M. P. Bocken, Ingrid de Pauw, Conny Bakker & Bram van der Grinten

Source

Nancy M. P. Bocken, Ingrid de Pauw, Conny Bakker & Bram van der Grinten (2016) Product design and business model strategies for a circular economy, Journal of Industrial and Production Engineering, 33:5, 308-320, DOI: 10.1080/21681015.2016.1172124

To link to this article: http://dx.doi.org/10.1080/21681015.2016.1172124

Strategy/Principle	Description	Criteria									
Design strategies for slowing resource loops	Designing long-life products. “Designing	Design for attachment and trust	Design for reliability and durability								
	Design for product-life extension	Design for ease of maintenance and repair	Design for upgradability and adaptability	Design for standardization and compatibility	Design for dis- and reassembly						
Design strategies for closing resource loops	Design for a technological cycle.										
	Design for a biological cycle										
	Design for Disassembly and reassembly										
Business model strategies for slowing resource loops	Access and performance model										
	Extending product value Exploiting										
	Classic long- life model										
	Encourage sufficiency Solutions										
Business model strategies for closing loops	Extending resource value										
	Industrial Symbiosis										

Taxonomy of design strategies for a circular design tool

Moreno M.A., Ponte O. and Charnley F

Source

Circular design aspect	DfX apprach	Strategy
Resource conservation	Design for energy conservation	Use clean energy consumption
		Reduce
		Reduce energy consumption in manufacture (eliminate yield losses)
		Improve manufacture (production steps, supply chain)
		Use processes suitable for low scale production Select
	Design for material conservation and eliminate waste	Select the best materials (non-toxic, pure if possible
		Choose local materials (no-rare to avoid scarcity)
		Consider a healthy material flow
		Eliminate unnecessary parts and sub-assemblies
		Reduce material (light weighting)
		Reduce or eliminate packaging
		Reduce the size of components (miniaturise)
		Avoid composites and coatings (dificult to separate materials)
		Avoid toxic adhesives, use easy-mechanic joints (fasteners, visible joints
		Use pure materials to allow biodegradability
Life Cycles (end-of-life)	Design for optimising/extend product life	Assure reliability (quality)
		Allow reusability
		Encourage maintenance (repair/refurbish)
		Ease assembly/disassembly
		Standardise parts for compatibility (modularity)
		Remanufacture
	Design for multiple life cycles	Recover material (easy to clean, collect and transport)
		Allow cascade use
		Motivate the user to recycle
		Assure spare parts availability
Whole system design	Design for sustainability	Shift the ownership of products into a service (swap, rent, share)
		De-materialise products into digital platforms
		Allow upgradabiliy and flexibility to adapt
		Strengthen local industry
		Create regenerative systems (biomimicry)
		Care about social impact
		Create walth through a good business practices (improve cost-benefit relationship)
		Develop a trace-and-return system
Costumer	Design for users	Customise to wants and needs of each person
		Enhance durability (avoid built-in obsolescence)
		Develop attachment/loyalty (experience, meaningful design
		Reduce waiting times in delivery to consumer
		Based on long-lasting trends, no ephemeral fashion (timeless aesthetics)
		Implement poka-yoke principles to ease use
Development	Design for the present towards the future	Use mobile technologies
		Use Machine-to-Machine communications (M2M)
		Use cloud computing
		Use social media technology
		Use big data analysis
		Use new material (intelligent, organic)
		Use 3D printing (avoid subtracting technologies)
		Create multi-functional teams to consider different aspects in the design

RESOLVE FRAMEwork	GROWTH WITHIN:A CIRCULAR ECONOMYVISION FOR A COMPETITIVE EUROPE
Source	https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf
Strategy/Principle	**Description**
REGENERATE	Shift to renewable energy and materials; reclaim, retain, and regenerate health of ecosystems; and return recovered biological resources to the biosphere
SHARE	Keep product loop speed low and maximise utilisation of products by sharing them among users (peer-to-peer sharing of privately owned products or public sharing of a pool of products), reusing them throughout their technical lifetime (second-hand), and prolonging their life through maintenance, repair, and design for durability.
OPTIMISE	Increase performance/efficiency of a product; remove waste in production and the supply chain (from sourcing and logistics to production, use, and end-of-use collection); leverage big data, automation, remote sensing, and steering. None of these actions requires changing the product or technology,
LOOP	Keep components and materials in closed loops and prioritise inner loops. For finite materials, this means remanufacturing products or components and as a last resort recycling materials, as Caterpillar, Michelin, Rolls Royce, and Renault are doing.
VIRTUALISE	Deliver utility virtually – books or music, online shopping, fleets of autonomous vehicles, and virtual offices. Google, Apple,38and most OEMs plan to release driverless cars in the next decade.
EXCHANGE	Replace old materials with advanced non-renewable materials; apply new technologies (e.g. 3D printing and electric engines); choose new products and services (e.g. multi-modal transport).

Source

Circular design guide

https://www.circulardesignguide.com/methods

	Strategy/Principle	Description
Understand	Understand circular Flows	Understand the different ways to shift your product or service to be more circular. How can you get started designing for the circular economy?
	Regenerative Thinking	As a regenerative system, the circular economy can have many positive consequences that enhance quality of life, community, and environment.
	Service Flip	Imagine how you might turn common products into a service model. Could your product be transformed into something that takes on a new or unexpected service experience?
	Insides Out	Take apart an everyday product to build empathy and understanding around the implications of disassembly and recovery of materials and parts.
	Inspiration: Digital Systems	Look at the components of digital systems and imagine how you can design for characteristics such as agile development, continuous feedback loops, and scalability.
	Learn from Nature	Ask "how might nature solve this problem?" for your design challenge. Learn how biological systems can help inspire new solutions for your product or service that are inherently more circular and holistic.
Define	Define Your Challenge	Articulate and frame what circularity challenge you want to solve and the impact you hope to have, and bring a team together to align on your goals and approach
	Find Circular Opportunities	Identify small, measurable opportunities to design for circularity. This will help you scaffold your approach to the project you're about to take on.
	Building Teams	Build teams to strengthen knowledge and expertise, build your relationships with stakeholders, and make implementation a success. Align on a shared goal and define how you collaborate.
	Circular Buy-In	Map your stakeholders, understand their perspectives, and create narratives to help them feel invested in your cause
	Circular Business Model	Develop or redefine your business model from a circular design perspective
	Create Brand Promise	Uncover which elements of circularity reinforce your brand purpose to hone your message to your customers. Build your brand around your circular innovation.
Make	User-Centred Research	Understand the needs of everyone involved in the use cycle of your circular proposition(s) – the end users or beneficiaries, but also suppliers, manufacturers, retailers and others who may reuse your materials.
	Circular Brainstorming	Learn how to brainstorm ideas around the principles of circularity
	Embed Feedback Mechanisms	Learn how to design feedback loops – creating a hypothesis of what you hope to learn about your product or service, articulating what evidence you think you need, and planning how you will capture that data.
	Smart Material Choices	Learn to make smart material choices by asking the right questions. These steps will help you make better choices about what materials go into your products as well as their impact on the wider system.
	Concept Selection	Prioritise which circular concepts to take forward, based on how they relate to your business strategy and ultimate impact, and consider how to mitigate risk.
	Rapid Prototyping	Create rough and rapid prototypes to test your concept before going to market. While design doesn't stop in the circular economy, prototyping will mitigate risk by testing ideas before building out for launch, reducing wasteful product cycles.
Release	Product Journey Mapping	Think about the cycles of use for your product or service and its parts. Ask yourself what will happen over time. How might your product break down? What happens then?
	Launch to Learn	Learn how to plan for a pilot, account for the different touchpoints of the pilot (designing for circularity means it will likely be testing a system of sorts), and create a plan for feedback along the way. Test how the outcomes relate to the goals of your circular initiative.
	Imagine New Partnerships	Imagine new or unexpected partnerships that strengthen your value chain, increase system effectiveness or make a more robust business case. This will also help to achieve alignment and clarity on how to move forward together.
	Create Your Narrative	Learn the basics of telling great stories around your product or service and how it relates to circularity. What is an immersive and emotional story that makes people feel invested in your brand?
	Align Your Organisation	Learn how to apply the principles of design thinking to ensure your organisation can support the change to circularity.
	Continuous Learning Loops	Learn how to use feedback to plan what's next with your product or service – this could be evolving your offer, new opportunities for business growth, or spotting your next circular intervention and even evolving the feedback mechanism itself.
Advanced	Materials Journey Mapping	Explore how materials choices can influence a design to fit a circular economy.
	Product Redesign Workshop	Explore the implications of safe and circular materials strategies on the design process through a redesign workshop.
	Material Selection	Choose the right materials for your new circular design.
	Moving Forward with Materials	Explore the next steps for making safe and circular material choices a driver for innovation in your design process.

BS 8001:2017

Source

Design focus area	Potential design strategies	Non-exhaustive options for design improvement
New concept, solution, value proposition, business model development	When considering more circular product design aspects during the early stages, care should be taken in identifying, understanding and defining the problem to be addressed and the system that it operates in. This might include stepping back from the usual solution or current way of doing things to explore alternative approaches, solutions and business models. Here the overarching values, mission, vision, brand of the organization can also be considered for alignment and ambition.	Alternative value proposition/business model development
		Identify alternative design solutions to solve the problem, root cause, system and life cycle perspective
		Consider the product, service opportunity in context of the organization's brand, vision, mission, values
Product–service systems	For circular design, designing with a holistic view of the role of the product, related services and the system it is part of is important. Design strategies to consider and ensure are designed in are: products built to last, shared, rented, repaired, remanufactured, refurbished, etc. When designing a product, various life cycle scenarios can be considered and what the end-of-life, first life strategy is. The role of the consumer here is also key and consideration of related behaviours, interactions with the product or service that might be required for the business model to succeed.	Optimize ease of reuse, disassembly and recycling
		Optimize product lifetime by designing for ease of maintenance, repair and upgradability
		Optimize product lifetime by designing for durability and reliability
		Consider modular product structure
		Consider open design and greater transparency
		Consider building stronger product-user attachment or classic design
		Consider encouraging reduced need for ownership and consumption, e.g. through shared use of the product
		Reduce impact during use: energy and water consumption, consumables
		Consider end-of-life strategies, e.g. reuse of product, remanufacturing/refurbishing, recycling of materials, waste-to-energy
		Reduce energy used in disassembly and recycling
Product and part, component level (including packaging)	Here many traditional ecodesign strategies can be used relating to material reduction, light weighting (where applicable) energy is use reduction through energy efficient choices. The choice of materials plays a large role here and should be considered from a life cycle perspective. There is not one right answer, it is dependent on a case by case basis when looking at the product and system it is part of. For example, if designing a durable product then a higher-grade material might be best or a particular fixing method could mean the product is not necessarily the easiest to disassemble or recycle.	Optimize product size, weight, volume
		Avoid design aspects detrimental to reuse and recycling, e.g. composites/mixtures of materials
		Select lower impact materials – cleaner/sustainable/renewable/lower energy/recycled content/recyclable
		Eliminate substances which are or could be potentially hazardous to human health or the environment that can or might be
		released during use
		Restrict or eliminate substances which are or could be potentially hazardous to human health or the environment which
		remain present in the product or part
		Reduce the use of materials with resource security risks
		Reduce number of parts
		Increase incorporation of used components
		Include similar considerations for packaging and consider role within distribution
Supply chain including manufacturing and distribution	When designing the product, service, the manufacturing methods, locations and supply chain also play a role and can be considered for minimizing or eliminating all types of waste in production and distribution (energy, water, material use). Alongside this supply chain and material considerations should also be given in terms of social and ethical responsibility as well as associated supply chain risks related to materials.	Optimize resource efficiency in production techniques
		Reduce energy consumption
		Reduce water consumption
		Reduce process waste
		Use internally reclaimed or recycled materials from process waste
		Reduce emissions to air, water and soil during manufacture
		Optimize shape and volume for efficient packing density
		Optimize transport/distribution in relation to fuel use and emissions

Building design and construction strategies for a circular economy

Source

Leonora Charlotte Malabi Eberhardt , Morten Birkved & Harpa Birgisdottir (2020): Building design and construction strategies for a circular economy, Architectural Engineering and Design Management, DOI: 10.1080/17452007.2020.1781588

Design and construction strategy	Description in literature
Assembly/ disassembly	Is used to design the building, components or materials to be easily assembled/disassembled to enable e.g. direct reuse or recycling, ease of maintenance/operation and ease of adaptability/flexibility. A precondition is reversible connections.
Material selection/ substitution	Choosing or substituting materials for materials that are e.g. local, renewable, natural/eco/bio, quality, durable, easy assembly/disassembly, reusable and recyclable, C2C certified, pure, maintenance free, retain or increase their value, match the performance lifespan, non-toxic/ hazardous etc.
Adaptability/ flexibility	Designing to be able to e.g. adapt to available materials, accommodate changes in future use/ function requiring modifications/remodelling/ expansion, secure easy and low cost operation/ maintenance, prolong the lifespan of the building, components or materials, reuse and recycle, enable/enhance design for disassembly, close materials loops, distinguish between longand short-life materials as well as low- and highvalue materials.
Modularity	Is used to e.g. allow for easier building/ component adaptability/flexibility (upgrade, demounting/disassembly, replacement, reconfiguration, reuse and recycling), build cheaper standard buildings and lean production.
Prefabrication	Also known as off-site construction. Is used to ensure e.g. reclamation, reusability and recyclability, construction time optimisation, enhanced assembly and disassembly, enhanced adaptability, avoidance of off-cut materials etc. e.g. wooden components such as gluelaminated timber.
Secondary materials	Integrating materials that are recycled in order to slow and close resource loops. E.g. recycled insulation materials, textiles, cellular glass, plywood etc.
Durability	Designing or using high quality durable long performance lifespan components and materials that are easy to maintain and upgrade and can handle several service lives.
Standardisation	Is used to e.g. maximise recovery of materials at end-of-life, ensure reuse and recycling options, limit the number of different components used, avoid material off-cuts, prolong product lifespan etc. (Geldermans, 2016) suggests that the dimensions of the elements do not necessarily need to be standardised if the connections between elements are.
Component and material optimisation	Reducing the amount of materials used as well as the number of different types of components and materials used. E.g. reducing the use of concrete and reducing excavation by choosing a shallow raft foundation.
Reusing existing building/ components/ materials	Is used to directly reuse existing buildings, components or materials for new construction projects. E.g. reusing existing buildings on the site, floor boards, cement tiles, rubble, steel beams etc.
Optimised shapes/ dimensions	Design to precise material measurements specification in order to: suit appropriate means of handling components and materials, enhance/enable future adaptability/flexibility by e.g. avoid over ordering and onsite material cut-offs. E.g. by simplifying the building form, using lightweight structures or reducing the customers' spatial needs by optimising floor areas.
Accessibility	Also known as 'open design'. Used to provide good access to connections between components to enhance design for assembly/ disassembly, to ease maintenance, maximise recovery of materials at end-of-life. E.g. accessible technical building services for easy service and maintenance, demountable and reconfigurable façade systems.
Layer independence	Is used to make building components and materials independent from each other's lifespan for easier operation and maintenance, material recovery, separation and adaptability/ flexibility. E.g. by making the long-lasting building elements flexible so that short-lasting elements can be easily changed. Clear definitions are required of which components belong to which 'shearing layer', with specific attention to intersection-zones.
Material storage	Is used to design buildings as material deposits to avoid degradation of material quality over time by temporarily storing the materials in the building and minimising in-between stockholding that may damage materials by using principles such as just-in-time delivery of the materials to subsequent building projects.
Short use	Opposite of 10 Design for durability: the building is only designed for its specific use and performance span. Material and product choices are adjusted accordingly. E.g. Brummen Town Hall in the Netherlands is designed for a building lifespan of 20 years, after which it will be relocated to accommodate shifting municipal borders (Ellen MacArthur Foundation, 2016a). Another example is the Queen Elizabeth Olympic Park in the UK, which was constructed for hosting the Olympics, after which is was taken apart for other purposes (Ellen MacArthur Foundation, 2016a).
Symbiosis/sharing	Is used to utilise residual resource outputs from one building as feedstock for another, often in relation to industrial parks e.g. sharing/ outsourcing surplus water, waste and energy

Circular Economy Practitioner guide

Source https://www.ceguide.org/Strategies-and-examples

Strategy/Principle	Description
Biomimicry	From material engineering and product design, to business models and infrastructure development, nature has derived solutions that can spark innovation. Biomimicry takes inspiration from nature to address human challenges. The concept rests on the idea that many of the challenges that business faces have already been solved in nature. To integrate biomimicry into your design process, answer the following questions: What challenge am I trying to address? How does nature address this challenge? Does this solution account for context (how, where, and by whom the solution will be used)?
Cradle to Cradle	Cradle to Cradle® is a design framework that calls for a shift in thinking about products as doing "less bad" (eco-efficiency) to doing "more good" (eco-effectiveness). The concept, developed by William McDonough and Dr. Michael Braungart in the 1990s, eliminates the concept of waste and instead perceives it as “food” for another product or cycle. Cradle to Cradle® identifies two material cycles: biological and technical. There are five principles to Cradle to Cradle®: Material Health Material Reutilization Renewable Energy Water Stewardship Social Fairness
Design for disassembly/deconstruction	Design principle that calls for the end-of-life options of how the product, components and materials can be deconstructed. Designing for disassembly has several benefits. It can make it easier for your product to be repaired or upgraded, prolonging its useful life. It can also help ensure your product is recycled and enable whole components to be reused. In fact, the degree to which your product can be disassembled easily often determines how the product will end its life. Designing for disassembly involves some straightforward tactics, for example: The fewer parts you use, the fewer parts there are to take apart. As with parts, the fewer fasteners (e.g. glue, screws, etc.) used, the better. Common and similar fasteners that require only a few standard tools will help to simplify and speed disassembly. Screws are faster to unfasten than nuts and bolts. Glues should be avoided. Building disassembly instructions into the product will help users understand how to take it apart.
Design for flexibility	Most commonly applied in the building design and construction sectors, the design for flexibility principle calls for use of underused space, expansion capacity, demountable partitions, and mobile or modular furnishings. This concept can and should be applied to product design as well. A. Bischof and L. Blessing developed guidelines for integrating product flexibility into the design process in 2008, which include the following principles: Ease and accessibility: mobility, parametric design, place quickly worn parts towards exterior Standardization and modularization: parts, fasteners, joints, tools required Transparency: minimize internal connections and dependencies Digitization: use software instead of hardware Anticipation: additional functions in the future, create buffers, add-ons, oversize, technology lock-in, redundancies
Design for maintainability/reparability	Design for maintainability or reparability prolongs product use, extending its useful lifetime. There are multiple elements that designers should consider in this case: Parts standardization and replacement Modular components and parts Accessibility, safety and disassembly Regular self-testing, error recognition and notification Affordability, simplicity and expediency
Design for recoverability/recyclability	Designers may choose to prioritize how easy to recover and recycle their products, finding ways to account for that product will be collected and recycled after use. Because there will be nuances across products and geographies, there are multiple things to consider when optimizing the recyclability of your product: Recyclable materials Limit the number of material types and composites Modularity and ease of disassembly Limit use of adhesives, dyes, paints and coatings (types and colors) Limit or eliminate hazardous materials and contamination It is common for manufacturers to partner with end-of-life resource management companies during the design phase to integrate the appropriate product features to facilitate end-of-life handling.
Design for the environment (eco-design)	Designing for the Environment (DfE) is a principle that calls for minimizing the negative environmental impacts of a product across its life cycle. DfE includes other design principles including: Designing for Maintainability/Reparability Designing for Recoverability/Recyclability Designing for Flexibility Designing for Reuse Designing for Disassembly Designing for Energy Efficiency Packaging Minimization Life Cycle Thinking Material Safety Green Chemistry, among others Companies often prioritize which elements of DfE (i.e. Material Safety) to include in their own processes. Typical DfE criteria account for hazardous materials, resource efficient production, packaging and end-of-life planning. The DfE criteria you adopt should align with material environmental issues and corporate sustainability targets.
Green chemistry	Green chemistry means designing chemical products and processes that minimize or eliminate the use or creation of hazardous substances. The concept applies to all stages of the chemical product life cycle, from design through end-of-life. There are 12 commonly accepted principles of green chemistry: Waste prevention Safer chemicals Fewer hazardous chemical synthetic methods Safer solvents and other substances Energy efficiency Renewable feedstocks Innocuous degradation Avoid chemical derivatives Atom economy maximization Real-time analysis for pollution prevention Accident prevention Use catalysts, not stoichiometric reagents
Integrated design process	Product or system integrated design is an approach that brings together different actors across the life cycle, providing new perspectives early in the design process. The integrated design process (IDP) is increasingly used in the building design and construction sectors because it brings immediate value to the process. Integrated design facilitates information sharing early, optimizing project management and product quality. The process also helps minimize unforeseen costs and issues later in the process. The IDP process requires six major principles: Diverse team collaboration Well-defined scope, vision, goals and objectives Open communication Innovation and idea synthesis Systematic decision-making Iterative process with feedback loops
Life cycle thinking	Life cycle thinking means accounting for economic, environmental and social impacts across all stages of a product or process life cycle. This perspective informs the design team of the product’s life cycle impacts across a range of sustainability issues (i.e. greenhouse gas emissions, jobs created, daily average life years, etc.). It’s not always easy for companies to decide which design alternatives are better. So, it’s up to the company to compare life cycle impacts of a product or process to their mission and goals. Life cycle thinking is based on and requires using some form of Life Cycle Assessment (LCA), such as: Environmental LCA Social LCA Life cycle cost analysis or total cost of ownership Streamlined LCA The typical life cycle stages companies consider when evaluating the impacts of a product or service are listed below. The number of stages to include in your life cycle thinking depends on the product or process. Transportation between all stages should be included as well: Raw material extraction Material processing Manufacturing Use End-of-Life
Lifetime extension & durability	Designers can incorporate characteristics that enable products to serve their originally intended functions longer. Lifetime extension is the counter-strategy to planned obsolescence, in which products are designed to fail after a specific time. There are multiple ways that a product’s lifetime (and value) can be extended: Design for maintainability, reparability, reuse and remanufacture Manufacture with high quality, durable materials and processes Move from a product seller to a service provider Identify and promote alternative uses for products that can no longer serve their original function
Regenerative design	Regenerative design is a principle that calls for products or services to contribute to systems that renew or replenish themselves. This ultimately means the materials and energy that go into a product or process can be reintroduced into the same process or system, requiring little to no inputs to maintain it. At the heart of regenerative design, there’s a strong connection to the place in which a product or process is extracted, produced, used and disposed of at end of life. There are four key premises to regenerative design: Understanding the product’s or processes’ relationship to place throughout its life cycle Determine goals that recognize regenerative capacity Become a partner to place instead of purely extracting from it Strive to achieve harmonization between people and place To achieve true regenerative design, you must incorporate systems thinking, interdisciplinary collaboration, and recognize dependence on natural capital.
Standardization	Standardization is the process of establishing uniformity across manufacturing materials and processes. Potential benefits of standardization include lower production and procurement costs through economies of scale, easier and less expensive repair and replacement, and faster and more efficient processes, for example. In developing a product for the market, considering standardization across the following elements may demonstrate financial benefits: Materials: colors, shapes, types, fasteners Processes: tools, equipment, scheduling One method to standardization is the “zero-based approach” in which you begin with the question “How can I build this widget using as few [specify material or process characteristic] as possible”? From there, you begin with a blank sheet and try to keep the number down to a minimum.
Systems thinking	Systems thinking is a design approach that accounts for interdependence between and collective evolution of system actors. There are many tools to facilitate systems thinking, including diagrams illustrating: Behavior over time Graphical function Policy structure Causal loop Structure-behavior relationships Systems archetype There are 10 systems archetypes defining common behavior patterns. These archetypes highlight the structure of the underlying system being evaluated. These archetypes can be used to identify root-causes of reoccurring issues or alert you of future unintended consequences: Limits to growth Burden shifting Eroding goals Escalation Success to the successful Tragedy of the commons Fixes that fail Growth and underinvestment Accidental adversaries Attractiveness principle

10 Golden rules of ecodesign

GR 1	Don’t use toxic substances and arrange closed loops for necessary but toxic ones.
GR 2	Minimise energy and resource consumption in production and transport through HOUSEKEEPING
GR 3	MINIMISE energy and resource consumption in the usage phase, especially for products with most significant environmental aspects in the usage phase.
GR 4	Promote repair and upgrading, especially for SYSTEM dependent products.
GR 5	Promote LONG LIFE, especially for products with most significant environmental aspects OUT of usage phase.
GR 6	Use structural features and high quality materials to minimise WEIGHT not interfering with necessary flexibility, impact strength or functional priorities
GR 7	Use better materials, surface treatments or structural arrangements to PROTECT products for dirt, corrosion and wear
GR 8	PREARRANGE upgrading, repair and recycling through access ability, labelling, modules, breaking points, manuals
GR 9	Promote upgrading, repair and recycling by using few, SIMPLE, recycled, not blended materials and no alloys
GR 10	Use as FEW joining elements as possible and use screws, adhesives, welding, snap fits, geometric locking etc. according to the life cycle scenario.

Luttropp, C., & Lagerstedt, J. (2006). EcoDesign and The Ten Golden Rules: generic advice for merging environmental aspects into product development. *Journal of Cleaner Production* , *14* (15–16), 1396–1408. https://doi.org/10.1016/j.jclepro.2005.11.022

10 principles for good design - by Dieter Rams

https://ifworlddesignguide.com/design-specials/dieter-rams-10-principles-for-good-design

1	**Good design is innovative**	The possibilities for innovation are not, by any means, exhausted. Technological development is always offering new opportunities for innovative design. But innovative design always develops in tandem with innovative technology, and can never be an end in itself.
2	**Good design makes a product useful**	A product is bought to be used. It has to satisfy certain criteria, not only functional, but also psychological and aesthetic. Good design emphasises the usefulness of a product whilst disregarding anything that could possibly detract from it.
3	**Good design is aesthetic**	The aesthetic quality of a product is integral to its usefulness because products we use every day affect our person and our well-being. But only well-executed objects can be beautiful.
4	**Good design makes a product understandable**	It clarifies the products structure. Better still, it can make the product talk. At best, it is self-explanatory.
5	**Good design is unobtrusive**	Products fulfilling a purpose are like tools. They are neither decorative objects nor works of art. Their design should therefore be both neutral and restrained, to leave room for the users self-expression.
6	**Good design is honest**	It does not make a product more innovative, powerful or valuable than it really is. It does not attempt to manipulate the consumer with promises that cannot be kept.
7	**Good design is long-lasting**	It avoids being fashionable and therefore never appears antiquated. Unlike fashionable design, it lasts many years - even in todays throwaway society
8	**Good design is thorough down to the last detail**	Nothing must be arbitrary or left to chance. Care and accuracy in the design process show respect towards the consumer.
9	**Good design is environmentally friendly**	Design makes an important contribution to the preservation of the environment. It conserves resources and minimises physical and visual pollution throughout the lifecycle of the product.
10	**Good design is as little design as possible**	Less, but better - because it concentrates on the essential aspects, and the products are not burdened with non-essentials. Back to purity, back to simplicity.

Circular Economy: Measuring innovation in product chains, Potting, J. Et al, PBL netherlands 2017

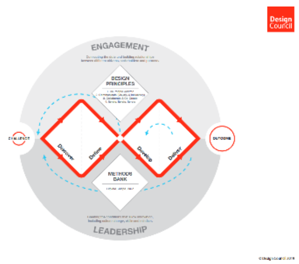
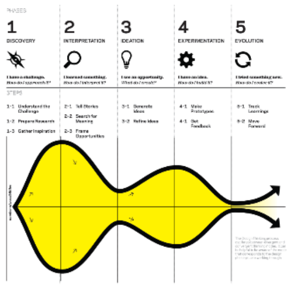
	The 9 R's	
	Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
Smarter product use and manufacture	Rethink	Make product use more intensive (e.g. by sharing product)
	reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
	Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils its original function
	Repair	Repair and maintenance of defective product so it can be used with its original function
Extend lifespan of product and its parts	refurbish	Restore an old product and bring it up to date
	remanufacture	Use parts of discarded product in a new product with the same function
	Repurpose	Use discarded product or its parts in a new product with a different function
Useful application of materials	Recycle	Process materials to obtain the same(high grade) or lower (lowgrade) quality
	Recover	Incineration of material with energy recovery

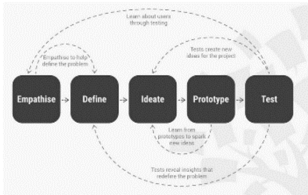
Products That Last

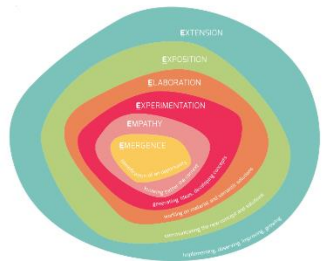
	fonte	Circular Design - Design for Circular Economy - Katerina Medkova & Brett Fifield
1	Design for Product Attachment and Trust	sometimes called ‘design for emotional durability’ is regarded as the most challenging, aims at responding to an emotional obsolescence by creating long lasting products that people will love and trust (Bakker & Hollander 2013; Bakker et al. 2014; Circular Economy 2015; Bocken et al. 2016).
2	Design for Product Durability	creates products resistant to wear and tear, in other words, physically durable products. Here, the material choice is crucial in overcoming functional obsolescence (Bakker & Hollander 2013; Bakker et al. 2014; Circular Economy 2015; Bocken et al. 2016).
3	Design for Standardization & Compatibility	fights against systemic obsolescence by designing product’s parts and interfaces suitable for other products and aims at multi-functionality and modularity (Bakker & Hollander 2013; Bakker et al. 2014; Circular Economy 2015; Bocken et al. 2016).
4	Design for Ease of maintenance and Repair	counters functional obsolescence by ease of maintenance to keep a product in working condition, and non-challenging reparability and replacement of broken parts to extend the end of the life (Bakker & Hollander 2013; Bakker et al. 2014; Circular Economy 2015; Bocken et al. 2016).
5	Design for Upgradability & Adaptability	avoids systemic obsolescence by maintaining product usability for a long time by upgrading its value and performance, and at the same time, by adaptation and modification towards the changing needs of a user (Bakker & Hollander 2013; Bakker et al. 2014; Circular Economy 2015; Bocken et al. 2016).
6	Design for Dis- and Reassembly	also avoids systemic obsolescence by designing products and their parts to be eventually easily separated and reassembled. This strategy has a big impact on component and material reuse and remanufacturing. (Bakker & Hollander 2013; Bakker et al. 2014; Circular Economy 2015; Bocken et al. 2016) Figure

Annex 7 – Design process approaches review

STRUCTURE OF THE DESIGN PROCESS AND APPROACH

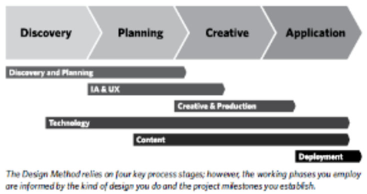
Source	Phase	Description
Design Council 	**Challenge**	The starting point for the Design process.
	Discover	The first diamond helps people understand, rather than simply assume, what the problem is. It involves speaking to and spending time with people who are affected by the issues.
	Define	The insight gathered from the discovery phase can help you to define the challenge differently.
	Develop	The second diamond encourages people to give different answers to the clearly defined problem, seeking inspiration from elsewhere and co-designing with a range of different people.
	Deliver	Delivery involves testing out different solutions at a small scale, rejecting those that will not work and improving the ones that will.
	Outcome	Result of the Design process.
Riverdale & IDEO 	**Discover**	Understand the challenge; Prepare Research; Gather inspiration
	Interpretation	Tell stories; Search for meaning;Frame opportunities
	Ideation	Generate Ideas; Refine ideas
	Experimentation	Make prototipes; Get feedback
	Evolution	Track learnings; Move forward

Interaction Design foundation 	**Empathise**	Understanding the human needs involved. Gain an empathic understanding of the problem to solve. Empathy allows Design teams to set aside their own assumptions about the world in order to gain insight into users and their needs.
	Define	Re-framing and defining the problem in human-centric ways Put together the information created and gathered during the Empathise stage. This is where the team will analyse the observations and synthesise them in order to define the core problems that has been identified up to this point.
	Ideate	Creating many ideas in ideation sessions. In the third stage of the Design Thinking process, designers are ready to start generating ideas.
	Prototype	Adopting a hands-on approach in prototyping. This is an experimental phase, and the aim is to identify the best possible solution for each of the problems identified during the first three stages The Design team will now produce a number of inexpensive, scaled-down versions of the product or specific features found within the product, so they can investigate the problem solutions generated in the previous stage.
	Test	Developing a testable prototype/solution to the problem. Designers or evaluators rigorously test the complete product using the best solutions identified during the prototyping phase. This is the final stage of the 5 stage-model, but in an iterative process, the results generated during the testing phase are often used to *redefine* one or more problems and inform the *understanding* of the users, the conditions of use, how people think, behave, and feel, and to empathise.
Mindshake Design Thinking Model Evolution 6²	**Emergence**	Identification of an opportunity
	Empathy	Knowing better the context
	Experimentation	Generation ideas, developing concepts



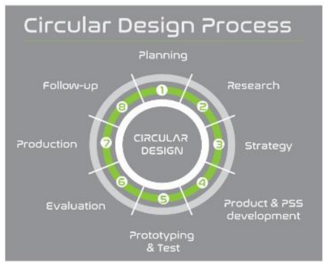
	Elaboration	Working on material and semantic solutions
	Exposition	Communicating the new concept and solutions
	Extension	Implementing, observing, improving, growing

The Design method: a philosophy and process for functional visual communication (Karjaluoto, 2014)



Discovery	Gathering data and becoming familiar with the situation through observation and analysis.
Planning	Identifying key needs and issues, and developing a strategy and actionable plan to address these concerns.
Creative	Exploring conceptual options and potential Design directions, and organizing these possibilities into a clear vision
Application	Implementing the approach and building out Design elements along with testing, measurement, evaluation, and refinement.

KATCH_e Design and development module



Planning	Understanding the context of the problem that the Design and development team has to solve.
Research	relevant baseline information concerning the need or opportunity that emerges from the previous step has to be gathered and analysed so that the circular strategies for the new solutions are appropriately defined based on a solid rationale.
Strategy	identifying and selecting the most promising circular and sustainable Design strategies for the product or service
Product and PSS development	Development of a new concept based on two distinct moments. The divergent thinking moment, in which several possible ideas are created, and a second moment, the convergent thinking moment in which the ideas are refined and narrowed down to the best idea.

	Prototyping	Test products and services ideas before the development of the final solution, including the test of the circularity and Sustainability potential.
	Evaluation	Analyse the circularity and Sustainability performance of the product and/or service against the defined objectives and the effectiveness and procedural aspects of the project
	Production	Production and placement in the market
	Follow-up	Follow-up activities to promote a circular approach to project development based on a continuous improvement idea.
Chicago architecture centre – Design process 	**Define the Problem**	You can't find a solution until you have a clear idea of what the problem is
	Collect Information	Collect sketches, take photographs and gather data to start giving you inspiration.
	Brainstorm and Analyse Ideas	Begin to sketch, make, and study so you can start to understand how all the data and information you've collected may impact your Design.
	Develop Solutions	Take your preliminary ideas and form multiple small-scale Design solutions.
	Gather Feedback	Present your ideas to as many people as possible: friends, teachers, professionals, and any others you trust to give insightful comments.
	Improve	Reflect on all of your feedback and decide if or to what extent it should be incorporated. It is often helpful to take solutions back through the Design Process to refine and clarify them.

Annex 8 – Rounding the Vertices Toolkit – e-book version

ROUNDING THE VERTICES

Toolkit for Circular Design

2022

CREATIVE NATURE HUB

Rounding the Vertices - Toolkit for Circular Design

Developed under the PhD research project “Transition to Circular and Sustainable Economy through Design”

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Content

Introduction

Basis and rationale for the development of the design model for circular economy

The integration of sustainability principles in product development has been a concern of many professionals since the 70s, having, in a way, been significantly influenced by Vitor Papanek's book "Design for the real world" (Papanek, 1970), in which he calls into question the practice of design and the relationship of this professional activity with the environmental and social impacts and problems associated with product development. From green design to design for the circular economy, we have witnessed an evolution in design, in the concepts, practice and growth in complexity by integrating a larger scope of sustainability criteria (Vicente et al., 2012).

The circular economy, which can be considered as new step in the evolution of a necessary and fundamental demand for a more sustainable future, presents itself as a possible path in this direction. Because of this, the scientific, academic and business communities are highly motivated and committed to it. However, despite the numerous developments in terms of methodologies, practices, tools, funding opportunities, etc., there is still a huge gap between theory and practice (Camocho et al., 2019), between what is being developed in research and development projects and what is actually applied in practice, in new solutions that reach the market and the users.

It is essential to narrow this gap and provide designers, who have a fundamental and irrefutable role in the development of new products, sustainable services and systems, with interdisciplinary practices supported by synthetic methods, tools and guidelines. This will result in sustainable solutions, contributing to an environmentally efficient future, fair from a social point of view and that creates value and wealth for business and for the society.

In this sense, the "Rounding the vertices - design for circular economy" is a design method that supports this practice and integrates the project development perspective, the management of the design project and the perspective of the business. The method was developed to implement these considerations in early phases of the project with high innovation potential.

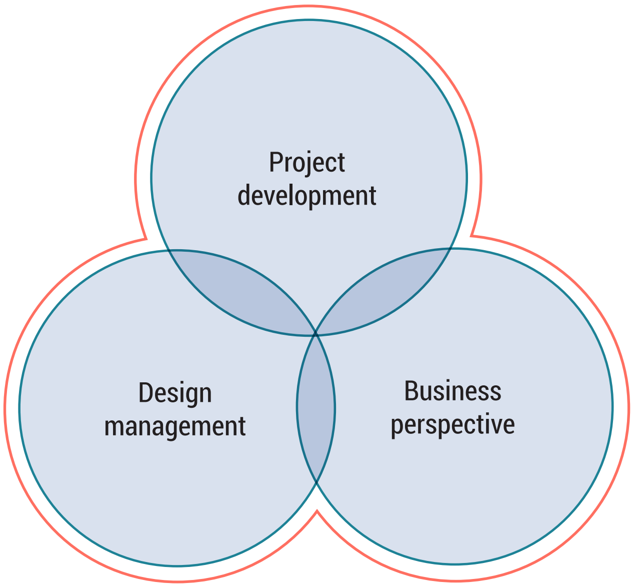


Figure 1: The 3 dimensions of the circular design model.

Rounding the vertices

The concept

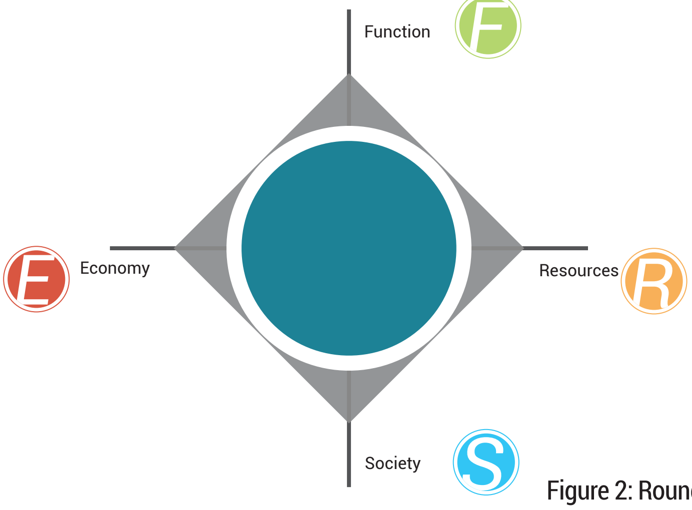


Figure 2: Rounding the vertices concept.

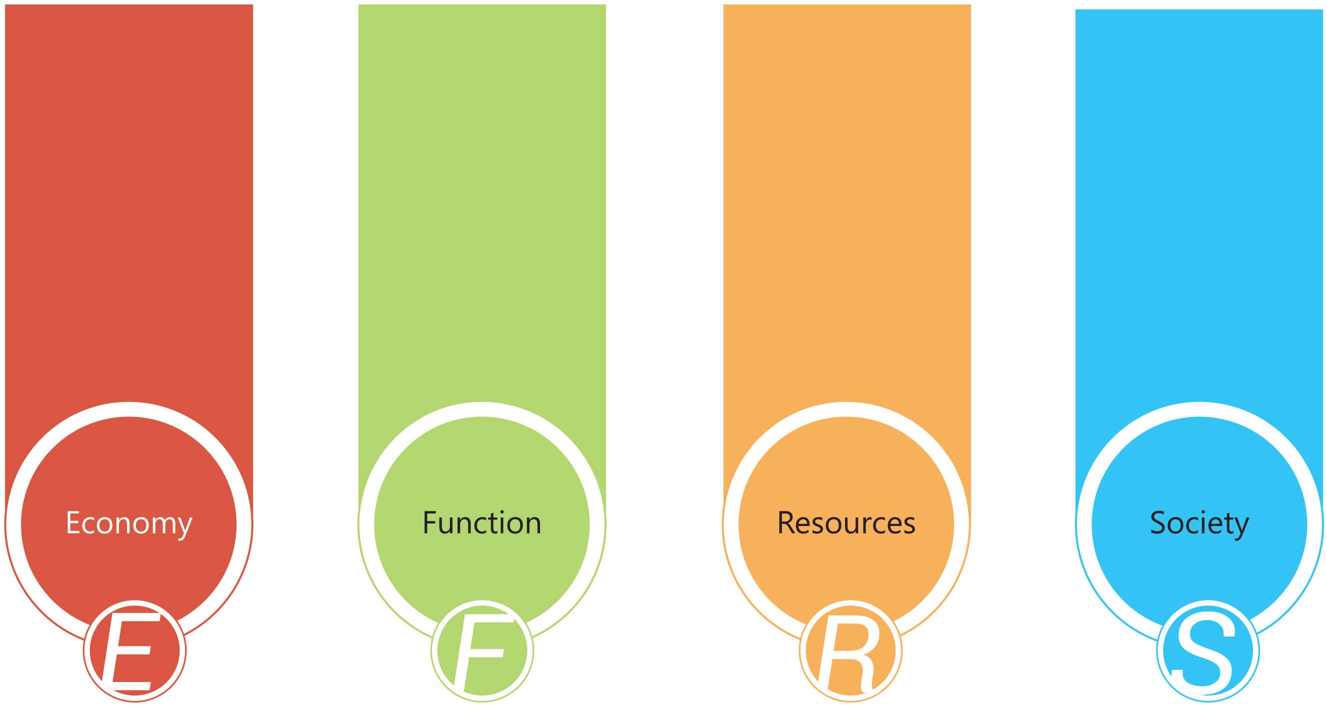
The transition from the linear economy to the circular economy relies on an improvement in the efficiency and effectiveness of the product and service systems. This transition, based on the maintenance of the materials in use in multiple cycles and the elimination of the production of waste through design options is seen as the potential path toward sustainability.

The Rounding the vertices is a design concept that aims to illustrate the design practice towards circularity that is based on that the transition from a square shape (an analogy to the current linear approach) to a circular shape by increasing the performance of products and services system requires less area. This means that to achieve circularity, we need to improve the system by reducing the consumption of material and energy as well as improving the efficiency of the life cycle.

The method is based on the improvement of the efficiency of an entire product or service system in a holistic approach, operating at various levels and improving the product's sustainability and the relation to the needs of the users. Only a concerted approach achieves an effective improvement, taking into account the implications of the design process in the various dimensions as well as the tradeoffs that result from the development process.

In the concept, the improvements in the transition to circularity are demonstrated by improvements in the 4 vertices, each one referring to a dimension that must be considered in a holistic and harmonized approach, thus resulting in a new shape and ideally reaching the circle that represents the achievment of circular solutions.

The four dimensions



The aim is to optimize the economic aspects related to the system creating sustainable value and wealth for all actors in the value chain through the design approaches and measures adopted in the project

The project should put into question the current solutions and rethink the system focusing on the function. Through a function approach, the design team has more levels of freedom to innovate and attain higher circularity and sustainability performance and can lead to out-of-the-box solutions.

The resources needed to fulfil the function should be optimized. The optimization and the efficiency of the consumption of materials, such as energy and water, in the product or service systems has the potential to improve the circularity and sustainability aspects of the systems.

Design for a better society should be also the motto for the design project. The creation and promotion of welfare, safety and good working conditions are an added value for the society that can be achieved through design.

Circular design development model

Development of the Circular Design Model and toolkit

Aiming to support and promote the design practice, the Rounding the vertices design model was developed. Built upon the results of the research, review, analysis of strategies, tools and methods, and other relevant information collected and analyzed, the structure of the model (figure 3) derives from the six main stages of a design project and relates the activities of the process with three levels that complement each other resulting in a robust model to support the design practice towards circularity and sustainability:

- The **Project management level** to support an efficient integration of circularity in the different phases and aspects of Design management
- The **Business level** to align the development with the strategy and considerations of the business, promoting the efficiency and sustainability of the system.
- The **Development level**, to support the practice and the integration of the circularity and sustainability considerations, methods and tools in the development of new and innovative products, services and systems.

The model establishes the relation of the design thinking process with the goals of the circular econmy to define how the resources can guide the design process to promote sustainability and circularity in processes.

The strategy for the design practice within a circular economy is supported by the four tools that can be applied by practitioners in their activity to develop innovative and sustainable circular solutions. The translation of the model into the practice is done through the design for circularity and sustainability toolkit.

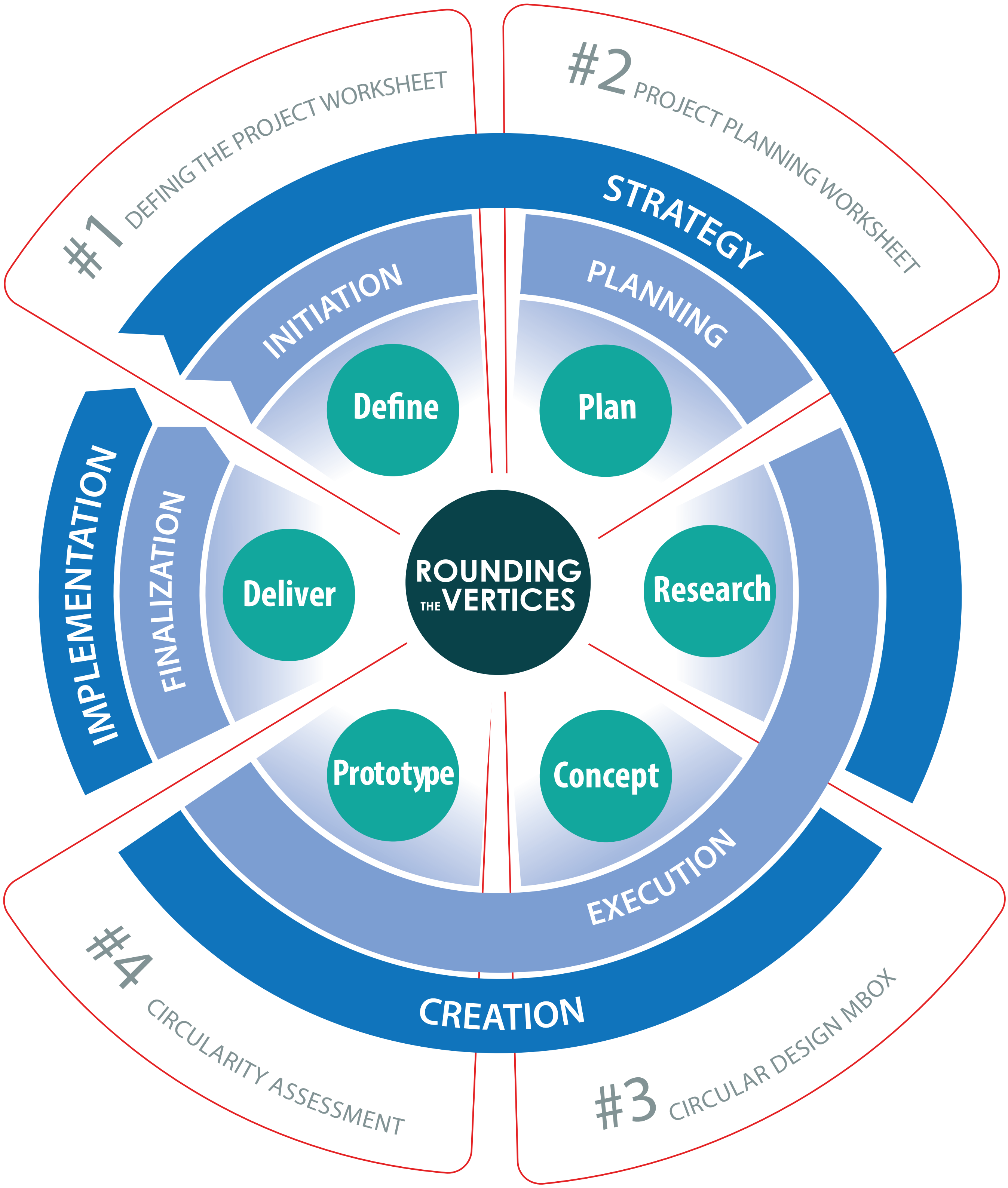
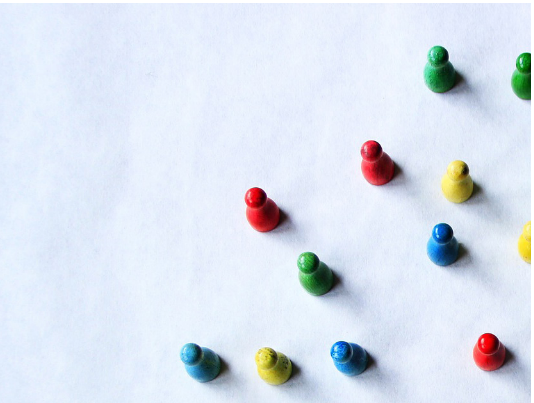


Figure 3: Rounding the vertices design model

Toolkit overview

The Rounding the vertices circular design toolkit is composed of a set of four tools that can support the design practice towards circularity and sustainability.

The tools are used according to the design process and are interlinked in order to guide the design process and help the design and development teams in the definition and planning of the project, identification of improvement measures and ideas to develop new solutions, and the validation and demonstration of the circularity performance of the design process undertaken and the results of the project.



#1 Definig the project worksheet

The first tool is focused on supporting the initiation of the project and the definition of what needs to be done. The goal in this phase is to systematize the process of the initial information, based on the strategic approach led by the business, and make sure that the development team always gets the information needed and guidance for the project development.
The result of the tool is a systematized definition of the strategy, goals and characteristics for the circular design project structured to improve the efficiency of the solutions according to the Function, Resources, Economy and Social levels

#2 Project planning worksheet

The project Planning worksheet helps the team in defining the work to be done and creates the roadmap and structure to follow within the project to meet the objectives defined previously.
The tool organizes the project through the identification of the activities to be held, the resources needed and the duration of the task within the project.

#3 Circular design Mbox

The circular design Mbox combines the concept of the morphological box tool, widely used by designers in the identification of design solutions, with 10 design principles for circularity and sustainability.
With the support of the tool, design teams can implement the design principles in a systematized approach, leading to the identification and creation of innovative and circular solutions for product and service development within the project.

#4 Circularity Assessment tool

The tool performs a qualitative assessment of the circular approach in the design project based on the four levels to round the vertices (Function, Resources, Economy and Social levels), based on the assessment of the performance of the project according to the 10 circular design principles, and their impact in the transition to a more circular and sustainable solution.

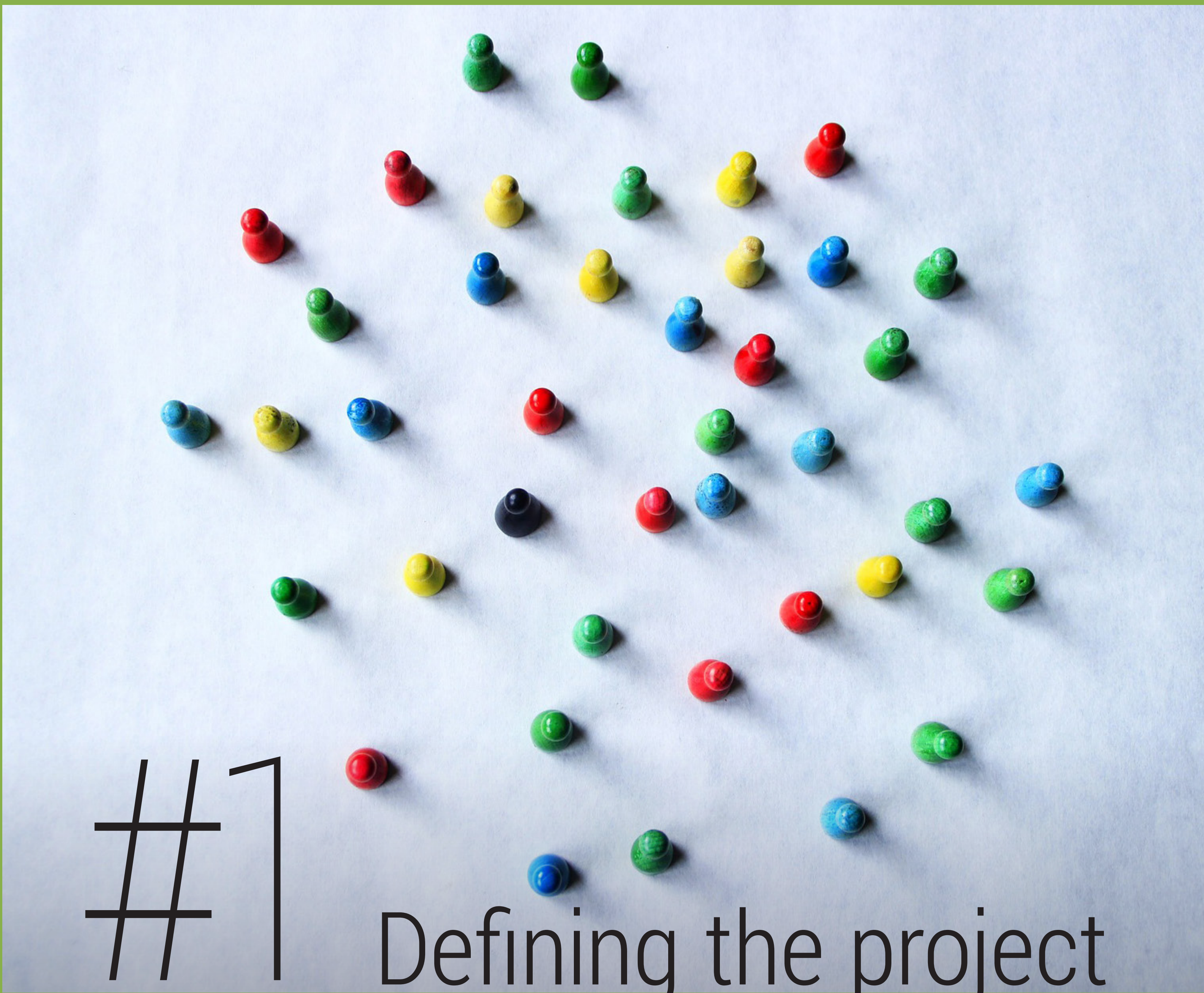
How to use the toolkit

The toolkit provides four tools to systematize the integration of circularity aspects in the design process. The tools were developed to be used to support the four stages of the design process: (1) The strategic definition of the project, (2) the management of the project, (3) the creation of new concepts and (4) the assessment of the design process and its results.

There are two versions of the tools that should be used according to the needs and experience of the design teams.

The e-book version – a comprehensive resource with the theoretical content. The 3 initial tools are composed by a set of worksheets in which the design team needs to reflect and fill in the tables. The assessment tool, due to the calculation features, is to be used only in the excel version. In the e-book, an explanation of this tool is presented.

Excel based tools - These versions of the tools were developed in excel so that the design team can fill in the spreadsheets in a more systematized way. These include calculations and features to simplify the filling-in process, however, it does have the limitations of the excel software.



#1 Defining the project

Worksheet

This worksheet helps the in the definition of the strategy for the development of products and services that meet the needs on the entire system.

Planning the business strategy towards project development

Defining the needs of the project

Identify the current needs and motivations of your business for the development of a circular economy design project

Defining the needs of the project supports the definition of the problem that the project will address. In this stage, the design and development team should identify why there is the need to develop a new design project with a circular economy approach, what are the motivations for the company, what moves the company towards circularity and what are the known barriers for the project.

Why does your business need to enrol in a design for a circular economy project?	What are the company's motivations for a CE design project?	What are the known barriers for a CE design project?

Defining the market

Identify the current and potential market for the business and their sustainability and circularity concerns

Based on market analysis, in this stage, the team must define the market for the product or service under development. This supports the guidance and definition of the project objectives and boundaries.

In this worksheet, the design team must identify the current market, the market that is already covered by the company and the current products, the potential market that can be achieved with the development of the new product and the opportunities for the project.

In this stage, the team must also understand what the market is demanding in terms of sustainability and circularity and how the business can meet these needs.

Identify the opportunities	Identify potential markets for the business

What are the barriers of your business to meet the needs of the market?	What are the sustainability and circular demands of the market?

Defining the business model

Describe the current business model

The business models define how the company plans to make money with its products or services. It outlines the structure and boundaries of the system in which the company operates and the relation with customers or users and the market.

Circular and sustainable business models focus on the value generated of a product or a service and try to capture value throughout its life, aiming to close resource loops and minimize the impacts over the life cycle.

In this stage, the design team must understand the current business model and how the company can innovate and increase its value.

Describe the current business model, determine how value is created and define the structure of the business	Identify and describe the main sustainability and circularity aspects of your business

New business models

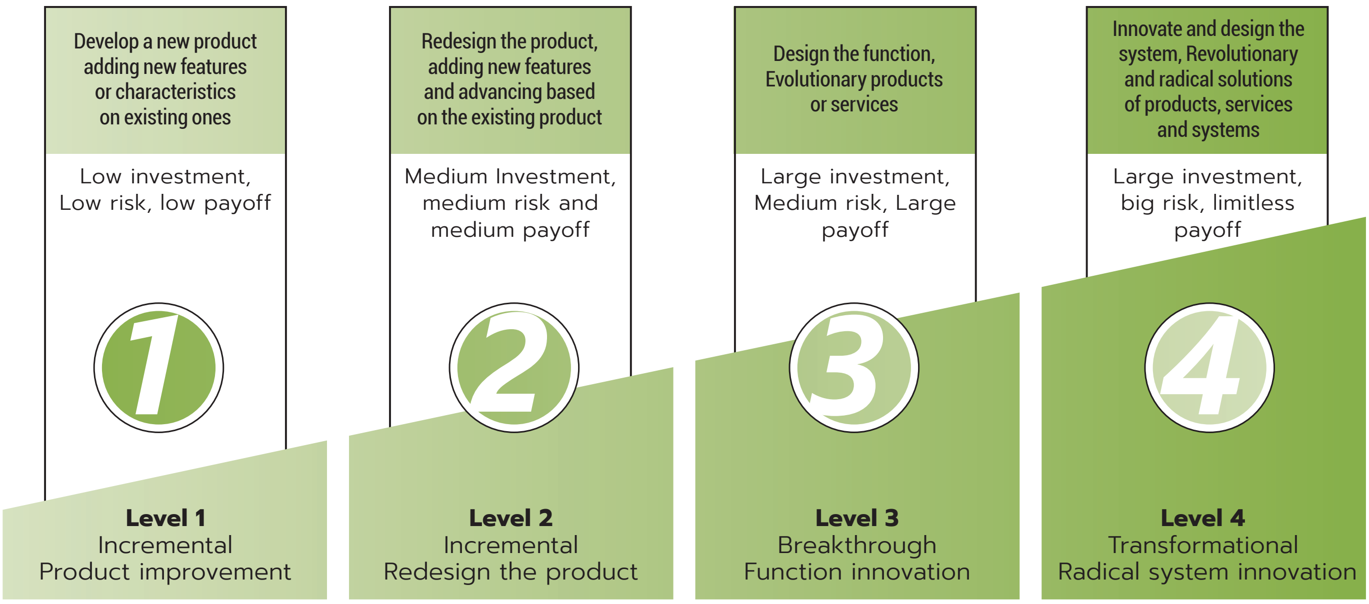
Does the company have the flexibility to adopt different business models? If yes, analyse the following circular business models and identify the potential of each model for your case.

Circular supplies	The circular supplies business model is particularly relevant for companies dealing with scarce commodities, in which scarce resources are replaced with fully renewable, recyclable or biodegradable resource inputs.	
Resource recovery	The resource recovery business model leverages technological innovations and capabilities to recover and reuse resource outputs that eliminates material leakage and maximizes economic value.	
Product life extension	The product life extension model helps companies to extend the lifecycle of their products and assets to ensure they remain economically useful. Material that otherwise would be wasted is maintained or even improved, such as through remanufacturing, repairing, upgrading or re-marketing.	
Sharing models	The sharing platform model is centered on the sharing of products and assets that have a low ownership or use rate. Companies that leverage this model can maximize the use of the products they sell, enhance productivity and value creation.	
Dematerialization from product to services	Through the product as a service BM, customers use products through a lease or pay-for-use arrangement versus the conventional buy-to-own approach. This model is attractive for companies with high operational costs and ability to manage maintenance of that service and recapture residual value at the end of life.	
Stewardship role in stakeholders engagement	Proactively engaging stakeholders to ensure their long-term health and well-being and promotion of co-development, co-creation and synergies	
Encourage sufficiency and efficiency	Solutions that seek to reduce consumption and production by eliminating superfluous features and improving the efficiently through design	
Develop Scale-up solutions	Delivering sustainable solutions on a large scale to maximise benefits for society and the environment.	

Sources: //www.greenbiz.com/article/5-business-models-put-circular-economy-work A literature and practice review to develop sustainable business model archetypes- N.M.P. Bocken*, S.W. Short, P. Rana, S. Evans University, adapted

Innovation level

The project can be oriented for a specific level of innovation according to the objectives and strategy of the company and the design team, however, the level of innovation has a direct relationship between the financial resources needed, the development time, the know-how, human resources, technologies, etc. In this step analyze the four innovation levels and indicate the level expected for the project.



Source: https://gbr.pepperdine.edu/2010/10/the-four-levels-of-innovation/

Figure 4: Innovation levels

Which is the innovation goal for your project? Level 1 ☐ Level 2 ☐ Level 3 ☐ Level 4 ☐

Justify your selection

Project definition (1)

Defining the strategy, goals and characteristics for the circular design project.

Based on the previous analysis, this worksheet aims to systematize and define the project under development.
This document will support the team in the definition of the project and will guide the design project.

What product or service has to be developed? Or what is the function or problem addressed?	Define the product, service, function or problem that will be addressed in the project	
Circularity and sustainability goals for the project?	Indicate the goals that will guide the project	
Motivations	Indicate the main motivations for the project	
Target group	Indicate for whom the product or service will be developed. Indicate the main characteristics of the target group	
Business model	Indicate the business model expected for the solution to be developed.	

Project definition (2)

Innovation Level	Indicate what is expected in terms of innovation for the new solutions according with the context in which the new project is based	
Resources available	Indicate the resources that are available for the project (Human resources, technological resources, budget, etc)	
Project team	Identify the project team (internal or external) and describe their role in the project	
Time available to develop the project	Indicate the expected or available time to develop the project	

Rounding the vertices

Define the strategy for the project aiming to improve the efficiency in each area.

Having in mind the project definition and the requirements identified, the design and development team should indicate in this stage which are the objectives and the strategy towards the four levels of the rounding the vertices concepts.
Here, the team will indicate how to improve the function of the product or service, how to improve the efficiency in term of resources used within the life cycle, and how to improve the economic and social aspects of the product or service system.

Function

F

How can the function of the product be improved?

Physical resources

R

How can the resources efficiency be improved?

Economic resources

E

How can the costs and revenues be improved?

Social dimension

S

How can the project improve society?

ROUNDING THE VERTICES

#2 Project Planning Worksheet

This worksheet helps design managers and design team in the planning and management of design projects for a circular economy.

Planning the design project towards circularity

Planning of the project

Defining the scope and deliverables for the project

Define the scope of the project and define the deliverables that are planned for the project.

Define the boundaries of the project.

Indicate the scope of the project under development and describe what should result from the project.

(eg. Tecnical drawings, renderings, mock-ups, prototypes,etc)

Planning of the project

Identifying the stakeholders for the project

Indicate the main stakeholders for the project and what will be their involvement and importance in the project.

STAKEHOLDER	PURPOSE	LEVEL OF IMPORTANCE
Insert the stakholder name (or type)	What will be the involvement of the stakeholder. Why do we need to involve this stakeholder?	Select the level of importance of each stakeholder (1 - low, 10 - High)

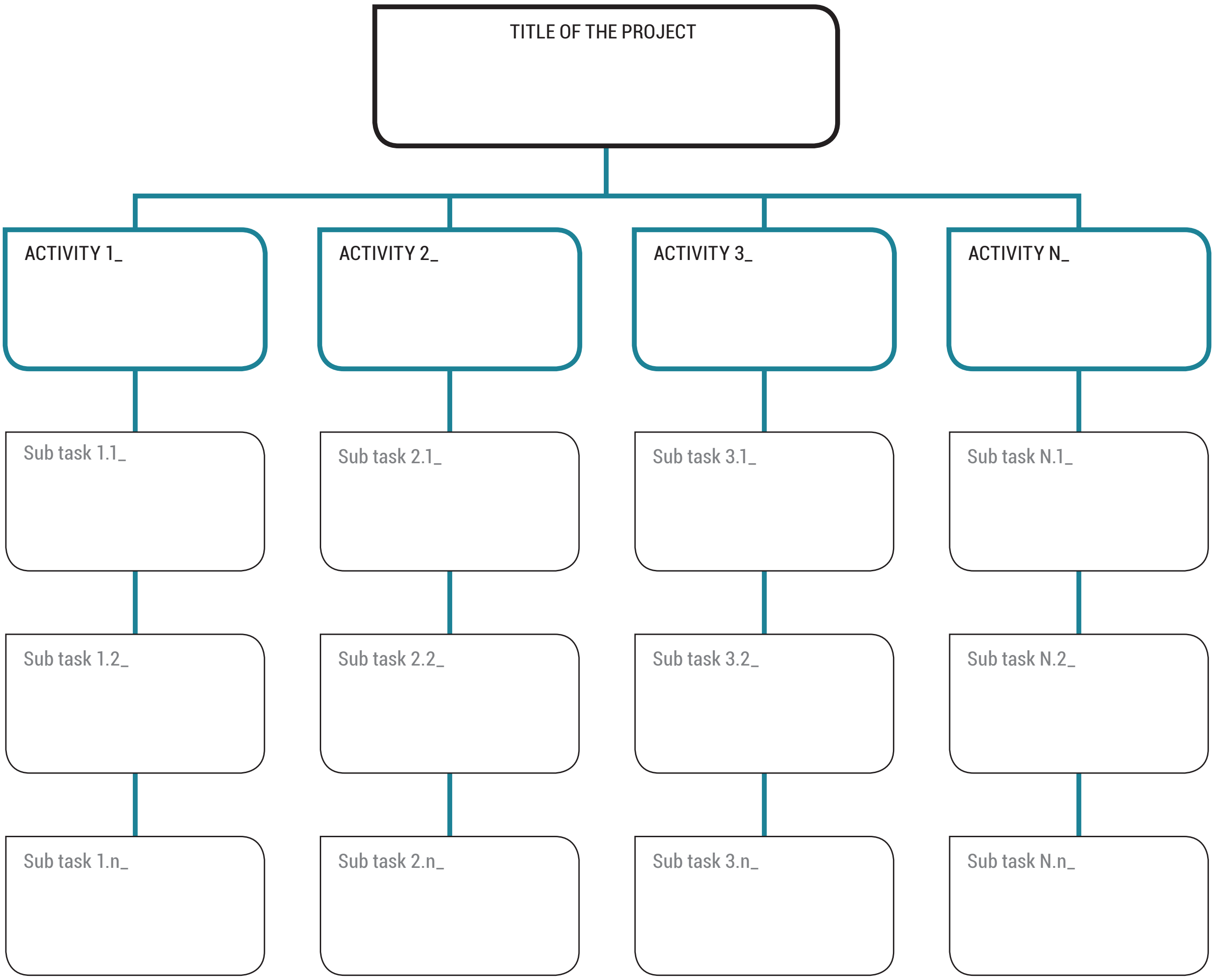
Source: CE Value Chains tool, KATCH_e

Planning of the project

Defining the activities and taks for the project

This worksheet helps design managers and design teams in the planning and management of design projects for a circular economy.

In this sheet, the management team should identify the main activities and their related subtasks in order to develop the circular design project. These must reflect the needs identified and the goals of the current project. The number of activities and sub tasks should be adapted to the specifications of the project.



In this step, the management team should identify the resources and time needed to perform the main activities and their related subtasks.

TITLE OF THE PROJECT

ACTIVITY	SUB TASKS	RESOURCES	DURATION
Indicate the activities defined for the project	Indicate the sub tasks defined for the project	Which resources are needed to fulfil the task?	How much time is needed to perform the task?
ACTIVITY 01_	Sub task 1.1_	Resources_	Estimation of time_
	Sub task 1.2_	Resources_	Estimation of time_
	Sub task 1.3_	Resources_	Estimation of time_
ACTIVITY 02_	Sub task 2.1_	Resources_	Estimation of time_
	Sub task 2.2_	Resources_	Estimation of time_
	Sub task 2.3_	Resources_	Estimation of time_
ACTIVITY N_	Sub task n.1_	Resources_	Estimation of time_
	Sub task n.2_	Resources_	Estimation of time_
	Sub task n.3_	Resources_	Estimation of time_

#3 Circular Design Mbox

This worksheet helps the design teams in the identification of ideas for circular product development

Development of new concepts

Circular Design Mbox

10 principles to support the design process towards more sustainable and circular products and services

In the design practice towards circular economy and sustainability, with the objective of creating innovative solutions for products and services, the design team can apply a set of principles that support and systematize the process.

The 10 principles that compose the Rounding the vertices approach were developed based on a research process in which several methodologies, tools and different approaches were analysed.

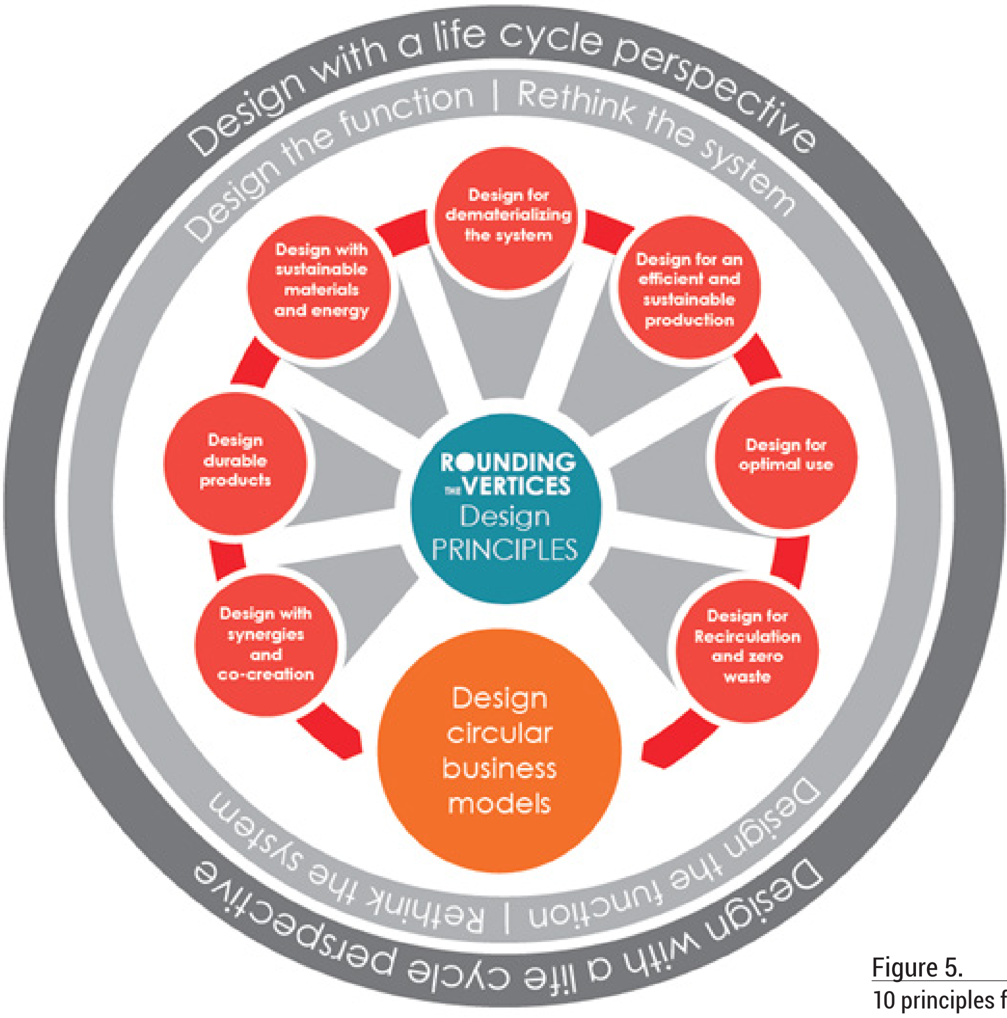


Figure 5.
10 principles for Circular Design

The principles, developed for designers, are project-oriented and through their analysis and implementation, the design teams can, in a holist approach, identify design opportunities that result in more circular and sustainable solutions.

The first two principles, **Design with a Life Cycle Perspective** and **Design the function/ Rethink the system** (outer rings in the figure 5), are seen as an umbrella principle that supports and validates the design process.

Considering the **life cycle perspective** is fundamental in the development of circular and sustainable products or services and to provide decision-makers with information on the impacts (environmental, economic and social) of different choices taking into account the positive and negative impacts of the entire life cycle (KATCH_e BOOK).

This approach allows a reasoned consideration of the trade-offs between different environmental aspects throughout all life cycle stages (IEC 62430:2019)

Life cycle perspective means the consideration of environmental aspects relevant to a product or service during its entire life cycle. This implies considering the interlinked stages that compose the life cycle (ISO 14006:2020). Within the design process, the life cycle perspective has as its main objective the reduction of the overall adverse environmental impacts of the product in parallel with the usual development aspects such as safety, quality, functionality, ergonomics, aesthetics, etc (IEC 62430:2019)

Without a life cycle perspective, there is no guarantee that the design team and the solutions attained in the project are really reducing the impacts of the product or the service. Through a life cycle analysis (quantitative or qualitative, depending on the objectives, the project, the resources, time, etc), the team, can validate the solutions and can communicate them to the stakeholders.

Design the function/Rethink the system aims to understand the function and the needs of the users and identify new opportunities to fulfil the needs in a more circular and sustainable way. Making something more circular requires rethinking the process, rethinking the system and the function of the product.

At the beginning of the project, the design team must put into question the function of the product. Does the user need the product? Does the product fulfil the function in an efficient way? Are there other ways to fulfill the function?

By having a function approach, there is more potential to innovate, to achieve out-of-the-box solutions, and new ways to attain a solution with an improved circularity and sustainability profile.

The following principles (red circles in figure 5.), are operational principles. These provide different aspects to consider in the design and development process.

DESIGN WITH SYNERGIES AND CO-CREATION focus on exploring the potential to establish collaborations in the design process and the product or service system

DESIGN DURABLE PRODUCTS, a principle to ensure a long utilization period of products, maintaining its function and service over a longer period of time.

DESIGN WITH SUSTAINABLE MATERIALS AND ENERGY focusing on the conscious selection of more efficient inputs within the entire life cycle of the product.

DESIGN FOR DEMATERIALIZING THE SYSTEM, a principle in which the needs of the users are fulfilled with more dematerialized solutions and product-services or services solutions

DESIGN FOR AN EFFICIENT AND SUSTAINABLE PRODUCTION, based on the optimization of the production process through design solutions.

DESIGN FOR OPTIMAL USE, aiming to optimize the relation of the product and the user

DESIGN FOR RECIRCULATION AND ZERO WASTE, aiming to close the loop by developing solutions to close the material cycles and eliminate the production of waste in the life cycle.

The final principle is the **DESIGN OF CIRCULAR BUSINESS MODELS**, (orange circle in figure 2.). This principle is the last one since it aggregates the results of the application of the previous principles. In the transition from the linear economy to a circular economy. We need to rethink the business models in order to achieve long-lasting and effective circular and sustainable solutions.

The circular design morphological box combines the concept of the morphological box tool, widely used by designers in the identification of design solutions, with the 10 design principles for circularity and sustainability.

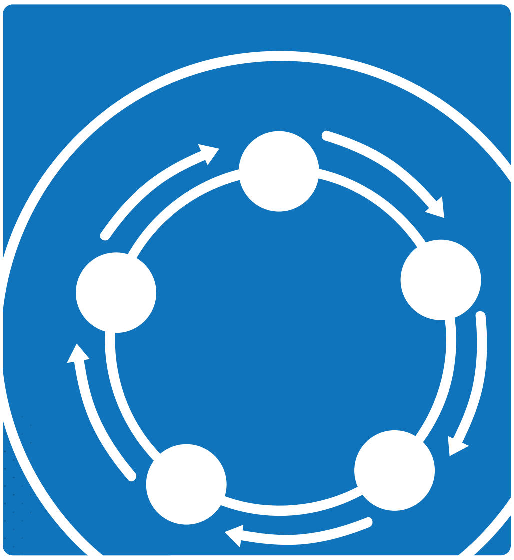
The 10 principles that compose the Rounding the vertices approach were developed based on a research process in which several methodologies, tools and different approaches were analysed.

These principles, developed for designers, are project-oriented and through their analysis and implementation, the design teams can, in a holist approach, identify design opportunities that result in more circular and sustainable solutions.

With the support of the tool, design teams can implement the design principles in a systematized approach, leading to innovative and circular solutions for product and service development.

In the next pages, the principles are explained and some ideas on what to consider in the design phase are presented. These should support the design teams in the identification of opportunities for the project and their application can result in new products and services.

1. Design with a Life Cycle Perspective



It is estimated that over 80% of all product-related environmental impacts are determined in the design phase. Therefore, it is crucial to design with a life cycle perspective in order to minimize, or ideally, eliminate impacts considering the entire life cycle of products and services.

The design and development teams should ensure that circular economy aspects are integrated into product design and development early in the development process with the aim of improving circularity and reducing impacts throughout the entire life cycle of the product or services (BS 8001), while still taking into account other design aspects such as safety, quality, ergonomics, aesthetics, and also, considering the trade-offs and compromises between different environmental aspects and the attained solutions (IEC 62430 2019).

Designing for the circular economy and aiming for a more effective and optimized management of resources across the life cycle with a holistic perspective should lead to a positive impact on the natural environment and society (BS 8001). Therefore, top management and decision-makers should ensure that strategies are planned, implemented and maintained, considering all stages in the life cycle of a product (ISO 14006:2020), through design.

If the reference product was developed with a life cycle perspective, please describe how it was considered.	
Indicate the objectives/gaps for your project in regard to life cycle perspective.	

What to consider in the design phase

1.1 Consider all life cycle phases

The design team, when designing with a circularity and sustainability focus, must adopt a holistic approach and consider the entire life cycle of the product or service in the process, considering all "*Consecutive and interlinked stages of a product (or service) system, from the raw material acquisition or generation from natural resources to final disposal. (...) including the acquisition of raw materials, design, production, transportation/ delivery, use, end-of-life treatment and final disposal.*" (ISO 14001)

1.2 Analise the impacts in each phase/ Conduct LCA studies

In order to guide the design process towards the minimization or elimination of impacts in the life cycle of products or services, the design team must have knowledge about the environmental profile of the products. In this regard, a life cycle assessment is fundamental to have a clear overview and perception of the impacts in each stage.
For the Identification and evaluation of environmental aspects, the team should establish, implement and maintain a process to identify and evaluate product-related environmental aspects and impacts throughout the life cycle. This assessment, according to the objectives and resources of the project can have a qualitative or quantitative evaluation and prioritization of the environmental aspects, however, where feasible, the quantitative approach is encouraged (IEC 62430:2019).
By conduction LCA studies, the team can also identify opportunities to improve the environmental performance of products acting in several stages in their life cycle, support the information to decision-makers for strategic planning, priority setting, product or process design or redesign, marketing purposes, or other (ISO/FDIS 14040).

1.3 Avoid the transference of impacts for other phases of the life cycle

The life cycle approach, through an overview of the impacts in all stages, can avoid the transference of impacts from one stage to another, which is a common result of projects developed without a life cycle approach.
The transference of impacts can occur from one stage to another, from one region to another or even from one impact category to another. For example, one solution can reduce the quantity of a material used in the product, however, for this reduction, the material was substituted by a different material, produced in a far location, resulting in a material with a higher embodied energy.

	DESCRIBE YOUR PRODUCT ACCORDING TO THE LIFE CYCLE STAGES	IDENTIFY THE MAIN IMPACTS RELATED TO THE STAGE
RESOURCES	Identify and describe the resources used in your product, considering materials, energy and water	Identify the impacts related to the resources used in your product
PRODUCTION	Describe the production of the product	Identify the main impacts related to the production
DISTRIBUCTION	Describe how the product is distributed	Identify the main impacts related to the distribution
USE	Describe how the product is used, including the use, consumables, maintenance, repair, etc	Identify the main impacts related to the use of the product
END OF FUNCTIONAL LIFE	Describe what hapens after the functional use of the product.	Identify the main impacts related to the end of funcional life of the product
Explain how the impacts were identified	In this field describe the source of the inputs. Are they based on a Life cycle analisys? Qualitative or quantitative?	

2. Design the Function /Rethink the System

The circular economy can be characterized by a Rethink approach. To make something more circular requires a rethinking process. (Morseletto, 2020)

Rethinking the system and the function of the product is a way to look at your product and envision sustainable alternatives by thinking outside the box and have new approaches and perspectives for the product and the system which are translated into new or reshaped objectives for the design project.

Rethinking allows an identification of alternative design solutions to solve the problem (BS8001). In a circular design approach, the focus should be on the outcome to fulfil a specific need. The key is to design the most sustainable way of producing that outcome. Outcome-driven thinking places the focus on the function the user needs and not on the solutions of how to produce or deliver the offering (Niinimäki & Hassi 2011).

Rethinking is about developing new ideas and solutions to provide certain product functions in line with the needs of the users, including the re-elaboration/reconceptualisation of ideas, dynamics, processes, concepts, uses, and post uses of a product (Morseletto, 2020).

Indicate the current situation. Explain briefly the funtion of your product or service	
Indicate the objectives/gaps for your project according to the function of your product	

What to consider in the design phase

2.1 Question the function

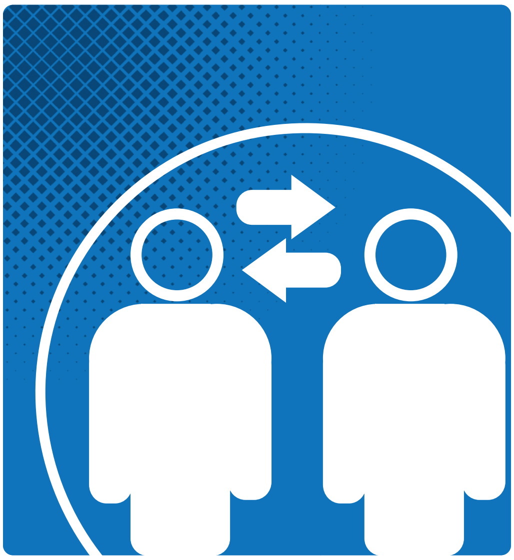
In a circular economy approach, aiming to close the material and component loops in a sustainable way, the design team should put into question the function of the product. Perhaps, the users do not need a product at all, or their needs can be fulfilled with a totally different solution. The circular economy needs an out-of-the-box approach in attaining innovative solutions.
By approaching the process through the function, the potential to innovate is higher.
In this regard, a function analysis, which is a fundamental phase in the value analysis methodology which consists of a systematic process to describe the product through its function, can be implemented. The product is not considered as a specific solution with a group of components, but through a set of functions that will satisfy the needs of the user (Justina et al., 2007), it supports a creative problem-solving approach by moving the focus away from the expected solution and placing the focus on the required performance or need (valueanalysis.ca.)

2.2 Develop new concepts

Most design projects are developed with a lower innovation level, focusing mainly on product improvements or product redesign. With this approach, the new solutions attained can improve the systems by developing better products with lower environmental impacts, however, disruptive solutions with a higher potential for circular economy and sustainability are almost impossible to occur.
To have an effective approach and reach a higher level of innovation and sustainability, the design teams must innovate with alternative ways to fulfil the functions and the needs of the users.
It is recommended to start by thinking “out of the box” and develop new concepts (Rocha et al, 2015) and new solutions that rethink the entire system. Not only the product itself but the entire context in which the product operates.

	WHAT IS THE FUNCTION OF THE PRODUCT?	
FUNCTION	Describe the function without describing the product	
FOR REFLECTION	DOES THE USER NEED A PHYSICAL PRODUCT?	
DEVELOP NEW CONCEPTS	Identify alternative ways to fulfil the funcion	

3. Design with Synergies and Co-creation



The design practice has been evolving. This evolution, from a user-centered approach to co-designing, is changing the roles of the designer, the researcher and the users (Elizabeth, 2008).

In design for a circular economy, as a new step in the design evolution, changes are needed in the field of design and design education towards disruptive innovations for transformation, intelligent systems, open design and others, and a new views and approaches on design processes. The participation of the stakeholders in the process is being promoted, especially through collaborative forms like open design, co-creation and participatory design (Hummels, 2012), and the establishment of synergies in the value chain.

Some authors even consider that without collaboration initiatives, it is unlikely that an organization can achieve a successful and substantial progress in the transition to a more circular and sustainable economy (BS 8001).

Indicate the current situation. Explain how synergies and co-creation are related to reference product or reference situation	
Indicate the objectives/gaps for your project regarding synergies and co-creation	

What to consider in the design phase

3.1 Collaborate and co-design

The design practice for circular economy and sustainability should promote the collaboration of designers and other professionals in order to attain the needs of the projects along the life cycle. Building teams to strengthen knowledge and expertise, building relationships with stakeholders (Circular design guide), providing space for customers and users, to be actively involved in design and development of products and services (Marlien, 2019) will influence the innovation and the identification of new ideas with a higher potential of success.

Adopting co-creation initiatives into the design practice will cause several changes to occur in the process. It will change the design practice, what is designed, and who designs (Elizabeth et al., 2008). Co-designing will promote a close collaboration between stakeholders in the design development process together with other professionals with other skills (Elizabeth et al., 2008) allowing to explore the potential of each actor, creating value in the process, reducing risks, costs and increase the potential for success.

3.2 Synergies

In a circular economy, it is advocated to optimize resources, optimise the material flows and create alternative and efficient ways of production and consumption focusing on maintaining materials and components in use without the generation of waste. These goals, to be effective and implemented in practice through design, must consider and explore the potential synergies that can be created in the value chain.

The creation of synergies which promote collaboration throughout the supply chain will increase transparency and create a joint value (Circle economy)

3.3 Industrial Symbiosis

The design of new products, services, or systems must consider the potential for the establishment of industrial symbiosis solutions, in which the waste or by-products of an industry or industrial process becomes the raw materials for another. The application of this concept allows a more sustainable use of resources and contributes to the creation of a circular and sustainable economy (ec.europa.eu 2018).

This process-orientated, approach focused on using residual outputs from one process as feedstock for another process must consider the geographical proximity of businesses (Bocken et al., 2016) in order to be efficient and add value for all actors involved in the process or system.

The benefits for the business network can have significant impacts, such as the reduction in overall operating cost and risks, the establishment of reliable alliances, increase the trust in partnerships, joint innovation processes, sharing of assets, services, etc.

	WHICH SYNERGIES AND CO-CREATION ACTIVITIES CAN BE IMPLEMENTED IN YOUR PROJECT?		
	COLLABORATE AND CO-DESIGN	SYNERGIES	INDUSTRIAL SYMBIOSIS
	Identify ideas for collaboration and co-design development within the project	Identify potential synergies that can support the project and the product or service developed	Identify potential industrial symbiosis related to the product and the company
01			
02			
03			
04			
05			

4. Design Durable Products

Designing durable products with a long-life is concerned with ensuring a long utilization period of products, maintaining its function and service over a longer period of time without loss of performance (Rocha et al., 2019), aims for a maximum potential lifetime of a product, component or material to perform a required function under intended conditions of use and maintenance before it becomes obsolete because it can't fulfil its function (BS8001).

New products should be designed to be durable for a long lifetime through the integration of solutions and features that facilitate easy repair, particularly by third parties, (BS8001), maintenance, upgrade, etc. The design team must also select effective materials and components that guarantee the durability of the product. Designing for durability is mainly focused on the physical durability, by the development of products that can take the wear and tear without breaking down, attained by design solutions and effective material selection, by designing reliable products that will operate throughout a specified period without (Bocken et al., 2016), and by developing product life extension features concerned with an increase in the use period of products, through maintenance, repair and upgrading characteristics defined at the design stage (Rocha et al., 2019).

The objective of this principle is to extend the technical, aesthetic and emotional lifetime of the product so that it will be used for as long as possible. While this strategy may seem unattractive for companies because they would "sell less", it can be interesting and competitive for certain types of products and market segments where high quality and durability are a strong sales argument (Rocha et al., 2015).

Developing durable products, that are used and maintained for longer is the counter-strategy to the implanted programmed obsolescence, which is linked to techniques and solutions by which an "organization seeks to deliberately limit product lifetime in order to increase replacement rate" (BS 8001).

Indicate the current situation. Explain how the reference product of reference situation is performing regarding durability	
Indicate the objectives/gaps for your project in terms of durability	

What to consider in the design phase

4.1 Quality of materials

The selection of the more suitable materials to fulfil the needs of the product and their function is crucial in design for the circular economy. The adequate material will promote the durability of the product without creating additional needs in the life cycle of the product.

The quality of the materials in the product should be selected according to the function, considering the implications and trade-offs in the life cycle of the product. For example, the selection of a high grade and high-quality material for a product that has a short life and will be recycled after a short period of time is not a good option.

4.2 Reparability

Durable products that can be used for long periods of time should rely on the possibility of being repaired easily and at an affordable cost for the user.

In the design phase, the design team should include features to promote and facilitate the reparability of the product. Features like a design for easy disassembly, the use of standard components, diagnosis systems, repair information, repair services, etc, should be developed.

4.3 Maintenance

Easy and affordable maintenance of the product can have a high impact on durability of a product. Maintenance involves functional checks, servicing, replacing consumables, cleaning, and other activities. For example, a product that due to its shape or material is difficult or expensive to clean tends to be discarded and replaced easily by the user.

4.4 Upgradability

The needs of the users tend to evolve over time, and these new needs can be attained by the replacement of the product by new versions of updated products, or by the upgrade of the current products. In the circular economy, to develop sustainable solutions, the product must be in use for the longest possible period of time. This can be attained by solutions to upgrade the existing products by developing solutions that promote the technical or aesthetical upgrade potential, with an added value for the user.

4.5 Wear-resistant design solutions

Durable products must be resistant to wear and the loss of properties over time. The design team must consider these aspects and include solutions to minimize them. This can be achieved by the selection of adequate materials, as well as by the design of the product. For example, products that are not user friendly, with complex features tend to have a higher pressure on the structure of the product, leading in most cases to a reduced use due to wear.

4.6 Product-user relation

The challenge for designers is to create products with a stronger emphatic relation with the user. Products that, due to their characteristics, will be attractive for users to purchase, use and maintain (Rocha et all 2015). Designing for attachment and trust or for emotional durability refers to the creation of products that will be used, liked or trusted longer (Bocken 2016).
By attaching this emotional aspect to products, the design team is able to develop solutions that by exploring the potential, will avoid the replacement by other products, reducing the needs of producing and placing more products in the market and therefore, the reduction of impacts in the system.

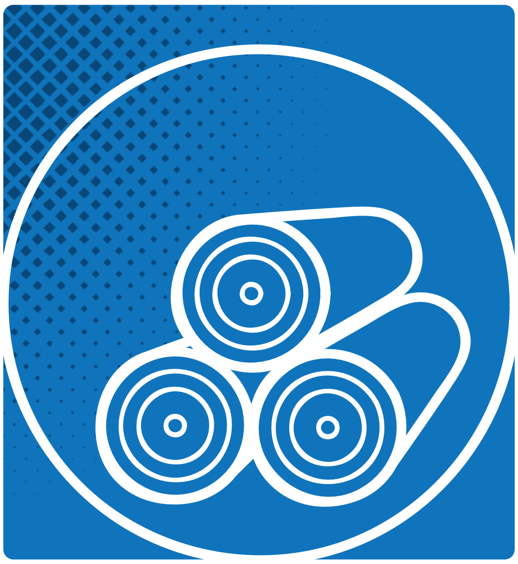
4.7 Simplicity principle

The simplicity principle has the potential to increase the durability of the products and it can be implemented in several ways. Simple solutions will promote a better use of the product, with a lower margin of error. The simple architecture of the product will promote the reparability and maintenance of the product. Simple and timeless design solutions will avoid disposal due to fashion issues.

	HOW CAN YOU CREATE AND DEVELOP A MORE DURABLE PRODUCT? (1)			
	QUALITY OF MATERIALS	REPARABILITY	MAINTENANCE	UPGRADABILITY
	Identify ideas for a selection of more suitable materials to fulfill the needs of the product and their function	Identify ideas that promote the reparability of your products	Identify ideas that promote the reparability or maintenance of your products	Identify ideas that promote the technical and aesthetical upgrade of you products
01				
02				
03				
04				
05				

	HOW CAN YOU CREATE AND DEVELOP A MORE DURABLE PRODUCT? (2)		
	WEAR-RESISTANT DESIGN SOLUTIONS	PRODUCT/USER RELATION	SIMPLICITY PRINCIPLE
	Identify ideas to improve the resistance to wear and loss of properties of your product	Identify ideas to create products with a stronger emphatic relation with the user	Identify ideas in order to simplify your product and promote efficient usage
01			
02			
03			
04			
05			

5. Design with Sustainable Materials and Energy



Material selection is a key step in design for circular economy and sustainability. The objective is to select sustainable materials without increasing costs or degrading the product functionality (IEC 62430:2019), seeking the best match between design requirements for the product and material properties (Rocha et al., 2019).

The selection of the energy that is used for and by the product is a crucial factor to be considered as well. In the design phase, the design teams can select materials and energy with lower impacts. The decisions taken in the design phase are fundamental to influence the efficiency and optimization of material and energy consumption in the life cycle of the product or service (Rocha et al., 2020).

The properties and functionality of materials are continuously evolving as a result of material innovation and new and more effective material applications. The selection of materials must have consider their sustainability and the designers should take into account the social, economic and environmental aspects throughout the material's life cycle (BS 8001).

Indicate the current situation. Explain how sustainable are the materials used in the reference product of reference situation	
Indicate the objectives/gaps for your project according to sustainable materials and energy	

What to consider in the design phase

5.1 Recyclable materials

In a circular economy approach, to attain the goal of closing material loops, the selection of materials has an important role. The materials selected for a new product must allow that after its use they can be recycled.

5.2 Recycled materials

In order to maintain the materials in the circular loop, the design solutions must replace virgin materials and consider the selection of recycled materials as much as possible.

5.3 Low embodied energy materials

In the transition to circular and sustainable solutions, the embodied energy should be considered by designers in the development of a product. Embodied energy comprises the energy consumed during the extraction and processing of raw materials, transportation of the raw materials, manufacturing of materials and components and the energy used for various processes during the end of life (Rocha et al 2020). The higher the energy consumption, the higher the environmental impact of the product.

5.4 Renewable materials

The selection of materials to meet the needs of the product must consider the use of renewable materials. These are potentially more sustainable since they are "*resources that are able to be renewed or replenished by ecological cycles or agricultural processes at a rate equal to or greater than consumption so that the products and services provided by these resources are not endangered and remain available for future use*" (BS8001).

5.5 Renewable energy

The design team should evaluate the consumption of energy along the product's life cycle and prioritize the selection of renewable energy sources.

5.6 Non-toxic materials

The selection of materials must consider their toxicity. Hazardous substances in the product must be avoided.

5.7 Efficient materials

Sometimes materials may seem not interesting from a sustainability point of view if considered alone, however they can have a positive influence on the product system and the life cycle. For example, a material can have a high consumption of energy in its production, but its application on a product will highly increase the durability.

5.8 Fair materials

Fair materials are materials that are fair from a social point of view. The materials used in a product have a direct impact on the environment and on the people that are linked to those materials in all stages of the life cycle. From the conditions in which they are extracted or produced, transported, the consequences of their use in production, use and in the valorization after the use. Problems like pollution, dangerous working conditions, child labour, etc, are linked to the materials "DNA" and these aspects must be considered in the selection of materials.

5.9 Local materials

In the selection of materials, their origin must be a criterion to consider due to the environmental impacts of transport, associated to the consumption of fossil fuels and the emissions. In most of the cases, the preference should be given to materials that are extracted and processed near the production facilities. (Rocha et al., 2015) This aspect also has social impacts that must be considered. Local materials tend to have benefits on local communities.

WHICH SUSTAINABLE MATERIASL AND ENERGY CAN YOU ADOPT FOR YOUR SOLUTION?				
	RECYCLABLE MATERIALS	RECYCLED MATERIALS	LOW EMBODIED ENERGY MATERIALS	RENEWABLE MATERIALS
	Which recyclable material can be applied in the project?	Which recycled material can be applied in the project?	Considering the embodied energy of materials, which are suitable for the project?	Which renewable materials can be applied in the project?
01				
02				
03				
04				
05				

	WHICH SUSTAINABLE MATERIASL AND ENERGY CAN YOU ADOPT FOR YOUR SOLUTION?			
	RENEWABLE ENERGY	NON TOXIC MATERIALS	EFFICIENT MATERIALS	FAIR MATERIALS
	How can renewable energy be used by the product?	How can we avoid the use of toxic materials in the life cycle of the product?	Which materials are efficient and have a positive impact in the product system?	Which fair materials from a social point of view can be used ?
01				
02				
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04				
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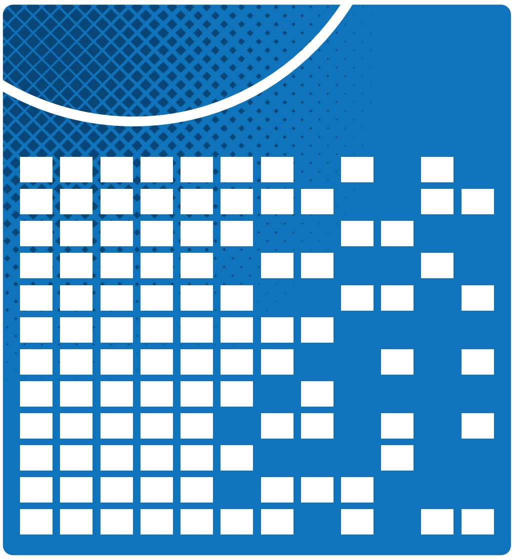
6. Design for Dematerializing the System



"We need to embrace dematerialisation, rethink concepts of ownership and move from resource efficiency to resource sufficiency". Janez Potočnik (Circle Economy, 2021).

We need to change the way to fulfil the needs of the users in a more sustainable and dematerialized way. If we achieve a reduction in the inputs of the material to fulfil the functions, we can achieve a higher circularity level and create more value.

With a dematerialization focus, the designer must deliver a function with no or reduced input of materials, often through moving from physical products to digital alternatives (BS 8001), to services or a combination of both. These new approaches to product and service development can be attained by strategies like the reuse of products and components, sharing, leasing, repair, refurbishment and recycling of products (EEA 2016), among other solutions.

The need towards the dematerialisation of production and consumption are not likely to happen through efficiency improvements. There is a need for shift from the current technological paradigm (Idil Gaziulusoy, 2015) through the design and development of new solutions.

Product/service-systems, as a means to dematerialize the system started to gain momentum due to the high potential for enhanced environmental performance and improved competitiveness (Mcaloone & Pigosso, 2017) and the combination of tangible products with intangible value-added services that lead to dematerialization by reducing the production of waste in the life cycle, by reducing the consumption of resources, and by decoupling the economic growth from environmental impacts, and by creating new revenue streams and extending the residual value of products (Romero & Rossi, 2017).

Indicate the current situation. Explain how the reference product of reference situation is performing according to dematerailization	
Indicate the objectives/gaps for your project according dematerialization	

What to consider in the design phase

6.1 Sharing
Sharing of product in order to meet the needs of the users enables an increased utilization rate of products and services by making possible a shared use or ownership among consumers. It enables customers to access a product, rather than owning it, and use it only as needed (BS8001). With this solution, the same product can satisfy the needs of more users which leads to solutions that use fewer raw materials and can still meet the demands of consumers, or even more.

6.2 Leasing
In leasing solutions, the needs of the users, through a contract with a regular fee, can be satisfied by products or services that are leased from a service provider. The provider retains ownership and is often responsible for maintenance, repair, and control (Rocha et al,, 2020, BS8001).

6.3 Virtualization
Deliver utility virtually. Replacing physical infrastructure and assets with digital/virtual services offers dematerialization advantages over tangible products, but without reducing the perceived value to the customer (BS8001).
Through digitalisation, everything becomes connected, such as intelligent infrastructure, energy networks, the "Internet of things", and social networks (Dutch Ministry of Infrastructure and the Environment & Ministry of Economic Affairs, 2016).

6.4 Increase service component
For the adoption of dematerialized solutions, the design team must develop the system in order to maintain the added value for the users. These solutions, in general, must optimize and increase the services that are provided to the user

	HOW CAN YOU DEMATERIALIZE THE SYSTEM IN WHICH YOUR PRODUCT OPERATES?			
	SHARING	LEASING	VIRTUALIZATION	SERVICITYZE, INCREASE SERVICE COMPONENT
	Identify ideas to meet the needs of the users with a solution in which the product is shared by several users	Identify ideas to satisfy the needs with products or services that are leased from a service provider	How can we deliver utility virtually? How to replace physical infrastructure and assets with digital/virtual services .	Identify ideas to increase the service component of the product or services system
01				
02				
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04				
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7. Design for Efficient and Sustainable Production

The Circularity approach is essential in the transformation of industry towards climate-neutrality and long-term competitiveness (European Commission, 2020) and continually challenges current business practices and methods (BS8001). The design practice can support and streamline the production processes to implement circularity, reduction of waste and optimization of resource consumptions, promotion of useful applications for materials, etc (Simeone et al, (2019). Leading the transition, 2017).

Design for an efficient production focuses on adopting design measures and innovative modes of operations that improve the production stage by reducing the consumption of resources per unit of output preventing/minimizing the generation of waste and emissions and improving the efficiency of the outputs, (products and subproducts) (Rocha et al., 2015, BS 8001).

The new product and service solutions should seek to maximise the resource efficiency, thereby minimising the waste production and the recirculation and reuse of waste and secondary products into the production (ESA, 2013) and considering the working conditions under which the products are made, including worker's rights and working conditions (Young et al 2008).

Indicate the current situation. Explain how the reference product of reference situation is produced	
Indicate the objectives/gaps for your project regarding the prodution process	

What to consider in the design phase

7.1 Reduce consumption of materials and energy

In a circular design approach, considering the entire life cycle of the product in the design phase, the design team must consider the production process and its stakeholders and implement measures to reduce the consumption of materials and energy. Simple solutions like changing the shape of a product can have a high impact on the production process by reducing the material needs or by eliminating steps in the productions, or even by avoiding failures.

7.2 Modularity

The adoption of modular solutions can optimize several aspects of the product life cycle. In production, this solution can have benefits at several levels. In production, it can optimize the process, reduce stocks, optimize costs, etc

7.3 Best available technics

Companies that apply the best available technics (BAT), potentially have benefits in terms of production. Usually, the new technics are more efficient in the production and consumption of resources. BAT allow also the integration of new features and developments with a higher potential to innovate.

7.4 Standardization

The use of standard solutions, materials and components in the production process tends to optimize the process, reducing production time, the needs of specific tools and equipment and the consequent reduction of costs. This approach has also benefits in other stages, it facilitates the assembly and disassembly process for repairing, upgrade, repurpose, recycling, etc.

	HOW CAN YOU PROMOTE A BETTER PRODUCTION SYTEM THROUGH DESIGN?			
	REDUCE CONSUMPTION OF MATERIALS AND ENERGY	MODULARITY	BEST AVAILABLE TECHNICS	STANDARDIZATION
	Indicate ideas to reduce the consumption of materials and energy	How can the solution adopt a modular solution?	Which are the best available technics that can be used?	Which standartization solutions can be applied?
01				
02				
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8. Design for Optimal Use

When considering the entire life cycle, the use phase is likely to have the greatest environmental impact. It involves the consumption of resources such as energy, consumables, and outputs such as waste and emissions during the use of the product (IEC 62430:2019).

In the design phase decisions that are made on products are crucial to influence the use phase positively (Rocha et al., 2019). The development team must consider and adopt strategies to prolong the life of the products, components and materials through durability, repair, upgrade etc, (BS8001).

Another crucial aspect is the interface and the relation between the product and the user. Products and services must be user friendly, effective and efficient in supporting the needs of the users without creating additional needs. Designing for an optimal use, will reduce the impacts and added values to the product or service system.

Indicate the current situation. Explain how the reference product of reference situation is performing in the use phase	
Indicate the objectives/gaps for your project for the use phase	

What to consider in the design phase

8.1 Reduce consumables

The design of a product or service must consider the consumables that will be needed for the product fulfill its function. Their optimization in terms of consumption, costs and impacts must be considered. In this stage it is also fundamental to avoid the creation of additional needs for the user.

8.2 Simplicity principle

The simplicity principle is a good approach to attain circular and sustainable solutions. By adopting simple solutions, the product is more user friendly, the product is used better, for longer, risk and damages are minimized and costs are reduced, etc

Through simplicity, by the opposition and in consequence of complexity, designers can potentially grant access to a better quality of life and improved access to technological artefacts and products by allowing its interaction and use in a simpler way (Duarte, 2013), Morseletto, 2020).

8.3 Inclusive design/design for all

Inclusive design, as defined by the British Standards Institute is ‘The design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible … without the need for special adaptation or specialised design.’ (BS 7000-6:2005).

When designing for the circular economy, the design team should, besides the circularity goals, assure that the solutions attained are sustainable considering the three pillars of sustainability, (environment, economy and society). Therefore, social aspects, which are often forgotten by most teams, are important to sustain the solutions and the welfare of society.

Since the design options have the potential to include or exclude users, it is relevant to consider an inclusive design approach, which emphasizes the contribution that understanding user diversity makes to informing designers decisions, and thus to including as many people as possible as potential users (Inclusive design toolkit).

	HOW CAN YOU OPTIMIZE THE USE OF YOUR PRODUCT?		
	REDUCE CONSUMABLES	SIMPLICITY PRINCIPLE	INCLUSIVE DESIGN/DESIGN FOR ALL
	How can the consumption of consumables be reduced in the use phase of the product or service?	Indicate ideas to simplfy the use of the product or service	Indicate solutions that are inclusive and can be used by all
01			
02			
03			
04			
05			

9. Design for Recirculation and Zero Waste

The circular economy is seen as a new way to design, produce and use products and services in a more efficient and sustainable way. Based on the principles of elimination of the generation of waste in the system, the recirculation of products and materials and the regeneration of natural systems, (EMF) the adoption of the concept maintains or even increases the value of products, materials and resources in the economy for as long as possible, contributing for an efficient and competitive economy (EC 2015).

The waste, seen as the result of system inefficiency and symbolising bad design options, should be considered as input material, as resources with value and potential to be used in the production process. The shift from "waste" to "resources" can boost the market for secondary materials, products and components. By reusing resources in the system and decreasing the dependence on virgin raw materials, it encourages the redesign of the resource life cycles (Eduzwace, 2020) and the improvement of the entire production and consumption system.

Indicate the current situation. Explain how the reference product of reference situation is performing according recirculation and zero waste	
Indicate the objectives/gaps for your project towards recirculation and zero waste	

What to consider in the design phase

9.1 Design for Reuse

Reuse is an action where products, components or materials can be used again for the same purpose for which they were conceived without the need for any modifications, reprocessing or treatment (BS 8001).
The reuse of products, components or materials means an extension of the utilization period, resulting in a slowdown of the flow of materials from production to recycling (Bocken et al, 2016). In order to promote an effective reuse, the products and services should be designed with features that optimize this potential (BS 8001).

9.2 Design for Recycling

Design for recycling is a method that incorporates recycling and recyclability criteria into the design phase of product intending to obtain recycled or recyclable products. Design for recycling is an important element in a circular economy with the potential to be exploited in order to increase recycling rates and close loops. Recycling is an important step in reducing demand for primary raw materials, minimizes the negative environmental impacts related to the production of primary material as well as reducing the volume of waste by closing the loop of material flows.
In the design phase, aiming to optimize the recyclability of products, the design team should consider the integration of features and properties to optimize the recycling process and optimize the quality of the materials resulting from the recycling process. Criteria such as the selection of materials, the compatibility of materials, the easy dissasembly and separation of different materials, etc, should be integrated in the design of the new product (Schuman, 2019)

9.3 Design for Remanufacturing

Remanufacturing is a production process in which the products, after their use, return to the factory, usually through a take-back system, and the whole product or components that are still in good condition can be used again as inputs for the production of new products. This concept avoids the need to produce new components and reduces the consumption of materials and energy, therefore, reducing the overall impacts of the product in their life cycle.
A remanufactured product should have the quality of a brand new one even when retrieving/reclaiming components from other products used as spare parts (Morseletto, 2020).

In order o allow this solution, the design team should develop the product and its components with this criterion in mind, the quality of the materials and components must allow the remanufacturing process and most important, an efficient take-back system must be implemented.

9.4 Refurbish

Refurbish refers to an aesthetic improvement of a product, component or material, which might involve making it look like new (BS 8001). After the end of their useful life, products can be refurbished in order to extend their lifetime. These solutions aim at restoring an old product and bringing it up to date. In the refurbishing process the function of a product that can be upgraded or modernized. In most cases, it does not involve a full disassembly but the replacement of parts. These products are upgraded and brought back to specified quality standards or satisfactory working and aesthetical conditions (Morseletto 2020).

9.5 Repair

By repairing the products, their lifetime is increased and the needs for the consumption of materials and energy to produce new products is reduced.
Repairing has the potential to retain finished goods and their parts in the economy for longer while maintaining or improving their value. Repair is also making a broken product operational again through fixing/replacing failed parts so it can be used with its original function (Morseletto, 2020).
Through design, features and services to promote the repairing process can be implemented. This consists of developing the product with solutions that allow the repairing process (easy disassembly, using of standard connecting elements, modular solutions, etc), and complemented by the availability of repairing services, availability of spare parts, supporting information on repairing, etc.

9.6 Eliminate waste

The circular economy approach advocates for the elimination of waste in the entire life cycle of the product and service. A zero-waste approach should be implemented by the design teams. In this regard, the team must, according to the specificities of the product or service, identify innovative solutions without the generation of unwanted outputs.
The Zero Waste concept focused on waste prevention that encourages the redesign of the resource life cycles so that all products and components are reused and integrated into the loops aims is for no trash to be sent to landfills, incinerators, the ocean (EDuzwace, 2020) or other.

	HOW CAN YOU RECIRCULATE MATERIALS AND COMPONENTES?		
	DESIGN FOR REUSE	DESIGN FOR RECYCLING	DESIGN FOR REMANUFACTURING
	Which features can you add in the solution to promote the reuse of components or materials	Indicate features to optimize the recycling process and optimization of the quality of the materials resulting from the recycling	Indicate ideas to implement a remanufaturing system
01			
02			
03			
04			
05			

	HOW CAN YOU RECIRCULATE MATERIALS AND COMPONENTES?		
	REFURBISH	DESIGN FOR REPAIR	ELIMINATE WASTE
	Indicate ideas to promote refurbishing in your solution	Which features and services can be implemented to promote the repairing process?	Indicate ideas to eliminate the production of waste considering the entire life cycle of the product or service
01			
02			
03			
04			
05			

10. Design Circular Business Models

In design for a circular economy, as seen in the previous pages, several solutions can be implemented to improve the circular and sustainable profile of products and services.
Many of these ideas can improve the product and the service, however, in most cases, to attain a higher potential for circularity, the business model needs to be adjusted, or new business models need to be created and developed. This new approach to circularity is leading to new businesses, new professions and new ways to fulfil the needs of the users with new opportunities to create greater value for all stakeholders.

Sustainable business models create a competitive advantage through superior customer value and contribute to the sustainable development of the company and society (Lüdeke-Freund, 2010), focused on efficiently offering a system of circular products and value-added services, and supporting circular systems (Romero & Rossi, 2017).

The creation of new sustainable business models promotes the integration of suitable approaches such as reuse, sharing, leasing, repair, refurbishment, recycling etc. By integrating the most suitable of these approaches to one's business- and product development will play a significant role in maintaining the utility of products, components and in realizing circular business models (Mcaloone & Pigosso, 2017).

Indicate the objectives/gaps for your project related to the business model	

What to consider in the design phase

10.1 Innovate the business model

Business model innovation, reflects the adjustments and changes in how a company delivers value to its customers, whether that's through the development of new structures, new revenue streams or new distribution channels. This innovation is focused on a conscious change of the existing business model or the creation of a new business model that satisfies the needs of the customer better than the current existing business models (Godinho, 2019).

10.2 Rethink and create new business models

Rethink the Business Model: Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services (Circle Economy, 2021). This can lead to the development and creation of new business models with a higher potential of circularity and sustainability

<table>
<tr><td></td><td colspan="2">WHAT IS THE BUSSINESS MODEL OF THE REFERENCE PRODUCT OR SERVICE?</td></tr>
<tr><td rowspan="2">CURRENT BUSINESS MODEL</td><td colspan="2">Describe the current bussiness model</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>FOR REFLECTION</td><td colspan="2">HOW CAN WE INNOVATE THE BUSINESS MODEL?</td></tr>
<tr><td rowspan="5">DEVELOP NEW BUSINESS MODELS</td><td colspan="2">Identify new business models that can be aplied for your solution</td></tr>
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NEW CONCEPT
development

NEW PRODUCT OR SERVICE AND BUSINESS MODEL FOR THE PROJECT/SOLUTION?
Based on the options selected develop the new product or service and describe the business model

NEW CONCEPT development

	DESCRIBE YOUR PRODUCT ACCORDING TO THE LIFE CYCLE STAGES
RESOURCES	Identify and describe the resources used in your product, considering materials, energy and water
PRODUCTION	Describe how your product is produced
DISTRIBUCTION	Describe how the product is distributed
USE	Describe how the product is used, including the use, consumables, maintenance, repair, etc
END OF FUNCTIONAL LIFE	Describe what happens after the functional use of the product

NEW CONCEPT - impacts

	IDENTIFY THE MAIN IMPACTS RELATED TO THE STAGE	
RESOURCES	Identify the impacts related to the resources used in your product	
PRODUCTION	Identify the main impacts related to the production	
DISTRIBUCTION	Identify the main impacts related to the distribution	
USE	Identify the main impacts related to the use of the product	
END OF FUNCTIONAL LIFE	Identify the main impacts related to the end of funcional life of the product	
Explain how the impacts were identified	In this field describe the source of the inputs. Are they based on a Life cycle analisys? Qualitative or quantitative?	

#4 Circularity assessment

For an assessment of circularity performance of the design process and the solutions developed

Circularity performance

Qualitative assessment of the circular approach in project design

How to asses the project and the results attained?

The **Design process Circularity Assessment** tool aims to evaluate the performance of the design project and its results, and how it contributes to the transition to circularity. Within the Rounding the vertices concept, with the tool, the user can assess how much the process led to a circular approach and how much the vertices of the initial square shape which represents the reference product was improved towards a more circular process and results.

The assessment relates the performance of the 10 design for circularity principles, which covers the entire design process, and reflects their impact in the four levels for circularity; the function level, the resources level, the social level and the economic level.

The tool results in a set of information, presented through chats, in which the user can:

- identify the overall performance of the project, meaning how much the vertices were rounded,
- the performance of each principle, and to what extent the principle was adopted in the process
- the performance of the project according to the four levels for circularity
- the impact of the performance of the 10 principles in the transition to circularity

These results are useful to demonstrate and communicate the results of the design for circularity and sustainability project, indicating where the improvements were performed and pointing out the potential for further improvement through a new design process.

Structure

The tool is composed of an introductory spreadsheet, 10 spreadsheets to evaluate the 10 design for circularity principles and a final spreadsheet with the results of the assessment. In the evaluation spreadsheets, the user should rate the level of integration of the principle in the project on a scale from 01 to 05 and explain how it was implemented.

In each spreadsheet, there is also and a brief explanation of why the principle is important in the design process.

In the final spreadsheet, the results of the assessment are displayed in a set of charts and a final table with the evaluation of the principles and their impact on the four levels. Since each principle has a different impact on each circularity level, their importance was weighted based on literature and in consultation with experts.

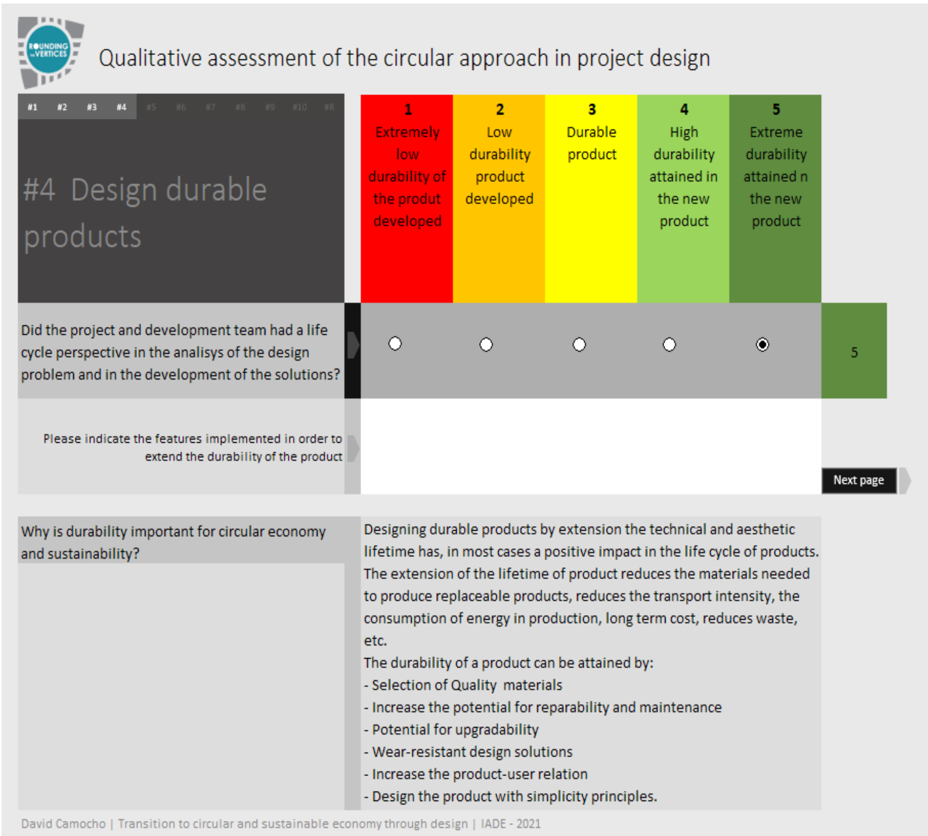
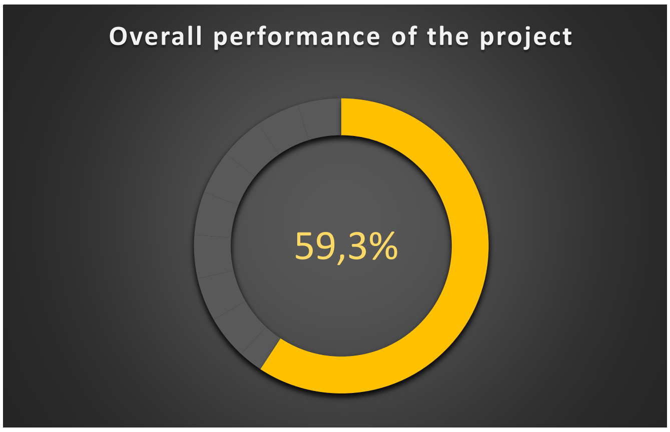
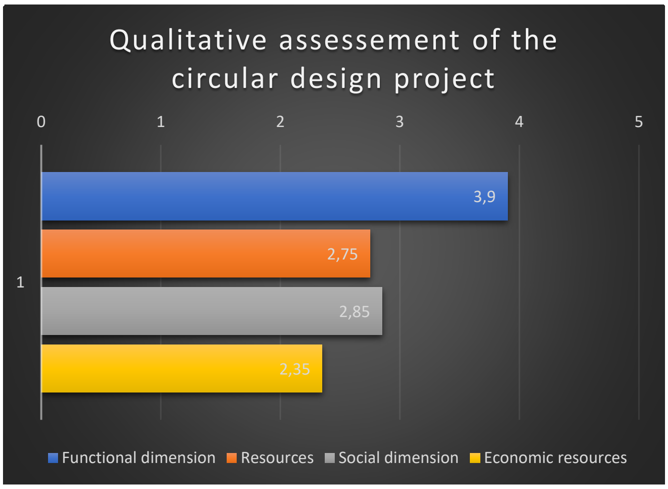
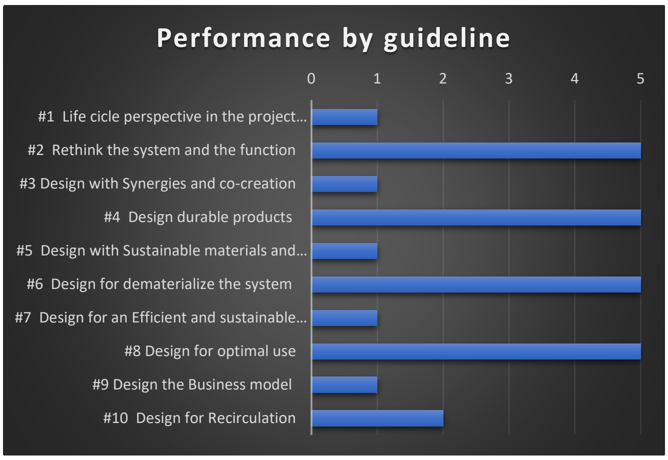


Figure 6: Assessment spreadsheet Design durable products

Results



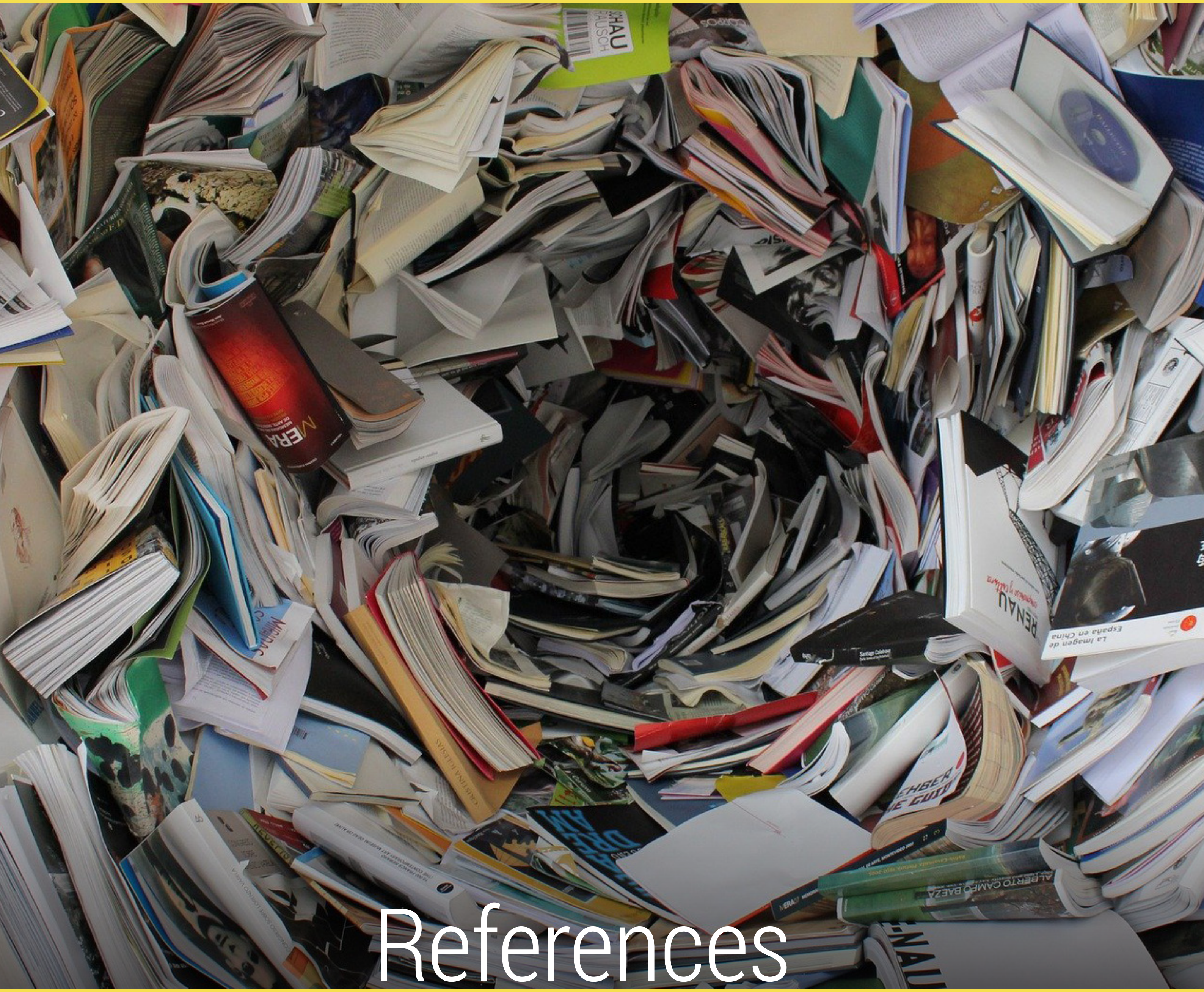




Through the inputs and the assessment of the performance in the implementation of the 10 circular design principles, the tool calculates:

- **The overall performance of the project**, indicating in which percentage the project fulfils the aim of rounding the vertices. In order to reach the maximum score, the project has to implement all the principles scoring 5 on the assessment scale from 01 to 05.
- **The performance of the four levels**, how the project and the results are performing in terms of the function of the product, the resources used within the life cycle, the social aspect and the economic aspects of the product or service. To reach the full potential in the transition for circularity, the project must address these four aspects and improve them in all stages of the life cycle.
- **The performance of each principle**. This detailed scoring allows a brief demonstration of where the product is performing better and where there is the need to improve the process towards circularity.

Figures 7-9 : Results of the assement tool / example



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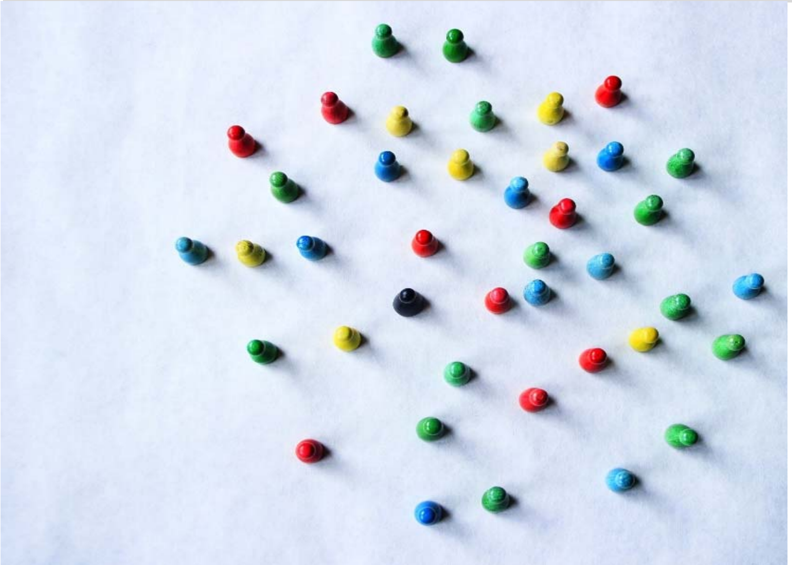
Annex 9 – Tool 1_Defining the project_excel version

Defining the project worksheet



The tool is ffocused on supporting the initiation of the project and the definition of what needs to be done.

The goal in this phase is to systematize the process of the initial information, based on the strategic approach led by the business, and make sure that the development team always gets the information needed and guidance for the project development.

The result of the tool is a systematized definition of the strategy, goals and characteristics for the circular design project structured to improve the efficiency of the solutions according to the Function, Resources, Economy and Social levels.

> Next page

Defining the needs of the project

Identify the current needs and motivations of your business for the development of a circular economy design project

Defining the needs of the project supports the definition of the problem that the project will address. In this stage, the design and development team should identify why there is the need to develop a new design project with a circular economy approach, which are the motivations for the company, what moves the company towards circularity and which are the known barriers for the project.

Why does your business need to enrol in a design for a circular economy project?	
What are the company's motivations for a CE design project?	
What are the known barriers for a CE design project?	

> Next page

Defining the market

Identify the current and potential market for the business and their sustainability and circularity concerns

Based on market analysis, in this stage, the team must define the market for the product or service under development. This supports the guidance and definition of the project objectives and boundaries.

In this worksheet, the design team must identify the current market, the market that is already covered by the company and the current products, the potential market that can be achieved with the development of the new product and the opportunities for the project.

In this stage, the team must also understand what the market is demanding in terms of sustainability and circularity and how the business can meet these needs.

Identify the opportunities	
Identify potential markets for the business	
What are the barriers of your business to meet the needs of the market?	
What are the sustainability and circular demands of the market?	

Defining the business model

Describe the current business model

The business models define how the company plans to make money with its products or services. It outlines the structure and boundaries of the system in which the company operates and the relation with customers or users and the market.
Circular and sustainable business models focus on the value generated of a product or a service and try to capture value throughout its life, aiming to close resource loops and minimize the impacts over the life cycle.
In this stage, the design team must understand the current business model and how can the company innovate and increase its value.

Describe the current business model
- Determine how value is created in the business
- Define the structure of the business

Identify and describe the main sustainability and circularity aspects of your business

New business models

Please select

Does the company have the flexibility to adopt different business models?	Yes

Does the company have the flexibility to adopt different business models? If yes, analyse the following circular business models and identify the potential of each model for your case.

Circular supplies	The circular supplies business model is particularly relevant for companies dealing with scarce commodities, in which scarce resources are replaced with fully renewable, recyclable or biodegradable resource inputs.	
Resource recovery	The resource recovery business model leverages technological innovations and capabilities to recover and reuse resource outputs that eliminates material leakage and maximizes economic value.	
Product life extension	The product life extension model helps companies to extend the lifecycle of their products and assets to ensure they remain economically useful. Material that otherwise would be wasted is maintained or even improved, such as through remanufacturing, repairing, upgrading or re-marketing.	
Sharing models	The sharing platform model is centered on the sharing of products and assets that have a low ownership or use rate. Companies that leverage this model can maximize the use of the products they sell, enhance productivity and value creation.	
Dematerialization from product to services	Through the product as a service BM, customers use products through a lease or pay-for-use arrangement versus the conventional buy-to-own approach. This model is attractive for companies with high operational costs and ability to manage maintenance of that service and recapture residual value at the end of life.	
Stewardship role in stakeholders engagement	Proactively engaging stakeholders to ensure their long-term health and well-being and promotion of co-development, co-creation and synergies	
Encourage sufficiency and efficiency	Solutions that seek to reduce consumption and production by eliminating superfluous features and improving the efficiently through design	
Develop Scale-up solutions	Delivering sustainable solutions at a large scale to maximise benefits for society and the environment.	

Innovation level

Describe the current business model

The project can be oriented for a specific level of innovation according to the objectives and strategy of the company and the design team, however, the level of innovation has a direct relationship between the financial resources needed, the development time, the know-how, human resources, technologies, etc. In this step analyze the four innovation levels and indicate the level expected for the project.

#1	#2	#3	#4
Develop a new product adding new features or characteristics on existing ones	Redesign the product, adding new features and advancing based on the existing product	Design the function, Evolutionary products or services	Innovate and design the system, Revolutionary and radical solutions of products, services and systems
Low investment, Low risk, low payoff	Medium Investment, medium risk and medium payoff	Large investment, Medium risk, Large payof	Large investment, big risk, limitless payoff
Level 1 – Incremental Product improvement	**Level 2 - Incremental Redesign the product**	**Level 3 - Breakthrough Function innovation**	**Level 4 – Transformational Radical system innovation**
○ Level 1	◉ Level 2	○ Level 3	○ Level 4

Delete selection

Please justify your selection and define your objectives	

> Next page

Project definition

Defining the strategy, goals and characteristics for the circular design project.

Based on the previous analysis, this worksheet aims to systematize and define the project under development.
This document will support the team in the definition of the project and will guide the design project.

What product or service has to be developed? Or which is the function or problem addressed?	Define the product, service, function or problem that will be addressed in the project	
Circularity and sustainability goals for the project?	Indicate the goals that will guide the project	
Motivations	Indicate the main motivations for the project	
Target group	Indicate for whom the product or service will be developed. Indicate the main characteristics of the target group	
Business model	Indicate the business model expected for the solution to be developed.	
Innovation Level	Indicate what is expected in terms of innovation for the new solutions according with the context in which the new project is based	
Resources available	Indicate the resources that are available for the project (Human resources, technological resources, budget, etc)	
Project team	Identify the project team (internal or external) and describe their role in the project	
Time available to develop the project	Indicate the expected or available time to develop the project	

> Next page

Rounding the vertices

Define the strategy for the project aiming to improve the efficiency in each area.

Having in mind the project definition and the requirements identified, the design and development team should indicate in this stage which are the objectives and the strategy towards the four levels of the rounding the vertices concepts.
Here, the team will indicate how to improve the function of the product or service, how to improve the efficiency in term of resources used within the life cycle, and how to improve the economic and social aspects of the product or service system.

Function

How can the function of the product be improved?

Resources

How can the resources efficiency be improved?

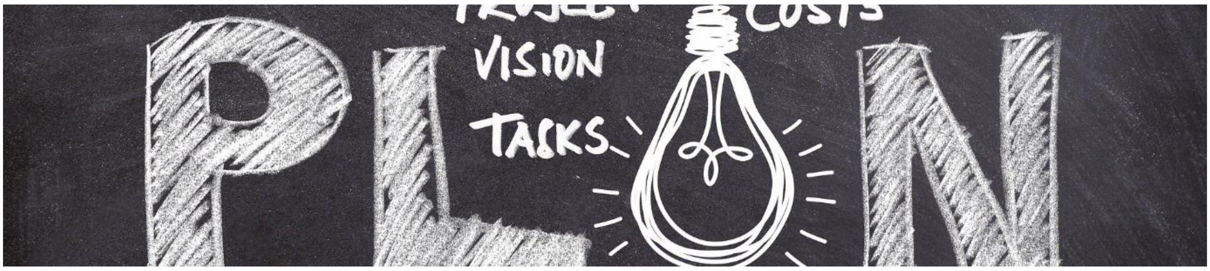
Economy

How can the costs and revenues be improved?

Society

How can the project improve society?

Annex 10 – Tool 2_project planning_Excel version



Project planning worksheet

The project Planning worksheet helps the team in defining the work to be done and creates the roadmap and structure to follow within the project to meet the objectives defined previously.

The tool organizes the project through the identification of the activities to be held, the resources needed and the duration of the task within the project.

Planning of the project

Defining the scope and deliverables for the project

Define the scope of the project and define the deliverables that are planned for the project.

Define the boundaries of the project.

Indicate the scope of the project under development	
Describe what should result from the project. (eg. Tecnical drawings, renderings, mock-ups, prototypes,etc)	

Planning of the project

Identifying the stakeholders for the project

Indicate the main stakeholders for the project and what will be their involvement and importance in the project.

Stakeholder	Purpose	Level of importance
Insert the stakholder name (or type)	What will be the involvement of the stakeholder. Why do we need to involve this stakeholder?	Select the level of importance of each stakeholder (1 - low, 10 - High)

Defining the business model

Defining the activities and taks for the project

This worksheet helps design managers and design teams in the planning and management of design projects for a circular economy.

In this sheet, the management team should identify the main activities and their related subtasks in order to develop the circular design project. These must reflect the needs identified and the goals of the current project.

The number of activities and sub tasks should be adapted to the specifications of the project.

Activity 01	Activity 02	Activity 03	Activity 04	Activity 05	Activity 06	Activity 07
Sub-task 1.1	Sub-task 2.1	Sub-task 3.1	Sub-task 4.1	Sub-task 5.1	Sub-task 6.1	Sub-task 7.1
Sub-task 1.2	Sub-task 2.2	Sub-task 3.2	Sub-task 4.2	Sub-task 5.2	Sub-task 6.2	Sub-task 7.2
Sub-task 1.3	Sub-task 2.3	Sub-task 3.3	Sub-task 4.3	Sub-task 5.3	Sub-task 6.3	Sub-task 7.3
Sub-task 1.4	Sub-task 2.4	Sub-task 3.4	Sub-task 4.4	Sub-task 5.4	Sub-task 6.4	Sub-task 7.4
Sub-task 1.5	Sub-task 2.5	Sub-task 3.5	Sub-task 4.5	Sub-task 5.5	Sub-task 6.5	Sub-task 7.5
Sub-task 1.6	Sub-task 2.6	Sub-task 3.6	Sub-task 4.6	Sub-task 5.6	Sub-task 6.6	Sub-task 7.6

> Next page

Resources and duration of the project

Defining the activities and taks for the project

In this sheet, the management team should identify the resources and time needed to perform the main activities and their related subtasks. These must reflect the needs identified and the goals of the current project.

Activity		Sub-task		Duration (hours)	Resources needed	Cost
1	0	1.1	0			
		1.2	0			
		1.3	0			
		1.4	0			
		1.5	0			
		1.6	0			
2	0	2.1	0			
		2.2	0			
		2.3	0			
		2.4	0			
		2.5	0			
		2.6	0			
3	0	3.1	0			
		3.2	0			
		3.3	0			
		3.4	0			
		3.5	0			
		3.6	0			
4	0	4.1	0			
		4.2	0			
		4.3	0			
		4.4	0			
		4.5	0			
		4.6	0			
5	0	5.1	0			
		5.2	0			
		5.3	0			
		5.4	0			
		5.5	0			
		5.6	0			
6	0	6.1	0			
		6.2	0			
		6.3	0			
		6.4	0			
		6.5	0			
		6.6	0			
7	0	7.1	0			
		7.2	0			
		7.3	0			
		7.4	0			
		7.5	0			
		7.6	0			

Activity		Duration (hours)	Cost
1	0	0	0,00 €
2	0	0	0,00 €
3	0	0	0,00 €
4	0	0	0,00 €
5	0	0	0,00 €
6	0	0	0,00 €
7	0	0	0,00 €
Total		0	0,00 €

Annex 11 – Tool 3_Circular Design MBox_Excel version

Circular design morphological box

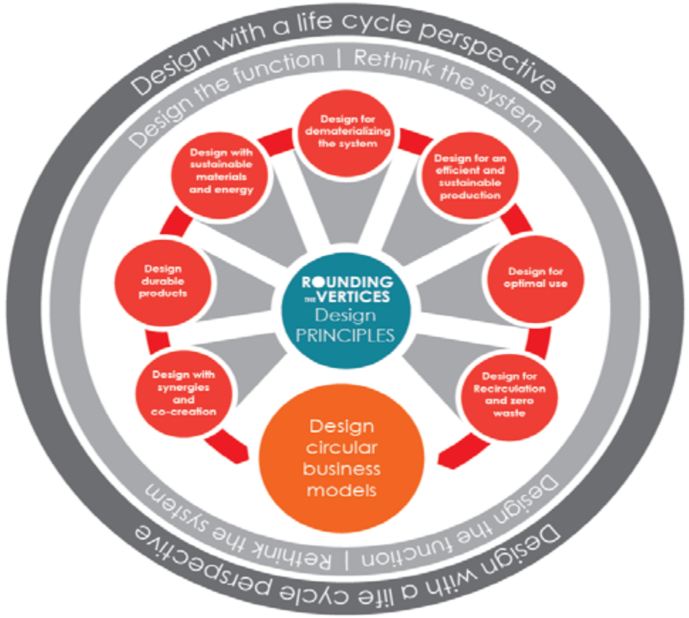
The circular design morphological box combines the concept of the morphological box tool, widely used by designers in the identification of design solutions, with the 10 design principles for circularity and sustainability.

In the design practice towards circular economy and sustainability, with the objective of creating innovative solutions for products and services, the design team can apply a set of principles that support and systematize the process.

The 10 principles that compose the Rounding the vertices approach were developed based on a research process in which several methodologies, tools and different approaches were analysed.

These principles were developed for designers, are project-oriented and through their analysis and implementation, the design teams can, in a holist approach, identify design opportunities that result in more circular and sustainable solutions.

With the support of the tool, design teams can implement the design principles in a systematized approach, leading to innovative and circular solutions for product and service development.



Circular Design morphological box

1 Design with a life cycle perspective

It is estimated that over 80% of all product-related environmental impacts are determined in the design phase. Therefore, it is crucial to design with a life cycle perspective in order to minimize, or ideally, eliminate impacts considering the entire life cycle of products and services.
The design and development teams should ensure that circular economy aspects are integrated into product design and development early in the development process with the aim of improving circularity and reducing impacts throughout the entire life cycle of the product or services (BS 8001), while still taking into account other design aspects such as safety, quality, ergonomics, aesthetics, and also, considering the trade-offs and compromises between different environmental aspects and the attained solutions (IEC 62430 2019).
Designing for the circular economy and aiming for a more effective and optimized management of resources across the life cycle with a holistic perspective should lead to a positive impact on the natural environment and society (BS 8001). Therefore, top management and decision-makers should ensure that strategies are planned, implemented, maintained, considering all stages in the life cycle of a product (ISO 14006:2020), through design.

If the reference product was developed with a life cycle perspective, please describe how it was considered.	
Indicate the objectives/gaps for your project in regard to life cycle perspective.	

2 Design the function/Rethink the system

The circular economy can be characterized by a Rethink approach. To make something more circular requires a rethinking process. (Morseletto, 2020)
Rethinking the system and the function of the product is a way to look at your product and envision sustainable alternatives by thinking outside the box and have new approaches and perspectives for the product and the system which are translated into new or reshaped objectives for the design project.
Rethinking allows an identification of alternative design solutions to solve the problem (BS8001). In a circular design approach, the focus should be on the outcome to fulfil a specific need. The key is to design the most sustainable way of producing that outcome. Outcome-driven thinking places the focus on the function the user needs and not on the solutions of how to produce or deliver the offering (Niinimäki & Hassi 2011).
Rethinking is about developing new ideas and solutions to provide certain product functions in line with the needs of the users, including the re-elaboration/reconceptualisation of ideas, dynamics, processes, concepts, uses, and post uses of a product (Morseletto, 2020).

Indicate the current situation. Explain briefly the funtion of your product or service	
Indicate the objectives/gaps for your project according to the function of your product	

3 Design with Synergies and Co-creation

The design practice has been evolving. This evolution, from a user-centered approach to co-designing, is changing the roles of the designer, the researcher and the users (Elizabeth, 2008).
In design for a circular economy, as a new step in the design evolution, changes are needed in the field of design and design education towards disruptive innovations for transformation, intelligent systems, open design and others, and a new views and approaches on design processes. The participation of the stakeholders in the process is being promoted, especially through collaborative forms like open design, co-creation and participatory design (Hummels, 2012), and the establishment of synergies in the value chain.
Some authors even consider that without collaboration initiatives, it is unlikely that an organization can achieve a successful and substantial progress in the transition to a more circular and sustainable economy (BS 8001).

Indicate the current situation. Explain how synergies and co-creation are related to reference product or reference situation	
Indicate the objectives/gaps for your project regarding synergies and co-creation	

4 Design durable products

Designing durable products with a long-life is concerned with ensuring a long utilization period of products, maintaining its function and service over a longer period of time without loss of performance (Rocha et al., 2019), aims for a maximum potential lifetime of a product, component or material to perform a required function under intended conditions of use and maintenance before it becomes obsolete because it can´t fulfil its function (BS8001).
New products should be designed to be durable for a long lifetime through the integration of solutions and features that facilitate easy repair, particularly by third parties, (BS8001), maintenance, upgrade, etc. The design team must also select effective materials and components that guarantee the durability of the product.
Designing for durability is mainly focused on the physical durability, by the development of products that can take the wear and tear without breaking down, attained by design solutions and effective material selection, by designing reliable products that will operate throughout a specified period without (Bocken et al., 2016), and by developing product life extension features concerned with an increase in the use period of products, through maintenance, repair and upgrading characteristics defined at the design stage (Rocha et al., 2019).
The objective of this principle is to extend the technical, aesthetic and emotional lifetime of the product so that it will be used for as long as possible. While this strategy may seem unattractive for companies because they would "sell less", it can be interesting and competitive for certain types of products and market segments where high quality and durability are a strong sales argument (Rocha et al., 2015).
Developing durable products, that are used and maintained for longer is the counter-strategy to the implanted programmed obsolescence, which is linked to techniques and solutions by which an "organization seeks to deliberately limit product lifetime in order to increase replacement rate" (BS 8001).

Indicate the current situation. Explain how the reference product of reference situation is performing regarding durability	
Indicate the objectives/gaps for your project in terms of durability	

5 Design with Sustainable Materials and Energy

Material selection is a key step in design for circular economy and sustainability. The objective is to select sustainable materials without increasing costs or degrading the product functionality (IEC 62430:2019), seeking the best match between design requirements for the product and material properties (Rocha et al., 2019).
The selection of the energy that is used for and by the product is a crucial factor to be considered as well. In the design phase, the design teams can select materials and energy with lower impacts. The decisions taken in the design phase are fundamental to influence the efficiency and optimization of material and energy consumption in the life cycle of the product or service (Rocha et al., 2020).
The properties and functionality of materials are continuously evolving as a result of material innovation and new and more effective material applications. The selection of materials must have consider their sustainability and the designers should take into account the social, economic and environmental aspects throughout the material's life cycle (BS 8001).

Indicate the current situation. Explain how sustainable are the materials used in the reference product of reference situation	
Indicate the objectives/gaps for your project according to sustainable materials and energy	

6 Design for dematerialize the system

We need to embrace dematerialisation, rethink concepts of ownership and move from resource efficiency to resource sufficiency". Janez Potočnik (Circle Economy, 2021).
We need to change the way to fulfil the needs of the users in a more sustainable and dematerialized way. If we achieve a reduction in the inputs of the material to fulfil the functions, we can achieve a higher circularity level and create more value.
With a dematerialization focus, the designer must deliver a function with no or reduced input of materials, often through moving from physical products to digital alternatives (BS 8001), to services or a combination of both. These new approaches to product and service development can be attained by strategies like the reuse of products and components, sharing, leasing, repair, refurbishment and recycling of products (EEA 2016), among other solutions.
The need towards the dematerialisation of production and consumption are not likely to happen through efficiency improvements. There is a need for shift from the current technological paradigm (Idil Gaziulusoy, 2015) through the design and development of new solutions.
Product/service-systems, as a means to dematerialize the system started to gain momentum due to the high potential for enhanced environmental performance and improved competitiveness (Mcaloone & Pigosso, 2017) and the combination of tangible products with intangible value-added services that lead to dematerialization by reducing the production of waste in the life cycle, by reducing the consumption of resources, and by decoupling the economic growth from environmental impacts, and by creating new revenue streams and extending the residual value of products (Romero & Rossi, 2017).

Indicate the current situation. Explain how the reference product of reference situation is performing according to dematerailization	
Indicate the objectives/gaps for your project according dematerialization	

7 Design for efficient and sustainable production

The Circularity approach is essential in the transformation of industry towards climate-neutrality and long-term competitiveness (European Commission, 2020) and continually challenges current business practices and methods (BS8001).
The design practice can support and streamline the production processes to implement circularity, reduction of waste and optimization of resource consumptions, promotion of useful applications for materials, etc (Simeone et al, (2019). Leading the transition, 2017).
Design for an efficient production focuses on adopting design measures and innovative modes of operations that improve the production stage by reducing the consumption of resources per unit of output preventing/minimizing the generation of waste and emissions and improving the efficiency of the outputs, (products and subproducts) (Rocha et al., 2015, BS 8001).
The new product and service solutions should seek to maximise the resource efficiency, thereby minimising the waste production and the recirculation and reuse of waste and secondary products into the production (ESA, 2013) and considering the working conditions under which the products are made, including worker's rights and working conditions (Young et al 2008).

Indicate the current situation. Explain how the reference product of reference situation is produced	
Indicate the objectives/gaps for your project regarding the prodution process	

8 Design for optimal use

When considering the entire life cycle, the use phase is likely to have the greatest environmental impact. It involves the consumption of resources such as energy, consumables, and outputs such as waste and emissions during the use of the product (IEC 62430:2019).
In the design phase decisions that are made on products are crucial to influence the use phase positively (Rocha et al., 2019). The development team must consider and adopt strategies to prolong the life of the products, components and materials through durability, repair, upgrade etc, (BS8001).
Another crucial aspect is the interface and the relation between the product and the user. Products and services must be user friendly, effective and efficient in supporting the needs of the users without creating additional needs. Designing for an optimal use, will reduce the impacts and added values to the product or service system.

Indicate the current situation. Explain how the reference product of reference situation is performing in the use phase	
Indicate the objectives/gaps for your project for the use phase	

9 Design for Recirculation and zero waste

The circular economy is seen as a new way to design, produce and use products and services in a more efficient and sustainable way. Based on the principles of elimination of the generation of waste in the system, the recirculation of products and materials and the regeneration of natural systems, (EMF) the adoption of the concept maintains or even increases the value of products, materials and resources in the economy for as long as possible, contributing for an efficient and competitive economy (EC 2015).
The waste, seen as the result of system inefficiency and symbolising bad design options, should be considered as input material, as resources with value and potential to be used in the production process. The shift from "waste" to "resources" can boost the market for secondary materials, products and components. By reusing resources in the system and decreasing the dependence on virgin raw materials, it encourages the redesign of the resource life cycles (Eduzwace, 2020) and the improvement of the entire production and consumption system.

Indicate the current situation. Explain how the reference product of reference situation is performing according recirculation and zero waste	
Indicate the objectives/gaps for your project towards recirculation and zero waste	

10 Design Circular Business Models

In design for a circular economy, as seen in the previous pages, several solutions can be implemented to improve the circular and sustainable profile of product and services.
Many of these ideas can improve the product and the service, however, in most cases, to attain a higher potential for circularity, the business model needs to be adjusted, or new business models need to be created and developed.
This new approach to circularity is leading to new businesses, new professions and new ways to fulfil the needs of the users with new opportunities to create greater value for all stakeholders.
Sustainable business models create a competitive advantage through superior customer value and contribute to the sustainable development of the company and society (Lüdeke-Freund, 2010), focused on efficiently offering a system of circular products and value-added services, and supporting circular systems (Romero & Rossi, 2017).
The creation of new sustainable business models promotes the integration of suitable approaches such as reuse, sharing, leasing, repair, refurbishment, recycling etc. By integrating the most suitable of these approaches to one's business- and product development will play a significant role in maintaining the utility of products, components and in realizing circular business models (Mcaloone & Pigosso, 2017).

Describe the current bussiness model	
Indicate the objectives/gaps for your project related to the business model	

> Next page

Circular Design morphological box

General Mbox - Overview

Principles	Design with a life cycle perspective	Design the function/Rethink the system	Design with Synergies and co-creation	Design durable products	Design with Sustainable materials and energy	Design for dematerialize the system	Design for an Efficient and sustainable production	Design for optimal use	Design for Recirculation	Design the Business model
Current situation. How the reference product of reference situation is performing according to each principle	0	0	0	0	0	0	0	0	0	0
objectives/gaps for your project according to each principle	0	0	0	0	0	0	0	0	0	0
1	Describe your product according with the life cycle stages	Question the function	Collaborate and co-design	Quality of materials	Recyclable materials	Sharing	Reduce consumption of materials and energy	Reduce consumables	Design for Re-use	Rethink the business model
2	Identify the main impacts related to the stage	Develop new concepts	Synergies	Reparability	Recycled materials	Leasing	Modularity	Simplicity principle	Design for Recycling	Innovates and create new business models
3			Industrial Symbiosis	Maintenance	Low embodied energy materials	Virtualization	Best available technics	Inclusive design/design for all	Design for Remanufacturing	
4				Upgradability	Renewable materials	Servicityze, Increase service component	Standardization		Refurbish	
5				Wear-resistant design solutions	Renewable energy				Design for Repair	
6				Product-user relation	Non toxic materials				Eliminate waste	
7				Simplicity principle	Efficient materials					
8					Fair materials					

Circular Design morphological box

Design with a life cycle perspective

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It is estimated that over 80% of all product-related environmental impacts are determined in the design phase, therefore, it is crucial to design with a life cycle perspective in order to minimize or ideally, eliminate impacts considering the entire life cycle of products and services.
The design and development teams should ensure that circular economy aspects are integrated into product design and development early in the development process with the aim of improving circularity and reducing impacts throughout the entire life cycle of the product or services while still taking into account other design aspects such as safety, quality, ergonomics, aesthetics, and also, considering the trade-offs and compromises between different environmental aspects and attained solutions throughout all life cycle stages.
Designing for the circular economy, aiming for a more effective and optimized management of resources across the life cycle with a holistic perspective should lead to a positive impact on the natural environment and society . Therefore, top management and decision-makers should ensure that strategies are planned, implemented, maintained and consider all stages in the life cycle of a product through design.

	Describe your product according with the life cycle stages	Identify the main impacts related to the stage
Resources	Identify and describe the resources used in your product , considering materials, energy and water	Identify the impacts related to the resources used in your product
Production	Describe how your product is produced	Identify the main impacts related to the production
Distribution	Describe how the product is distributed	Identify the main impacts related to the distribution
Use	Describe how the product is used, including the use, consumables, maintenance, repair, etc	Identify the main impacts related to the use of the product
End of functional life	Describe what hapens after the functional use of the produtc.	Identify the main impacts related to the end of funcional life of the product
Explaind how the impacts were identified	In this field describe the source of the inputs. Are they based on a Life cycle analisys? qualitative or quantitative?	

> Next page

Circular Design morphological box

x Delete inputs

Design the function/Rethink the system

The circular economy can be characterized by a Rethink approach. To make something more circular requires rethinking a rethinking process.
Rethinking the system and the function of the product is a way to look at your product and envision sustainable alternatives by thinking outside the box and have news approaches and perspectives for the product and the system which are translated into new or reshaped objectives for the design project.
Rethinking allows an identification of alternative design solutions to solve the problem, root cause, system and life cycle perspectives . In a circular design approach, the focus should be on the outcome to fulfil a specific need and the key is to design the most sustainable way of producing that outcome. Outcome-driven thinking places the focus on the function the user needs and not on the solutions of how to produce or deliver the offering
Rethinking is about developing new ideas and solutions to provide certain product functions, in line with the needs of the users, including the re-elaboration/reconceptualisation of ideas, dynamics, processes, concepts, uses, and post uses of a product.

	What is the function of the product?
Function	Describe the function withou describing the product
Reflection..	

Develop new conceps		
	☐	☐
	☐	☐
	☐	☐
	☐	☐
	☐	☐

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Option selected

Circular Design morphological box

x Delete selection

Design with synergies and co-creation

The design practice has been evolving. This evolution, from a user-centred approach to co-designing, is changing the roles of the designer, the researcher and the users .

In design for a circular economy, as a new step in the design evolution, changes are needed in the field of design and design education towards disruptive innovations for transformation, intelligent systems, open design and others, and a new view and approach on design processes. The participation of the stakeholders in the process is being promoted, especially through collaborative forms like open design, co-creation and participatory design, and the establishment of synergies in the value chain.

Some authors even consider that without collaboration initiatives, it is unlikely that an organization can achieve a successful and substantial progress in the transition to a more circular and sustainable economy

Which synergies and co-creation activities can be implemented in your project?

	Collaborate and co-design	Synergies	Industrial Symbiosis
	Identify ideas for collaboration and co-design development within the project	Identify potential synergies that can support the project and the product or service developed	Identify potential industrial symbiosis related to the product and the company
1	☐	☐	☐
2	☐	☐	☐
3	☐	☐	☐
4	☐	☐	☐
5	☐	☐	☐
6	☐	☐	☐
7	☐	☐	☐
8	☐	☐	☐
9	☐	☐	☐
10	☐	☐	☐

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Selected options			

Circular Design morphological box

Design durable products

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Designing durable products with a long-life is concerned with ensuring a long utilization period of products, maintaining its function and service over a longer period of time without loss of performance. Durability aims for a maximum potential lifetime of a product, component or material to perform a required function under intended conditions of use and maintenance for a long period of time before it becomes obsolete because it can no fulfil is function.
New products should be designed to be durable for a long lifetime through the integration of solutions and features that facilitate easier repair, particularly by third parties. Maintenance, upgrade, etc. the design team must also select effective materials and components that guarantee the durability of the product.
Designing for durability is mainly focused on the physical durability, by the development of products that can take the wear and tear without breaking down, attained by design solutions and effective material selection. BY designing reliable products that will operate throughout a specified period without , and by developing Product life extension features concerned with an increase in the use period of products, through maintenance, repair and upgrading characteristics defined at the design stage.
The objective of this principle is to extend the technical, aesthetic and emotional lifetime of the product so that it will be used for as long as possible. While this strategy may seem unattractive for companies because they would "sell less", it can be interesting and competitive for certain types of products and market segments where high quality and durability are a strong sales argument.
Developing durable products, that are used and maintained for longer, is the counter-strategy to the implanted programmed obsolescence, which is linked to techniques and solutions by which an "organization seeks to deliberately limit product lifetime in order to increase replacement rate"

How can you create and develop a more durable product?

	Quality of materials	Reparability	Maintenance	Upgradability	Wear-resistant design solutions	Product-user relation	Simplicity principle
	Identify ideas for a selection of more suitable materials to fulfill the needs of the product and their function	Identify ideas that promote the reparability of your products	Identify ideas that promote the reparability of your products maintenace of your products	Identify ideas that promote the technical and aesthetical upgrade of you products	Identify ideas to improve the resistance to wear and loss of properties of your product	Identify ideas to create products with a stronger emphatic relation with the user	Identify ideas in order to simplify your product, promoting a efficient use
1	☐	☐	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐	☐	☐
6	☐	☐	☐	☐	☐	☐	☐
7	☐	☐	☐	☐	☐	☐	☐
8	☐	☐	☐	☐	☐	☐	☐
9	☐	☐	☐	☐	☐	☐	☐
10	☐	☐	☐	☐	☐	☐	☐

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Selected options							

Circular Design morphological box

x Delete selection

Design with Sustainable materials and energy

Materials selection is a key step in design for circular economy and sustainability. The objective is to select sustainable materials without either increasing costs or degrading the product functionality, seeking the best match between design requirements for the product and material properties.
The selection of the energy that is used for and by the product is a crucial factor to be considered as well. In the design phase, the design teams can select materials and energy with lower impacts. The decisions taken in the design phase are fundamental to influence the efficiency and optimization of material and energy consumption in the life cycle of the product or service.
The properties and functionality of materials are continuously evolving as a result of materials innovation and new and more effective material applications. The selection of materials must have consider their sustainability and the designers should take into account the social, economic and environmental aspects throughout the material's life cycle

	Which sustainable materiasl and energy can you adopt for your solution?							
	Recyclable materials	Recycled materials	Low embodied energy materials	Renewable materials	Renewable energy	Non toxic materials	Efficient materials	Fair materials
	Which recyclable material can be applied in the project?	Which recycled material can be applied in the project?	Considering the embodied energy of materials, which are suitable for the project?	Which renewable materials can be appied in the project?	How can renewable energy can be used by the product?	How can we avoid the use of non toxic materials in the life cycle of the product?	Which materials are efficient and have a positive impact in the product system?	How can we selects materials that are fair from a social point of view?
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selected options								

Circular Design morphological box

Design durable products

x Delete selection

We need to embrace dematerialisation, rethink concepts of ownership and move from resource efficiency to resource sufficiency.'
We need to change the way to fulfil the needs of the users in a more sustainable and dematerialized way. If we achieve a reduction in the inputs of the material to fulfil the functions, we can achieve a higher circularity level and create more value in our systems.
With a dematerialization focus, the designer must delivery a function with no or reduced needs in terms of materials, often through moving from physical products to digital alternatives , to services or a combination of both. These new approaches to product and service development can be attained by strategies like the reuse of products and components, sharing, leasing, repair, refurbishment and recycling of products, among other solutions.
The needs towards the dematerialisation of production and consumption to achieve sustainable solutions are not likely to happen through efficiency improvements. There is a need for shifting from the current technological paradigm through the design and development of new solutions.
Product/service-systems, as a mean to dematerialize the system started to gain momentum due to the high potential for enhanced environmental performance and improved competitiveness and the combination of tangible products with intangible value-added service can lead to dematerialization by reducing the production of waste in the life cycle, by reducing the consumption of resources, and by decoupling the economic growth from environmental impacts by creating new revenue streams and extending the residual value of products

	How can you dematerialize the system in which your product operates?			
	Sharing	Leasing	Virtualization	Servicityze, Increase service component
	Identify ideas to meet the needs of the users with a solution in wich the product is shared by several users	Identify ideas to satisfy the needs with products or services that are leased from a service provider	How can we deliver utility virtually. How to replace physical infrastructure and assets with digital/virtual services ?	Identify ideas to increase the service component of the product or services system
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selected options				

Circular Design morphological box

Design for Efficient and sustainable production

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The Circularity approach is essential in the transformation of industry towards climate-neutrality and long-term competitiveness European Commission. (2020).. and continually challenges current business practices and methods.
The design practice can support and streamline the production processes to implement circularity, reduction of waste and optimization of resource consumptions, promotion of useful applications for materials, etc .
Design for an efficient production focuses on adopting design measures and innovative mode of operations that improve the production stage by reducing the consumption of resources per unit of output preventing / minimizing the generation of waste and emissions and improving the efficiency of the outputs, (products and subproducts).
The new product and service solutions should seek to maximise the resource efficiency, thereby minimising the waste production and the reciculation and reuse of waste and secondary products into the production, and considering the working conditions under which the products are made, including worker rights.

How can you promote a better production sytem through design?

	Reduce consumption of materials and energy	Modularity	Best available technics	Standardization
	Indicate ideas to reduce the consumption of materials and energy	How can the project adopt a modular solution?	Which are the best available technics that can be used?	Which standard solution can be applied?
1	☐	☐	☐	☐
2	☐	☐	☐	☐
3	☐	☐	☐	☐
4	☐	☐	☐	☐
5	☐	☐	☐	☐
6	☐	☐	☐	☐
7	☐	☐	☐	☐
8	☐	☐	☐	☐
9	☐	☐	☐	☐
10	☐	☐	☐	☐

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selected options				

Circular Design morphological box

Design for optimal use

x Delete selection

When considering the entire life cycle, the use phase is likely to have the greatest environmental impacts. It involves the consumption of resources such as energy, consumables, and outputs such as waste and emissions during the use of the product.
The impacts in the use phase are related to strategies that improve this stage. In the design phase decisions that are made of products are crucial to influence the use phase positively. The development team must consider and adopt strategies to prolong the life of the products, components and materials through durability, repair, upgrade etc.
Another crucial aspect is the interface and the relation between the product and the user. Products and services must be user friendly, effective and efficient in supporting the needs of the users without creating additional needs.
Designing for an optimal use will reduce the impacts and added values to the product or service system.

How can you optimize the use of your product?

	Reduce consumables	Simplicity principle	Inclusive design/design for all
	How can the consumption of consumables be reduced in the use phase of the product or service?	Indicate ideas to simplfy the use of the product or service	Indicate solutions that are inclusive and can be used by all
1			
2			
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selected options			

Circular Design morphological box

Design for Recirculation and zero waste

x Delete selection

	How can you recirculate materials and componentes?					
	Design for Re-use	Design for Recycling	Design for Remanufacturing	Refurbish	Design for Repair	Eliminate waste
	Which features can you add in the solution to promote the reuse of components or materials	Indicate features to optimize the recycling process and optimization of the quality of the materials resulting from the recycling	Indicate ideas to implement a remanufatoring system	Indicate ideas to promote the refurbishing in your solution	Which features and services to promote the repairing process can be implemented?	Indicate ideas to eliminate the production of waste considering the entire life cycle of the product or service
1	☐	☐	☐	☐	☐	☐
2	☐	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐	☐
4	☐	☐	☐	☐	☐	☐
5	☐	☐	☐	☐	☐	☐
6	☐	☐	☐	☐	☐	☐
7	☐	☐	☐	☐	☐	☐
8	☐	☐	☐	☐	☐	☐
9	☐	☐	☐	☐	☐	☐
10	☐	☐	☐	☐	☐	☐

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Circular Design morphological box

x Delete inputs

Design Circular Business models

In design for a circular economy, as seen in the previous pages, several solutions can be implemented to improve the circular and sustainable profile of product and services.
Many of these ideas can improve the product and the service, however, in most cases, to attain a higher potential for circularity, the business model needs to be adjusted, or new business models need to be created and developed.
This new approach to circularity is leading to new business, new professions and new ways to fulfil the needs of the users with new opportunities to create greater value for all stakeholders.
Sustainable business models create a competitive advantage through superior customer value and contribute to the sustainable development of the company and society focused on efficiently offering a system of circular products and value-added services, and supporting circular systems
The creation of new sustainable business models promotes the integration of suitable approaches such as reuse, sharing, leasing, repair, refurbishment, recycling etc. By integrating the most suitable of these approaches to one's business- and product development will play a significant role in maintaining the utility of products, components and in realizing circular business models

	What is the bussiness model of the reference product or service?
Current business model	Describe the current bussiness model
Reflection..	How can we innovate the bussiness model?

Develop new business models	Identify new businees models that can be aplied for your solution	
	☐	☐
	☐	☐
	☐	☐
	☐	☐
	☐	☐

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selected option

Circular Design morphological box

General Mbox - Overview

	Reference product of reference situation performance according to each principle	Objectives/gaps for your project according to each principle								
Design the function/Rethink the system	0	0	0 0							
Design with Synergies and co-creation	0	0	Collaborate and co-design	Synergies	Industrial Symbiosis					
Design durable products	0	0	Quality of materials	Reparability	Maintenance	Upgradability	Wear-resistant design solutions	Product-user relation	Simplicity principle	
Design with Sustainable materials and energy	0	0	Recyclable materials	Recycled materials	Low embodied energy materials	Renewable materials	Renewable energy	Non toxic materials	Efficient materials	Fair materials
Design for dematerialize the system	0	0	Sharing	Leasing	Virtualization	Servicityze, Increase service component				
Design for an Efficient and sustainable production	0	0	Reduce consumption of materials and energy	Modularity	Best available technics	Standardization				
Design for optimal use	0	0	Reduce consumables	Simplicity principle	Inclusive design/design for all					
Design for Recirculation	0	0	Design for Re-use	Design for Recycling	Design for Remanufacturing	Refurbish	Design for Repair	Eliminate waste		

New concept development

New product or service and Business model for project/solution?	Based on the options selected develop the new product or service and describe the business model

			Resources	Production	Distribution	Use	End of functional life
Design with a life cycle perspective	Reference produt	Description of the reference product	0	0	0	0	0
	New concept	Describe your product according with the life cycle stages					
		Identify the expected benefits in each phase					

Annex 12 – Tool 4_Assessent_Excel version

Qualitative assessment of the circular approach in design project

#1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #R

#1 Design with a Life Cycle Perspective

	1 No	2 Yes briefly	3 Yes, some stages considered	4 Yes, all life cycle stages considered	5 Yes, supported by quantitative LCA studies	
Did the project and development team had a life cycle perspective in the analisys of the design problem and in the development of the solutions?	○	○	●	○	○	3
Please explain how the Life cycle perspective was integrated in the project management and development						

Next page

Why is life a Life cycle perspective important?

Having a life cycle perspective is fundamental for any project with a sustainability focus. By analyzing all stages of the life cycle, from the extraction and processing of materials, through the production, distribution, use and end-of-life, the design team can identify the problems in each phase and identify opportunities to improve the environmental profile of the product or service. The LC perspective avoids also the transference of impacts from one stage to another and allows a holistic perception of the consequences and impacts.

Qualitative assessment of the circular approach in design project

#2 Rethink the system and the function

	1	2	3	4	5	
	No changes were implemented in the solution developed	Incremental product improvement	Redesign of the product	Functional improvement or new functions added	Radical innovation in the product system	
Indicate the innovation level attained with the project and how the new solution developed meets the needs of the target groups	○	○	○	●	○	4
Please indicate the solutions developed in the project						

Next page

Why is important to rethink the function and the system?

At the beginning of any design project, the team should put into question the function and the needs of the target groups and the stakeholders of the project. Do the users need such a product?
Does the function of the product is in line with the user needs? There are different ways to fulfil the needs of the users?

Innovative ways to fulfil the functions and the needs can lead to more innovative and sustainable solutions.

Qualitative assessment of the circular approach in design project

#3 Design with Synergies and co-creation

	1	2	3	4	5	
	Co creation and synergies not considered in the project	Explored but with no impact in the results of the project	Considered but with a low impact in the results of the project	Positive impact attained with co-creation ans synergies	High impact and innovation attained	
The project was developed with a co-creation approach and explored potential synergies to innovate and improve the circularity and sustainability potential?	○	◉	○	○	○	2
Please explain the synergies and co-creation activities involved in the project						

Next page

Why synergies and co-creation is important?

The establishment of co-creation activities has the potential of exploring new possibilities and strengthen relationships between different stakeholders in the value chain. Co-creation opens the development process to external contributions and collaborative innovation. Ideas are shared and improved together, fostering the innovation potential and success of the solutions. The establishment of synergies in the development process has the potential to optimise the value chain focusing in a win-win situation for all actors involved.

Qualitative assessment of the circular approach in design project

#1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #R

#4 Design durable products

	1	2	3	4	5	
	Extremely low durability of the produt developed	Low durability product developed	Durable product	High durability attained in the new product	Extreme durability attained n the new product	
Did the project and development team had a life cycle perspective in the analisys of the design problem and in the development of the solutions?	○	○	○	●	○	4

Please indicate the features implemented in order to extend the durability of the product

Next page

Why is durability important for circular economy and sustainability?

Designing durable products by extension the technical and aesthetic lifetime has, in most cases a positive impact in the life cycle of products. The extension of the lifetime of product reduces the materials needed to produce replaceable products, reduces the transport intensity, the consumption of energy in production, long term cost, reduces waste, etc.

The durability of a product can be attained by:

- Selection of Quality materials
- Increase the potential for reparability and maintenance
- Potential for upgradability
- Wear-resistant design solutions
- Increase the product-user relation
- Design the product with simplicity principles.

Qualitative assessment of the circular approach in design project

#1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #R

#5 Design with sustainable materials and energy

	1	2	3	4	5	
	Unsustainable materials and energy are widely used in the product	The maerials and energy used have high impacts	The impactes related to materials and energy are moderate	The materials and energy used have low impacts	All materials and energy used are sustainable	
How sustainable are the materials and the energy used in the product, considering the entire life cycle?	○	○	●	○	○	3
Please explai the constibution of the project in the selection of sustainable materials and energy						

Next page

Why are sustainable materials and sustainable energy important?	In the design phase, the designer must select the material with a higher sustainability potential according to the needs and specifications of the project. this selection will define the impacts of the product along the different stages of the life cycle. in this regard, the design team should select: - Low impact materials - Low embodied energy materials - Renewable materials - Non-toxic materials - Renewable energy - Cost-effective materials -Fair materials

Qualitative assessment of the circular approach in design project

#1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #R

#6 Design for dematerializing the system

	1	2	3	4	5	
	No dematerialization attained	The funtion is fulfiled with product with low service intensity	Combination of produts and services developed to fulfil the function	High level attained by using a combination of products and services	Produt totaly dematerialized though services	
At what extend dematerialization was attained in the new solution developed?	○	○	○	◉	○	4
Please explain measures adopted to dematerialize the system						

Next page

Why is the dematerialization and transition from product to services important?	Solutions in line with the dematerialization of the system have the potential to reduce the environmental impacts of the system. The transition from product-based solution to service-based solutions reduces the needs of material inputs t fulfil the needs of the users. These solutions have the potential to develop new business models like: - Sharing solutions - Leasing - Virtualize - Servicityze/ Increase service - Etc.

Qualitative assessment of the circular approach in design project

#1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #R

#7 Design for Efficient and sustainable production

	1	2	3	4	5	
	No changes in efficiency and sustianability of the production	Slight improvement in production efficciency and sustianability	Yes. Improvement in production efficciency and sustianability attained	Yes, there is a fair increase in the efficiency of the production process	Yes, the new design allows a sustainable and efficient production process	
Does the design of the new solution improves the efficiency and sustainability of the production process?	○	○	○	●	○	4

Please explain how the production process was improved due to design solutions defined whithin the project

Next page

Why is an effective and sustainable production important?

Usually, the production stage has is responsible for a large part of the impacts of the product life cycle. The transformation of raw materials (inputs) in products (outputs) should be optimized by design choices in order to:

- Reduce consumption of materials and energy
- Adopt modular solutions
- Select Best available technics
- Adopt standard solutions to optimize the system
- Etc

Qualitative assessment of the circular approach in design project

#1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #R

#8 Design for optimal use

	1	2	3	4	5	
	No optimization attained	Low improvment in the use of the solution	Medium optimization attained	The use of the product is optimized	The use of the new solution is highly optimized	
At what extend the new solution optimizes the use of the product?	○	○	●	○	○	3
Pleasehoe the use phase was impreved throug the design project						

Next page

Why is an optimal use is important?

Is in the use phase that the product is in his highest value. The product is developed to fulfil the needs of the user and in the stage, is important to optimize the use to fulfil the needs of the user, for as long as possible, with the lower impacts as possible.
In this stage, is important to reduce consumables, improve the user interface, adopt simple procedures and inclusive design.

Qualitative assessment of the circular approach in design project

#1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #R

#9 Design Circular Business Models

	1	2	3	4	5	
	No, business as usel adoted in the new solution	Small changes in the BM with low impact in Circularity and sustainability	BM updated to meet some circularity and sustaianbility aspects	New business model implemented with good optimization	Totally new circular and sustainable BM implemented	
Does the project considered new business models to fulfil the needs of the users and the the business and stakheolders in the value chain?	○	○	●	○	○	3

Please justify your answewer

Next page

Why are the changes in the business model important?

The transition to circular economy and sustainability shouldn't focus on redesigning solutions. In order to attain a higher circularity and innovation potential, the design team and the business should look at the business model and improve it or develop new business models.
The team should rethink the business model, innovate the business model and create new business models.

Qualitative assessment of the circular approach in design project

#1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #R

#10 Design for recirculation and zero waste

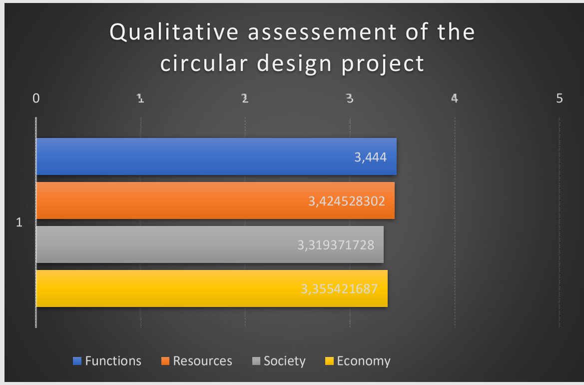
	1	2	3	4	5	
	No recircuation features were implemented in the new solution	Low value recirculation through features to recirculate materials and components	Medium value recirculation through features to recirculate materials and components	Fair value recirculation through features to recirculate materials and components	High value recirculation through features to recirculate materials and components	
How does the new solution promotes the recirculation of materials and components?	○	○	○	●	○	4
Please indicate the measures adopet to recirculate materials and components in the system						

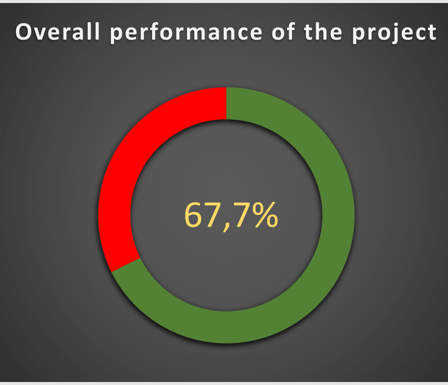
Next page

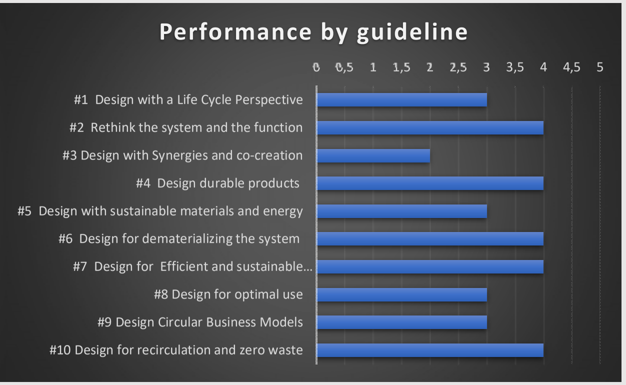
Why is the recirculation of materials and components important?

The circular economy approach is based on the premises of eliminating the concept of waste in the system and the recirculation of materials and components. In this regard, the design team should adopt measures to enable the Re-use, Recycle, Remanufacture, Renew, Repair, among others.

Qualitative assessment of the circular approach in design project







back

Annex 13 – Assessment Criteria definition

Qualitative assessment of the circular approach in design project

Defining the influence of the 10 design for circularity principles in the four dimensions - Reflection exercise and expert survey

Within the develpment of the toolkit for circular design, the approach was strucured in four main areas or dimensions. The Funcitonaly dimention of the product or service addressed, the efficiency of the resources used in terms of materials and energy, the impact of the social aspects of the product or service system, and the economy factors related to the project.
In the design for circularity approach and model developed, 10 main principles that must be considered in the project development were defined and their adoption will have direct or indirect impact in the four dimensions. These values will be used to develop an assessment tool that will measure the performance of the project and will give the indication of how much the design team were able to improve their design process towards circularity and sustainability.

Thank you for your collaboration!

Next page

Dimensions for circular design

Function	The project should put into question the current solutions and rethink the system focusing on the function. Through a function approach, the design team has more levels of freedom to innovate and attain higher circularity and sustainability performance and can lead to out-ofthe-box solutions.
Resources	The resources need to fulfil the function should be optimized. The optimization and the efficiency of the consumption of materials, energy and water in the product or service systems has the potential of improve the circularity and sustainability aspects of the systems.
Society	Design for a better society should be also the motto for the design project. The creation and promotion of welfare, safety, good working conditions are na added value for the society that can be achieve through design
Economy	The aim is to optimize the the economic aspects related to the system creating a sustainable value and wealth for all actors in the value chain through the design approach and measures adopted in the project

Qualitative assessment of the circular approach in design project

Defining the influence of the 10 design for circularity principles in the four dimensions - Reflection exercise and expert survey

STEP 01 - Define the level of influence of the 10 design principles in each dimension.

Please use the scale 0 to 5:

"0" for No influence
"1" for Very low influence
"2" for Low influence
"3" for Medium influence
"4" for High influence
"5" for Very High influence

Note: By default, all cells are pre-filled with "0" No influence.

	Function	Resources	Society	Economy
#1 Life cycle perspective in the project development	1	2	3	4
	Very low influence	Low influence	Medium influence	High influence
#2 Rethink the system and the function	2	3	4	5
	Low influence	Medium influence	High influence	Very high influence
#3 Design with Synergies and co-creation	3	4	5	1
	Medium influence	High influence	Very high influence	Very low influence
#4 Design durable products	4	5	1	2
	High influence	Very high influence	Very low influence	Low influence
#5 Design with Sustainable materials and energy	5	1	2	3
	Very high influence	Very low influence	Low influence	Medium influence
#6 Design for dematerialize the system	1	2	3	4
	Very low influence	Low influence	Medium influence	High influence
#7 Design for an Efficient and sustainable production	2	3	4	5
	Low influence	Medium influence	High influence	Very high influence
#8 Design for optimal use	3	4	5	1
	Medium influence	High influence	Very high influence	Very low influence
#9 Design the Business model	4	5	1	2
	High influence	Very high influence	Very low influence	Low influence
#10 Design for Recirculation and zero waste	5	1	2	3
	Very high influence	Very low influence	Low influence	Medium influence

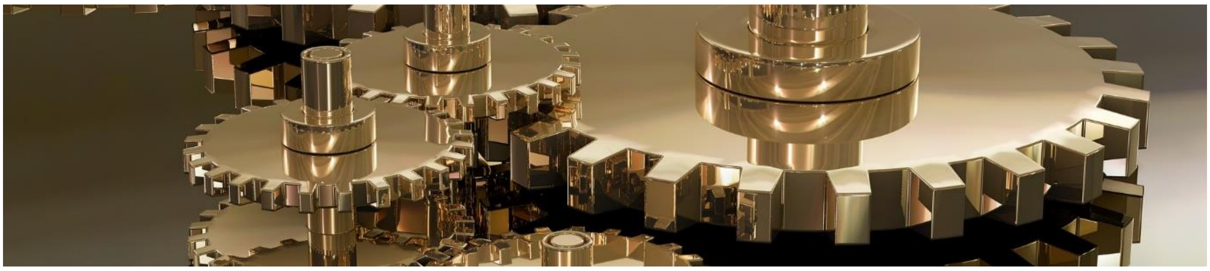
Next Step

Qualitative assessment of the circular approach in design project

Defining the influence of the 10 design for circularity principles in the four dimensions - Reflection exercise and expert survey

Dimension		#1 Life cycle perspective in the project development	#2 Rethink the system and the function	#3 Design with Synergies and co-creation	#4 Design durable products	#5 Design with Sustainable materials and energy	#6 Design for dematerialize the system	#7 Design for an Efficient and sustainable production	#8 Design for optimal use	#9 Design the Business model	#10 Design for Recirculation and zero waste	
Function	Level of influence	1	2	3	4	5	1	2	3	4	5	
	%	3,3%	6,7%	10,0%	13,3%	16,7%	3,3%	6,7%	10,0%	13,3%	16,7%	100%
Resources	Level of influence	2	3	4	5	1	2	3	4	5	1	
	%	6,7%	10,0%	13,3%	16,7%	3,3%	6,7%	10,0%	13,3%	16,7%	3,3%	100%
Society	Level of influence	3	4	5	1	2	3	4	5	1	2	
	%	10,0%	13,3%	16,7%	3,3%	6,7%	10,0%	13,3%	16,7%	3,3%	6,7%	100%
Economy	Level of influence	4	5	1	2	3	4	5	1	2	3	
	%	13,3%	16,7%	3,3%	6,7%	10,0%	13,3%	16,7%	3,3%	6,7%	10,0%	100%

Annex 14 – Questionnaire _Validation _pre test DRIW



Rounding the vertices – Toolkit for circular design

Rounding the vertices

CONCEPT

Part 01- Rounding the vertices – Toolkit for circular design - DRIW 21 - Workshop

The Rounding the Vertices toolkit, developed within the "Transition to circular and sustainable economy through design" PhD research project aims to narrow the gap between what is being developed in research and development projects and what is actually applied in the design practice in the development of circular and sustainable products and services.

The project is being developed with the supervision of Dr Ana Margarida Ferreira from IADE - ana.margarida.ferreira@universidadeeuropeia.pt and co-supervised by Dr José Vicente from UBI - jmanvicente@gmail.com.

The "Rounding the vertices - design for a circular economy" is a design method that supports the practice and integrates the project development perspective, the management of the design project and the perspective of the business. The method was developed to implement these considerations in the early phases of the project with high innovation potential. The toolkit is composed of a set of tools that support the design practice.

The following questions aim to collect feedback to improve its results and align them with the needs of the designers and product developers.

Concerning the protection of individuals about the processing of personal data, the information provided will be processed only for scientific research purposes, and in an aggregate way, thus guaranteeing the most complete anonymity.

If you have any doubts or questions about this survey, please let us know.
david.camocho@gmail.com

We thank you in advance for your attention and input!

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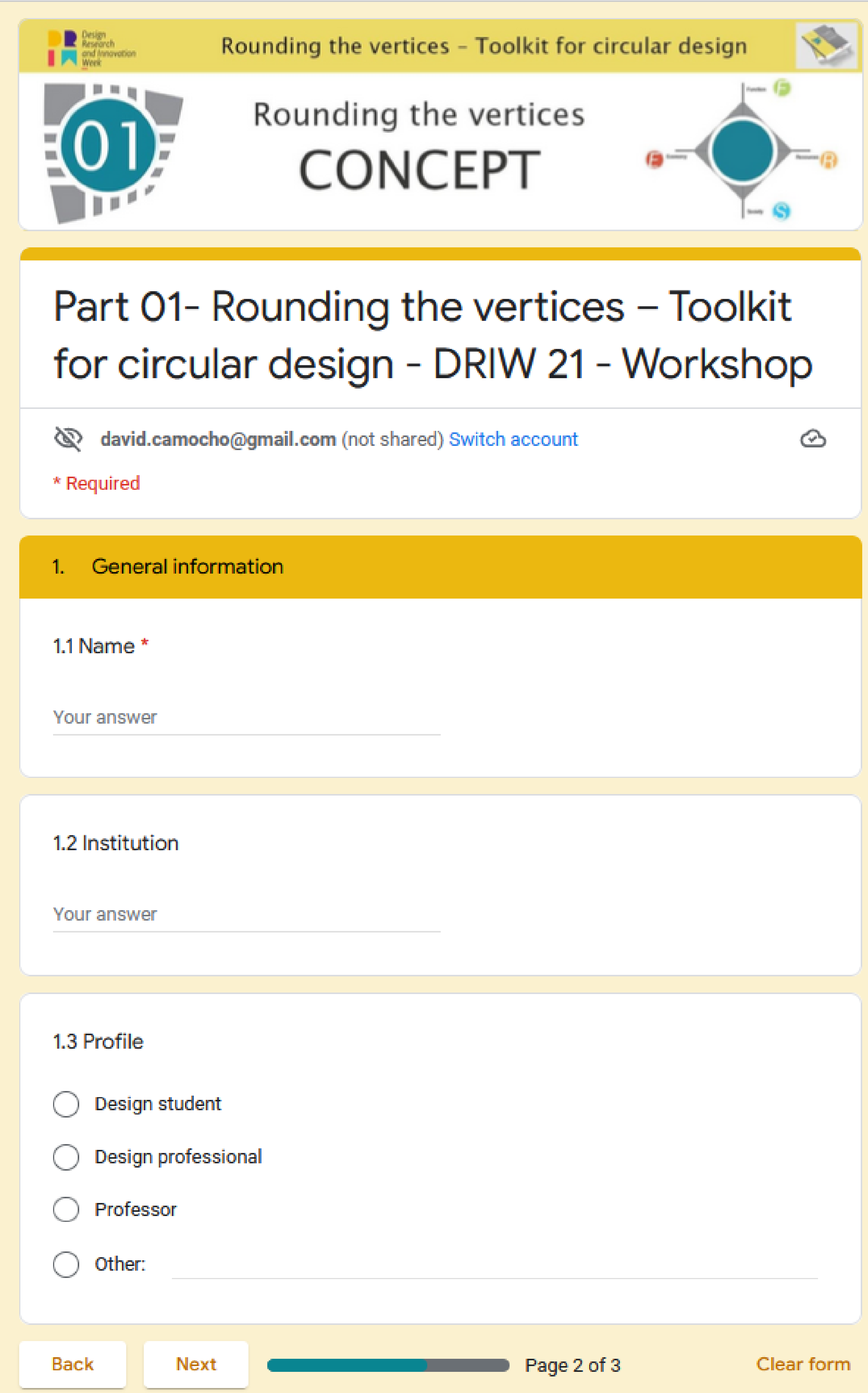
Rounding the vertices – Toolkit for circular design

Rounding the vertices
CONCEPT

Part 01- Rounding the vertices – Toolkit for circular design - DRIW 21 - Workshop

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* Required

1. General information

1.1 Name *

Your answer

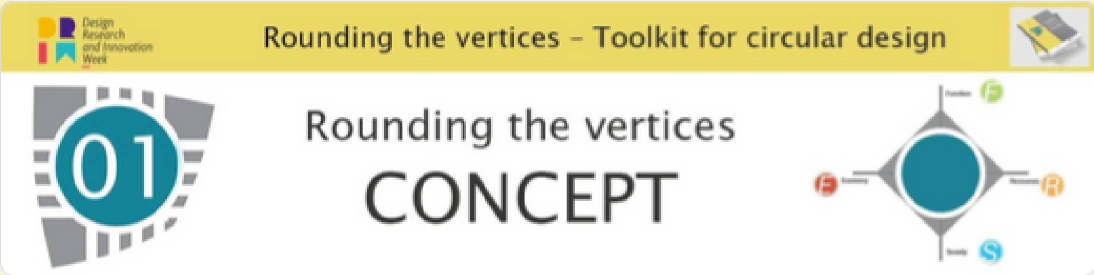
1.2 Institution

Your answer

1.3 Profile

- Design student
- Design professional
- Professor
- Other:

Back | Next | Page 2 of 3 | Clear form



Part 01- Rounding the vertices – Toolkit for circular design - DRIW 21 - Workshop

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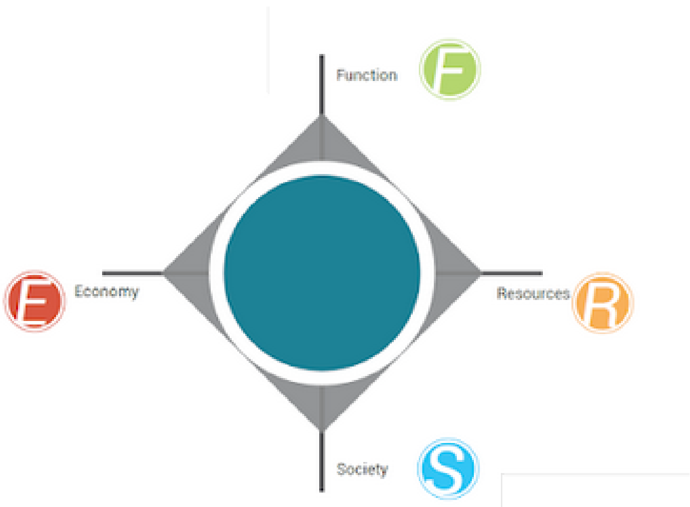
2. Rounding the vertices concept

The Rounding the vertices concept is based on system optimization to support the transition to circular economy through design. The transformation of a square, which illustrates the linear economy into a circle, related to circular economy presupposes an optimization at various levels.
Within this project, 4 fundamental dimensions were defined. Economy. Resources, Society and Function.

Rounding the vertices concept



2.1 At what extent do you agree with the definition of these 4 dimensions in order to support the design process?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

2.2 Relevance of the concept to promote the design practice for circular economy

	1	2	3	4	5	6	
Not relevant	○	○	○	○	○	○	Highly relevant

2.3 Do you have any suggestions for other dimensions that should be represented in the concept?

Your answer

2.4 Do you have any suggestions to improve the concept?

Your answer

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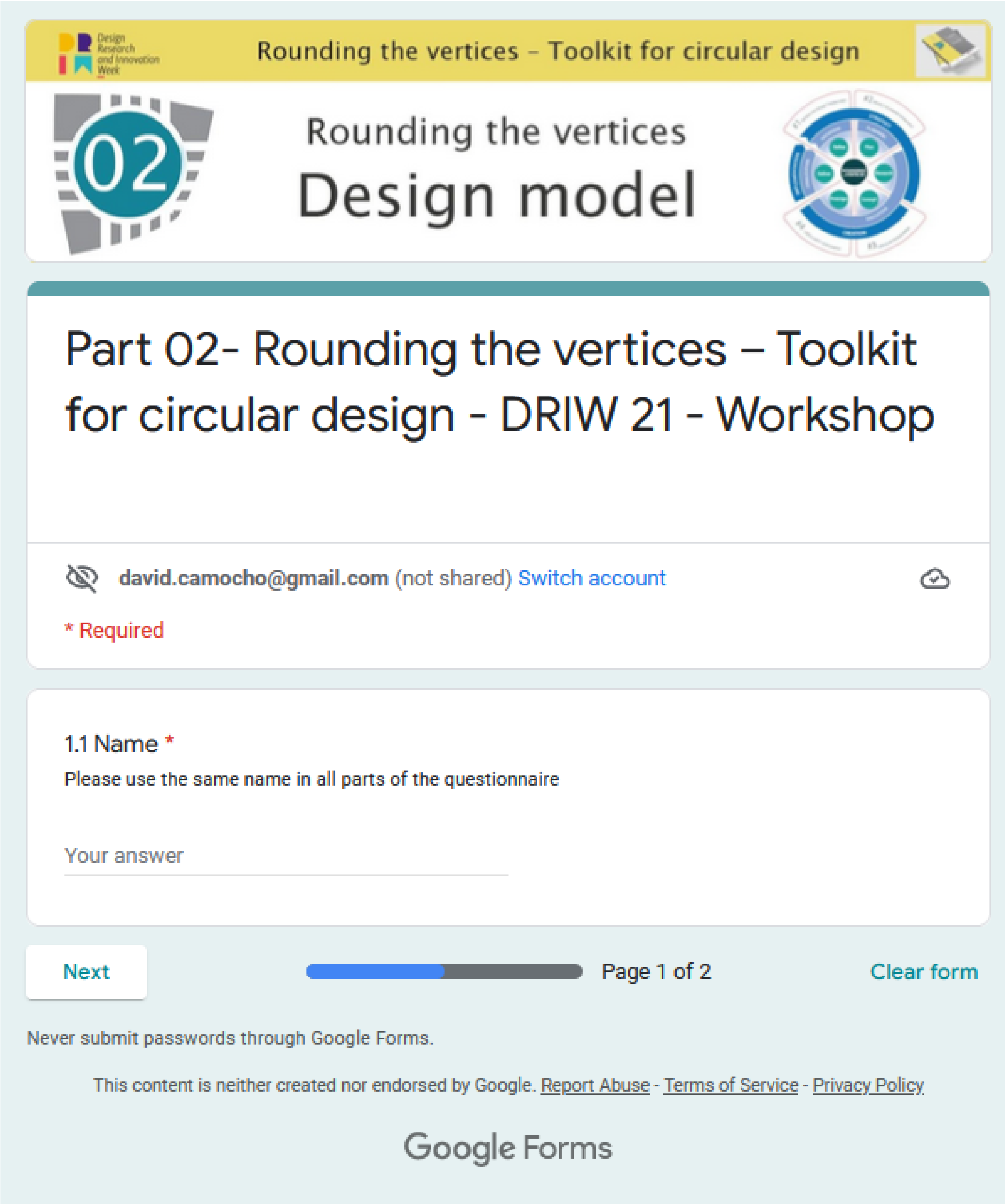

Rounding the vertices – Toolkit for circular design

Rounding the vertices
Design model

Part 02- Rounding the vertices – Toolkit for circular design - DRIW 21 - Workshop

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* Required

1.1 Name *

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Your answer

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Rounding the vertices - Toolkit for circular design

Rounding the vertices

Design model

Part 02- Rounding the vertices – Toolkit for circular design - DRIW 21 - Workshop

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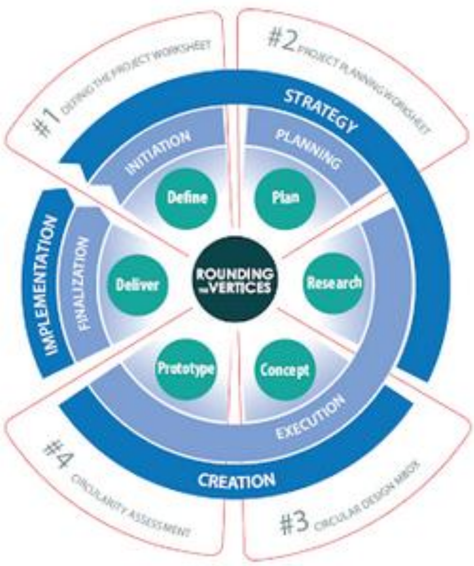
3. Design and development model

In order to operationalize the integration of the concept in the development of design projects oriented to the circular economy a model composed by 3 interlinked layers was developed. A layer that corresponds to a strategic performance, oriented to the strategic objectives of the company, client, and project team, a layer oriented to the management of the design process, and an operational layer, oriented to the effective development of the project.



3.1 This model is useful to structure the design practice for the circular economy

	1	2	3	4	5	6	
Strongly disagree	○	○	○	○	○	○	Strongly agree

3.2 The 3 levels (Strategic, Management and Operational levels) are important to organize the design project and define the different approaches

	1	2	3	4	5	6	
Strongly disagree	○	○	○	○	○	○	Strongly agree

3.3 If you could change something in the model, what would you change?

Your answer

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Rounding the vertices – Toolkit for circular design

#1 Defining the project worksheet

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* Required

1.1 Name *

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Your answer

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Design Research and Innovation Week
Rounding the vertices – Toolkit for circular design
03
#1 Defining the project worksheet
Part 03- Rounding the vertices – Toolkit for circular design - DRIW 21 - Workshop
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#1 Defining the project worksheet
ROUNDING THE VERTICES
#1 Defining the project Worksheet
This worksheet helps the in the definition of the strategy for the development of products and services that meet the needs on the entire system.
Planning the business strategy towards project development

3.1 Do you think the tool is useful to help in the definiton of the project?

- Yes
- No

3.2 Based on your perception of the tool, what are the main Weaknesses identifyed?

Your answer

3.3 Based on your perception of the tool, what are the main Strengths identifyed?

Your answer

3.4 If you could change something in the tool, what would you change? Do you have any idea or suggestion on how to improve the tool?
Plese insert some ideas about how to improve the tool

Your answer

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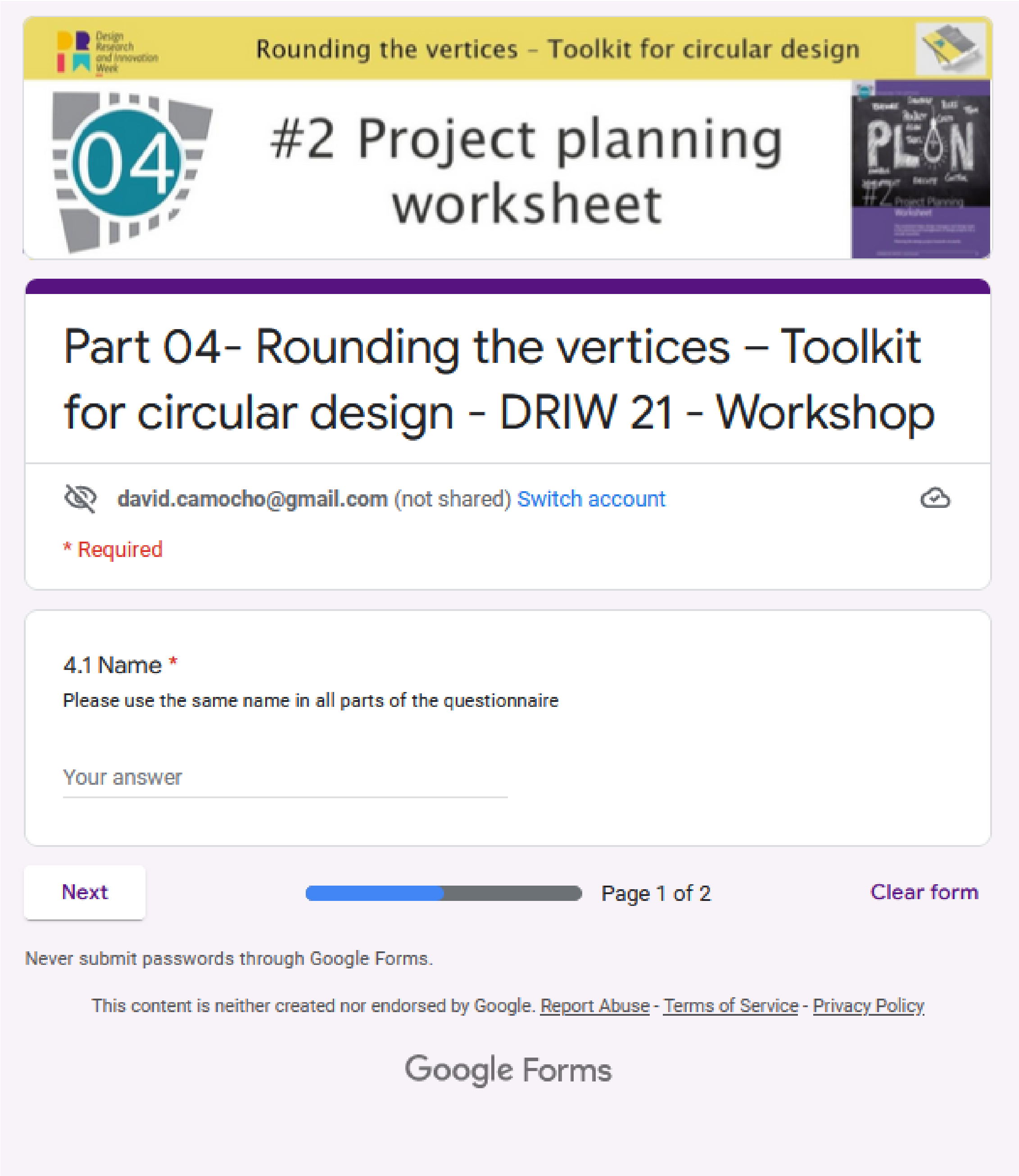

Rounding the vertices – Toolkit for circular design

#2 Project planning worksheet

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* Required

4.1 Name *

Please use the same name in all parts of the questionnaire

Your answer

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Rounding the vertices – Toolkit for circular design

#2 Project planning worksheet

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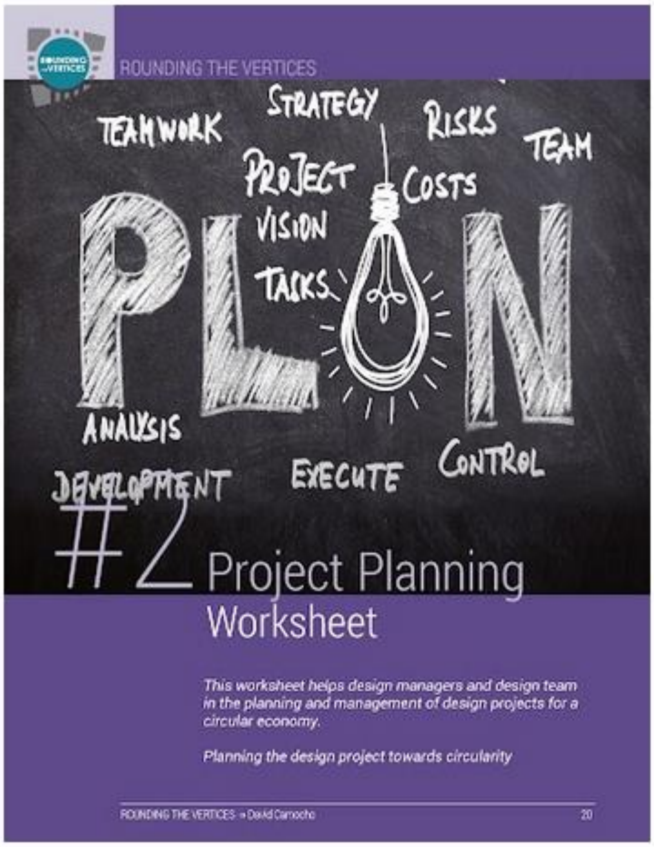
#2 Project planning worksheet



4.1 Do you think the tool is useful to help in the definiton of the project?

- ◯ Yes
- ◯ No

4.2 Based on your perception of the tool, what are the main Weaknesses identifyed?

Your answer

4.3 Based on your perception of the tool, what are the main Strengths identifyed?

Your answer

4.4 If you could change something in the tool, what would you change? Do you have any idea or suggestion on how to improve the tool?

Plese insert some ideas about how to improve the tool

Your answer

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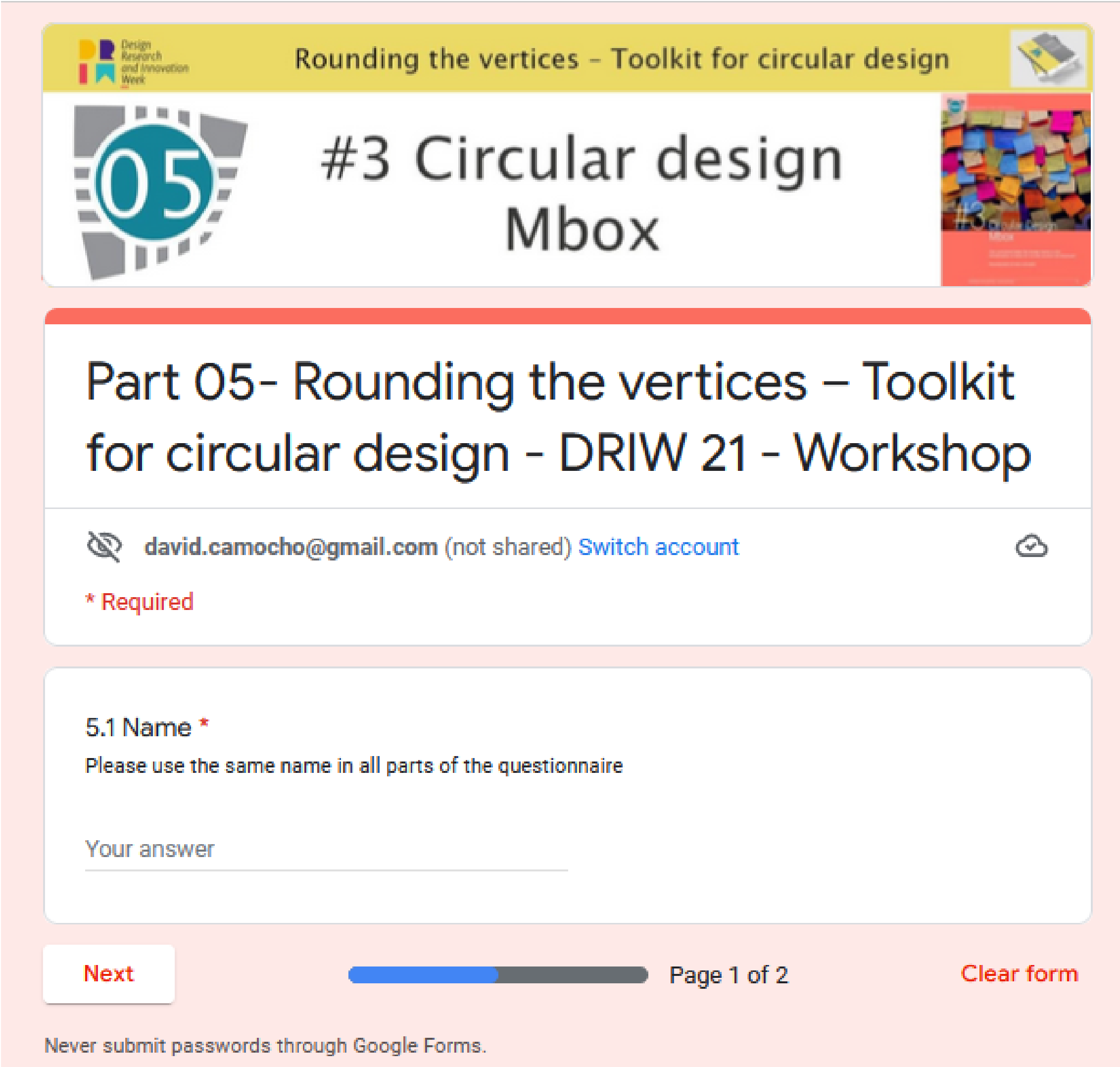
Design Research and Innovation Week

Rounding the vertices – Toolkit for circular design

05

#3 Circular design Mbox

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* Required

5.1 Name *

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Your answer

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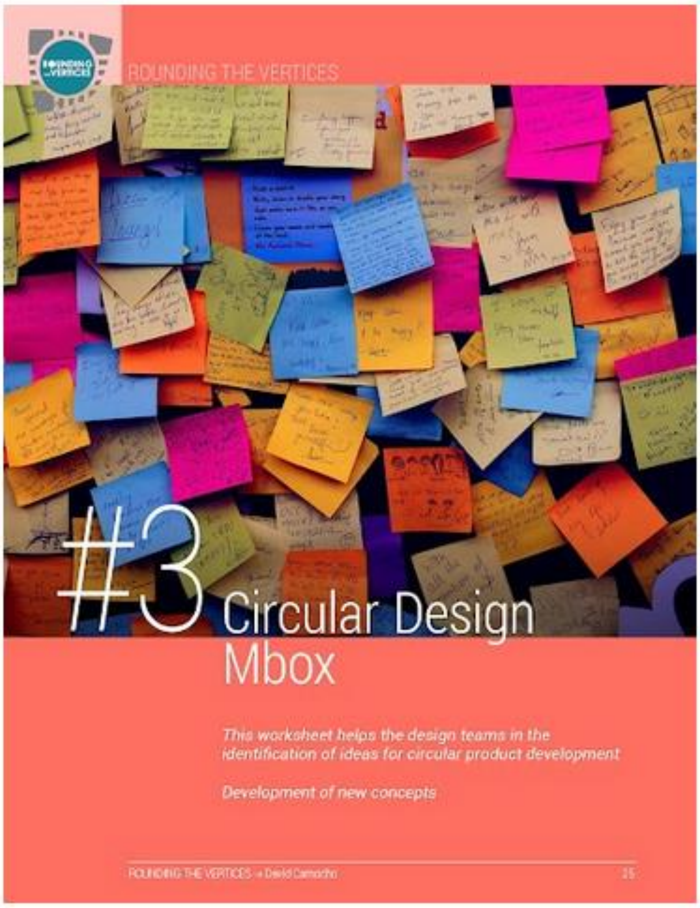
#3 Circular design Mbox



5.1 Do you think the tool is useful to help in the definiton of the project?

- ◯ Yes
- ◯ No

5.2 Based on your perception of the tool, what are the main Weaknesses identifyed?

Your answer

5.3 Based on your perception of the tool, what are the main Strengths identifyed?

Your answer

5.4 If you could change something in the tool, what would you change? Do you have any idea or suggestion on how to improve the tool?

Plese insert some ideas about how to improve the tool

Your answer

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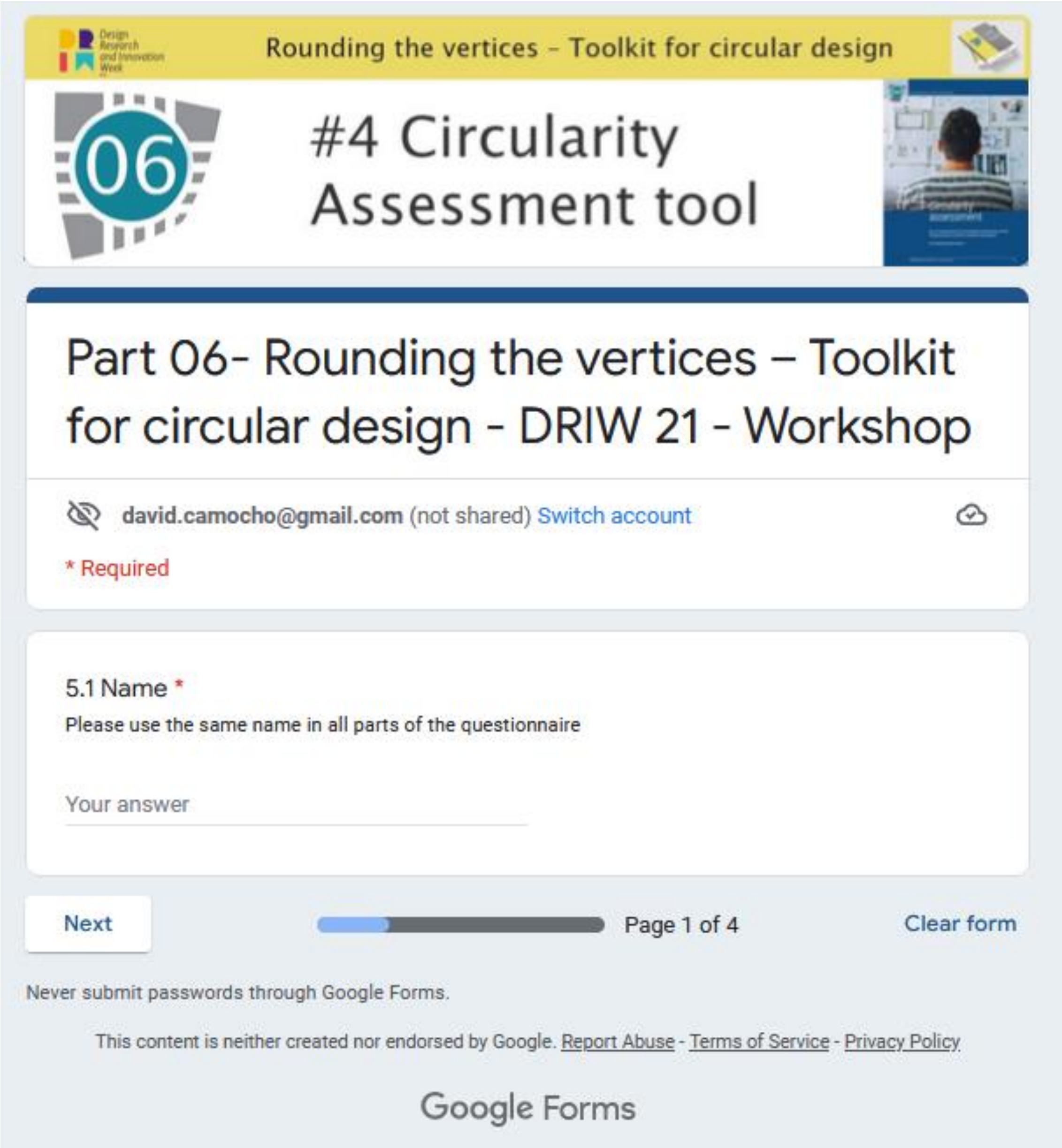

Rounding the vertices – Toolkit for circular design

#4 Circularity Assessment tool

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* Required

5.1 Name *

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Your answer

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Rounding the vertices - Toolkit for circular design

#4 Circularity Assessment tool

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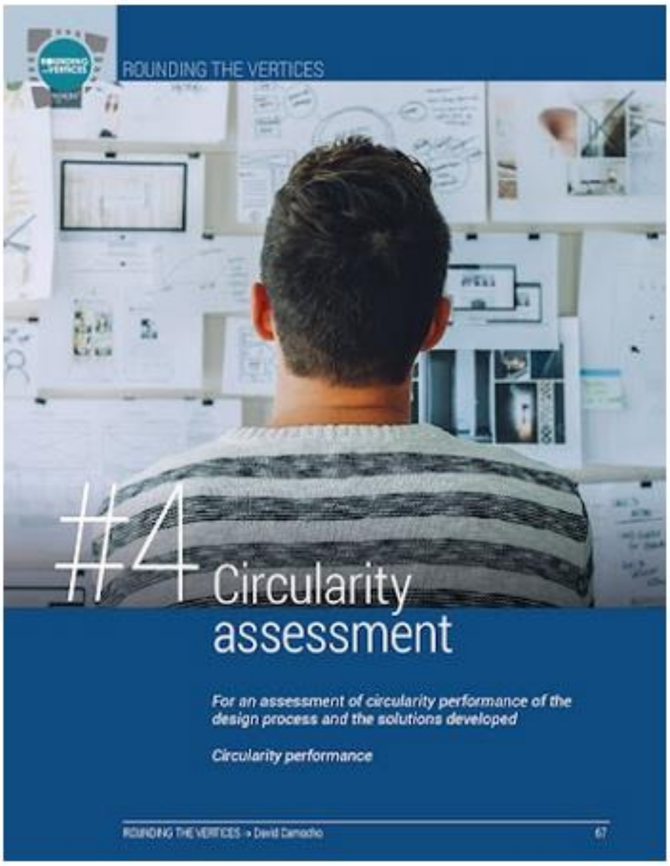
6. General information

5.1 Name



6.1 Do you think the tool is useful to help in the definiton of the project?

- ◯ Yes
- ◯ No

6.2 Based on your perception of the tool, what are the main Weaknesses identifyed?

Your answer

6.3 Based on your perception of the tool, what are the main Strengths identifyed?

Your answer

6.4 If you could change something in the tool, what would you change? Do you have any idea or suggestion on how to improve the tool?

Plese insert some ideas about how to improve the tool

Your answer

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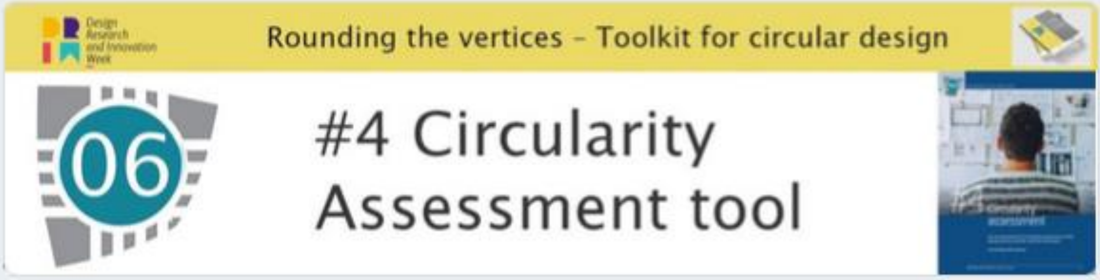

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#4 Circularity Assessment tool

6.1 Do you think the tool is useful to help in the definiton of the project?

	Poor	Low	Medium	Good	Very good
Structure	◯	◯	◯	◯	◯
Graphic design	◯	◯	◯	◯	◯
Content	◯	◯	◯	◯	◯
Lenght	◯	◯	◯	◯	◯
Usability	◯	◯	◯	◯	◯
Adequacy to the					

Usability	◯	◯	◯	◯	◯
Adequacy to the design professionals	◯	◯	◯	◯	◯

6.2 Based on your perception of the tool, what are the main Weaknesses identifyed?

◯ Yes

◯ No

6.3 Based on your perception of the tool, what are the main Strengths identifyed?

Plese insert some ideas about how to improve the toolkit

Your answer

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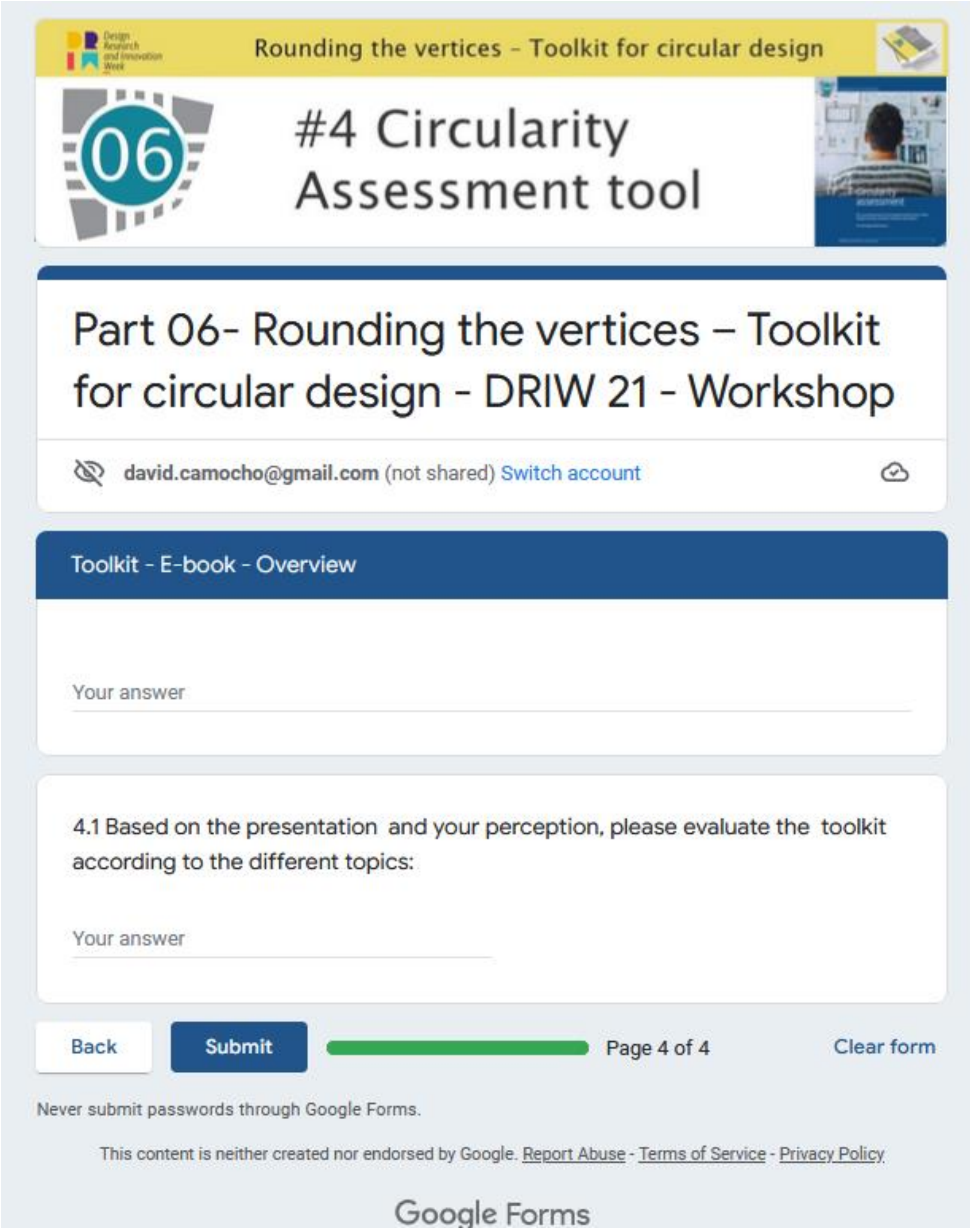

Rounding the vertices - Toolkit for circular design

#4 Circularity Assessment tool

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Toolkit - E-book - Overview

Your answer

4.1 Based on the presentation and your perception, please evaluate the toolkit according to the different topics:

Your answer

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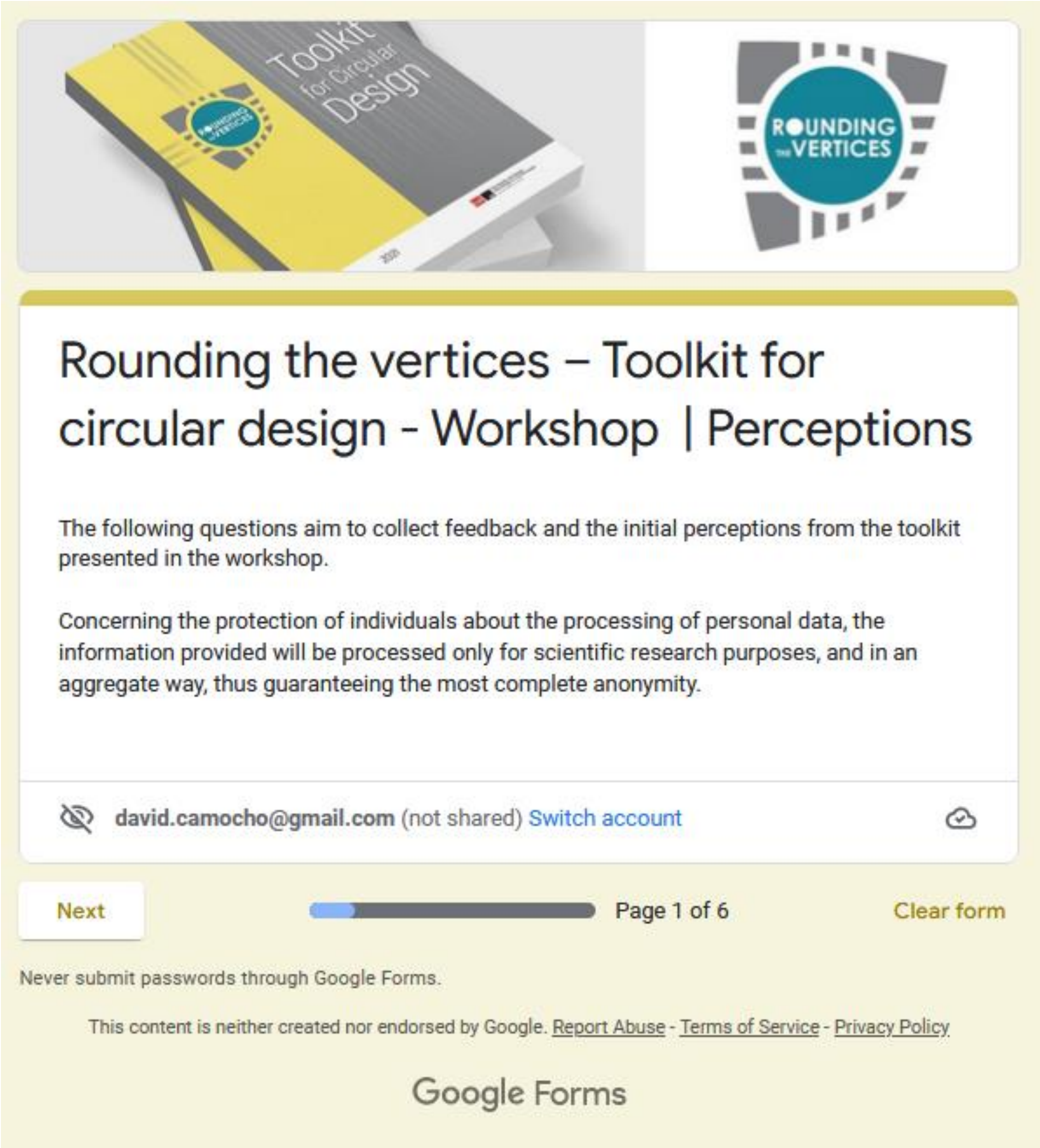
Annex 15 – Questionnaire experts review WS Perceptions- Online



Rounding the vertices – Toolkit for circular design - Workshop | Perceptions

The following questions aim to collect feedback and the initial perceptions from the toolkit presented in the workshop.

Concerning the protection of individuals about the processing of personal data, the information provided will be processed only for scientific research purposes, and in an aggregate way, thus guaranteeing the most complete anonymity.

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1. General information

1.1 Name

Your answer

1.3 Main field of expertise

- ◯ Design
- ◯ Circular economy
- ◯ Sustainability
- ◯ Other:

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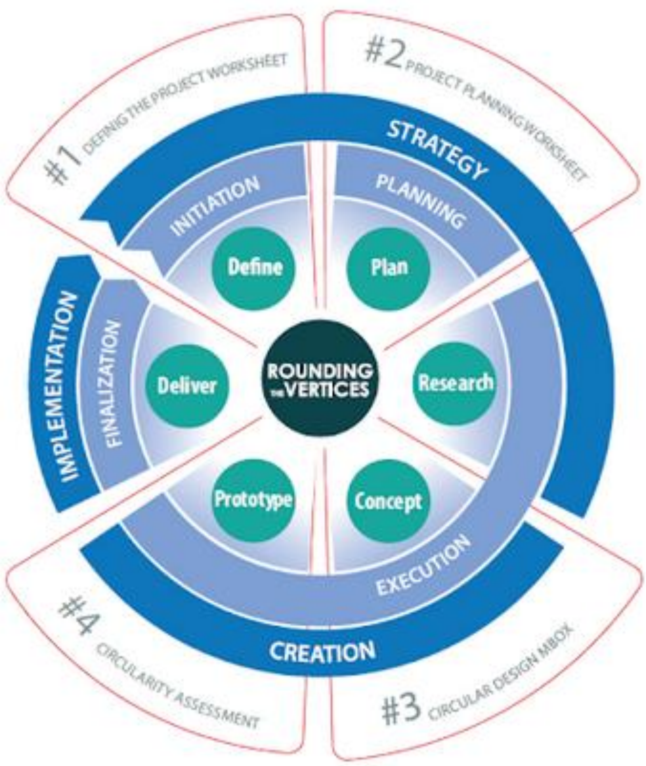
2. Design and development model



2.1 This model is useful to structure the design practice for the circular economy

Please ansewer the question based on the presentation.

	1	2	3	4	5	6	
Strongly disagree	○	○	○	○	○	○	Strongly agree

2.2 The 3 levels (Strategic, Management and Operational levels) are important to organize the design project and define the different approaches

	1	2	3	4	5	6	
Strongly disagree	○	○	○	○	○	○	Strongly agree

2.3 If you could change something in the model, what would you change?

Your answer

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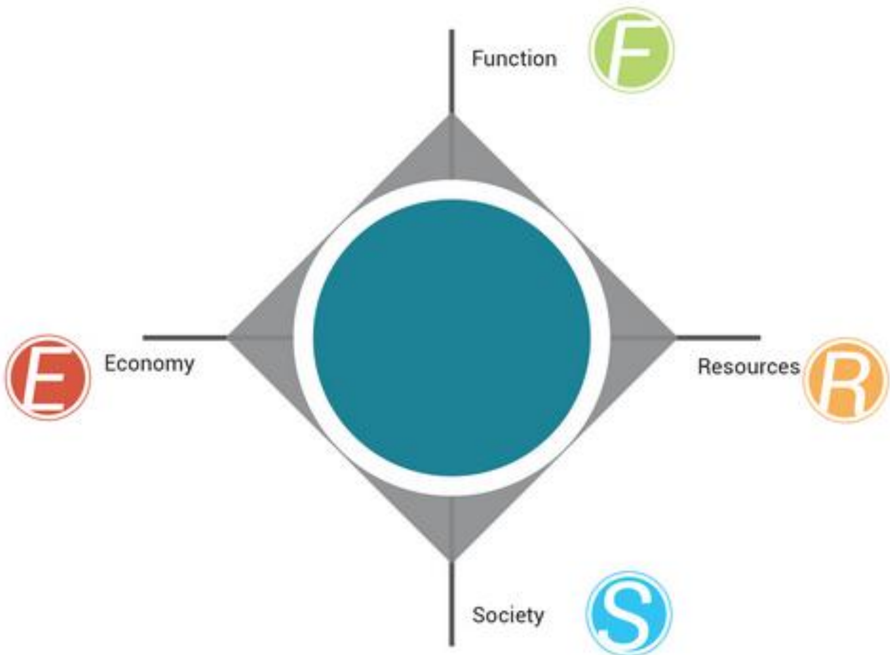
3 Rounding the corners concept



3.1 Relevance of the concept in promoting the transition to circular economy in practice

	1	2	3	4	5	6	
Not relevant	○	○	○	○	○	○	Highly relevant

3.2 Do you have any suggestions for other levels or ideas that should be represented in the concept?

Your answer

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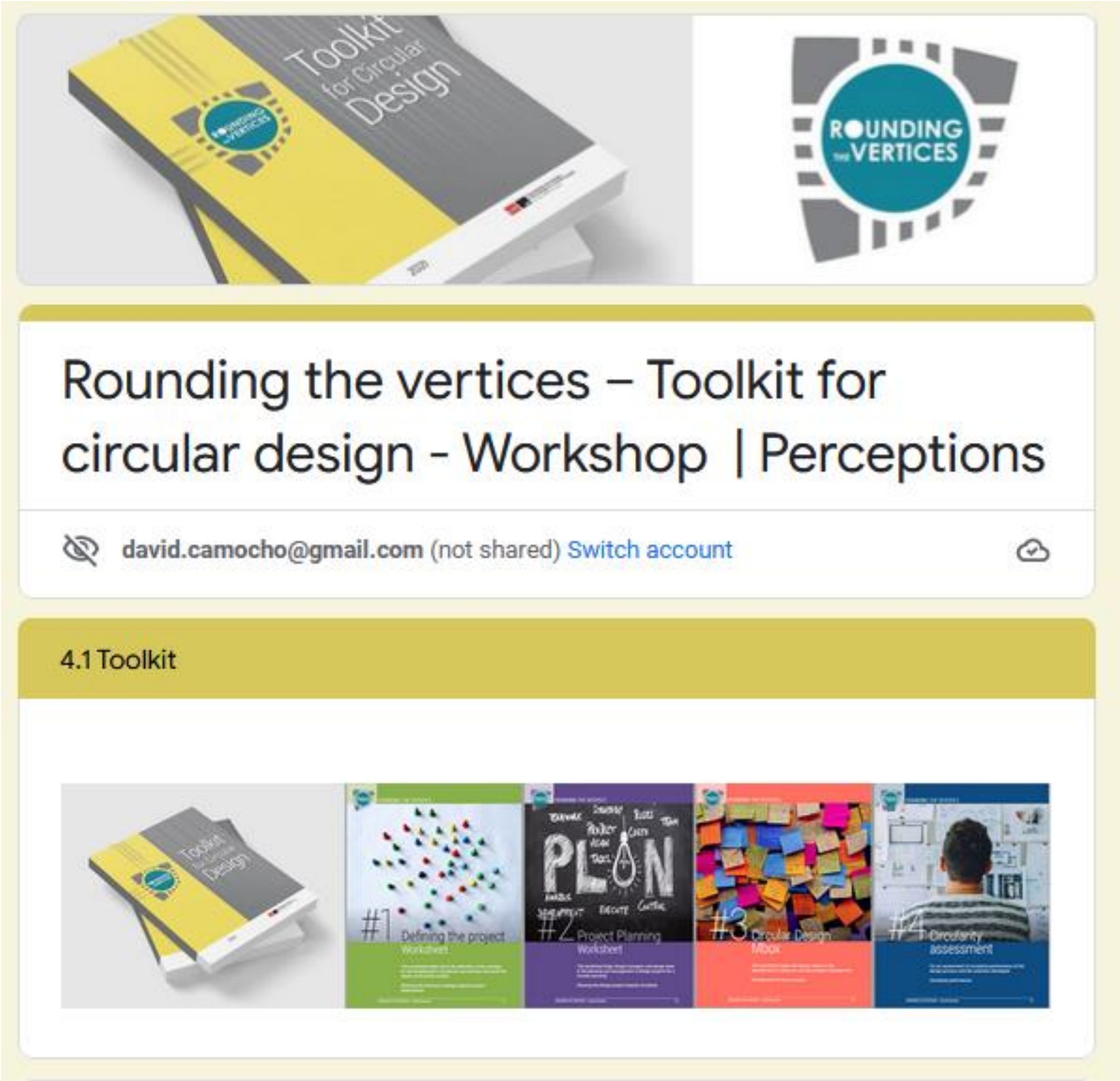

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4.1 Toolkit

Based on the presentation, please share your perceptions of the toolkit according to the different topics:

	Poor	Low	Medium	Good	Very good	Column 6
4.1.1 Structure	◯	◯	◯	◯	◯	◯
4.1.2 Graphic design	◯	◯	◯	◯	◯	◯
4.1.3 Content	◯	◯	◯	◯	◯	◯
4.1.4 Lenght	◯	◯	◯	◯	◯	◯
4.1.5 Usability	◯	◯	◯	◯	◯	◯
4.1.6 Language	◯	◯	◯	◯	◯	◯
4.1.7 Adequacy to the design professionals	◯	◯	◯	◯	◯	◯

4.2 Do you think the toolkit is adequate to the users' needs?

◯ yes

◯ No

4.3 If you could change something in the toolkit, what would you change? Do you have any idea or suggestion on how to improve the toolkit?

Plese insert some ideas about how to improve the toolkit

Your answer

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Rounding the vertices – Toolkit for circular design - Workshop | Perceptions

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7. Other comments, suggestions or remarks

7.1 Please use the following field to include other comments, suggestions and remarks not adressed in the above mentioned questions

Your answer

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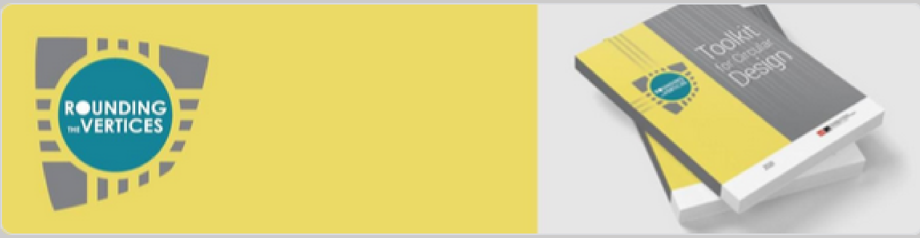
Annex 16 – Questionnaire experts review – Online



Rounding the vertices – Toolkit for circular design - Expert validation

The Rounding the Vertices toolkit, developed within the "Transition to circular and sustainable economy through design" PhD research project aims to narrow the gap between what is being developed in research and development projects and what is actually applied in the design practice in the development of circular and sustainable products and services.

The project is being developed with the supervision of Dr Ana Margarida Ferreira from IADE - ana.margarida.ferreira@universidadeeuropeia.pt and co-supervised by Dr José Vicente from UBI - jmanvicente@gmail.com.

The "Rounding the vertices - design for circular economy" is a design method that supports the practice and integrates the project development perspective, the management of the design project and the perspective of the business. The method was developed to implement these considerations in the early phases of the project with high innovation potential. The toolkit is composed of a set of tools that support the design practice.

The following questions aim to validate and collect feedback from a selected group of experts in the fields of design, sustainability and circular economy to improve its results and align them with the needs of the designers and product developers.

Concerning the protection of individuals about the processing of personal data, the information provided will be processed only for scientific research purposes, and in an aggregate way, thus guaranteeing the most complete anonymity.

If you have any doubts or questions about this survey, please let us know.
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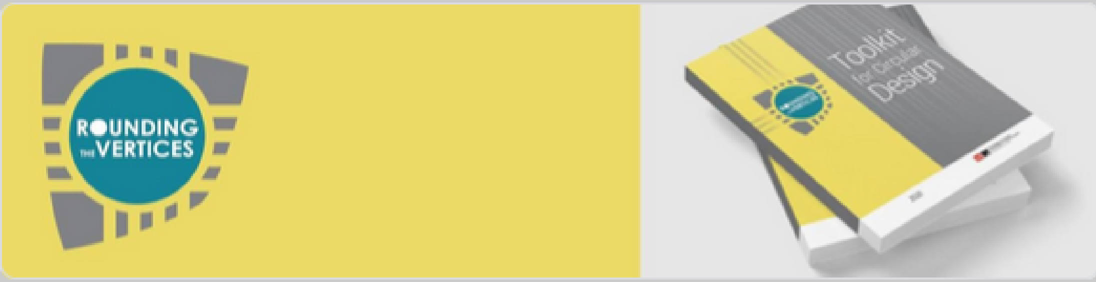

Rounding the vertices – Toolkit for circular design - Expert validation

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1. General information

1.1 Name

Your answer

1.2 Institution

Your answer

1.3 Main field of expertise

- ◯ Design
- ◯ Circular economy
- ◯ Sustainability
- ◯ Other: ____________

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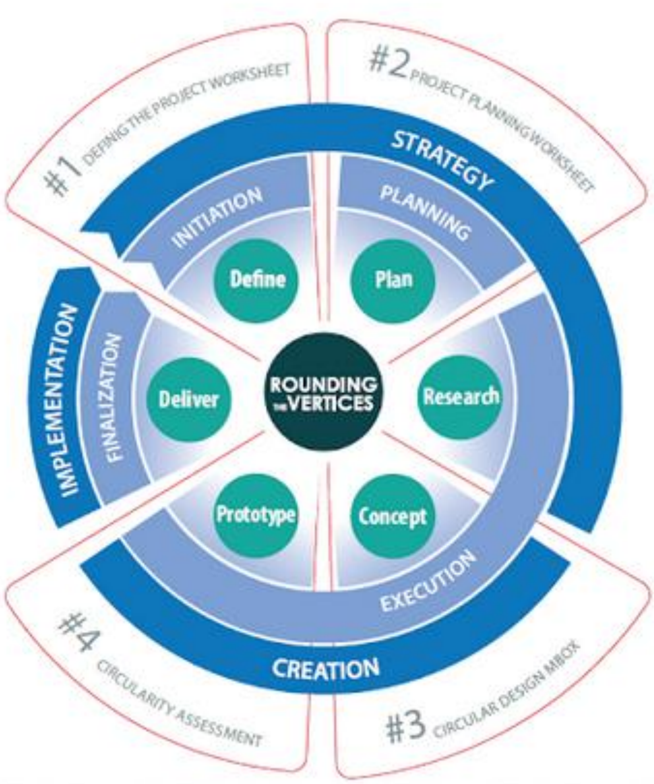
2. Design and development model

In order to operationalize the integration of the concept in the development of design projects oriented to the circular economy a model composed by 3 interlinked levels was developed. A level that corresponds to a strategic performance, oriented to the strategic objectives of the company, client, and project team, a level oriented to the management of the design process, and an operational level, oriented to the effective development of the project.



2.1 This model is useful to structure the design practice for the circular economy?

	1	2	3	4	5	6	
Strongly disagree	○	○	○	○	○	○	Strongly agree

2.2 The 3 levels (Strategic, Management and Operational levels) are important to organize the design project and define the different approaches?

	1	2	3	4	5	6	
Strongly disagree	○	○	○	○	○	○	Strongly agree

2.3 If you could change something in the model, what would you change?

Your answer

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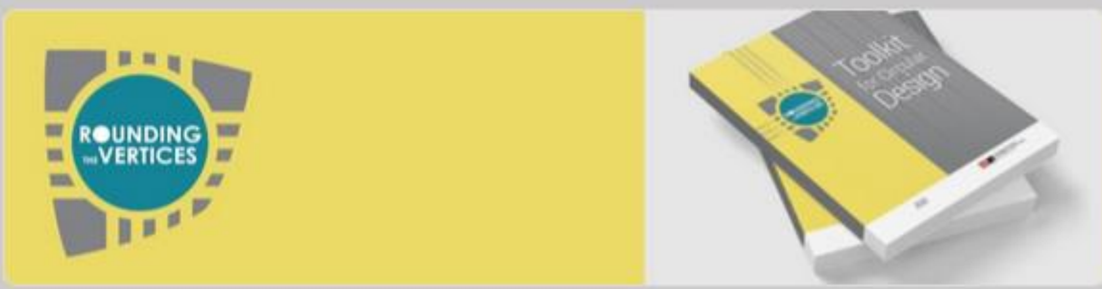

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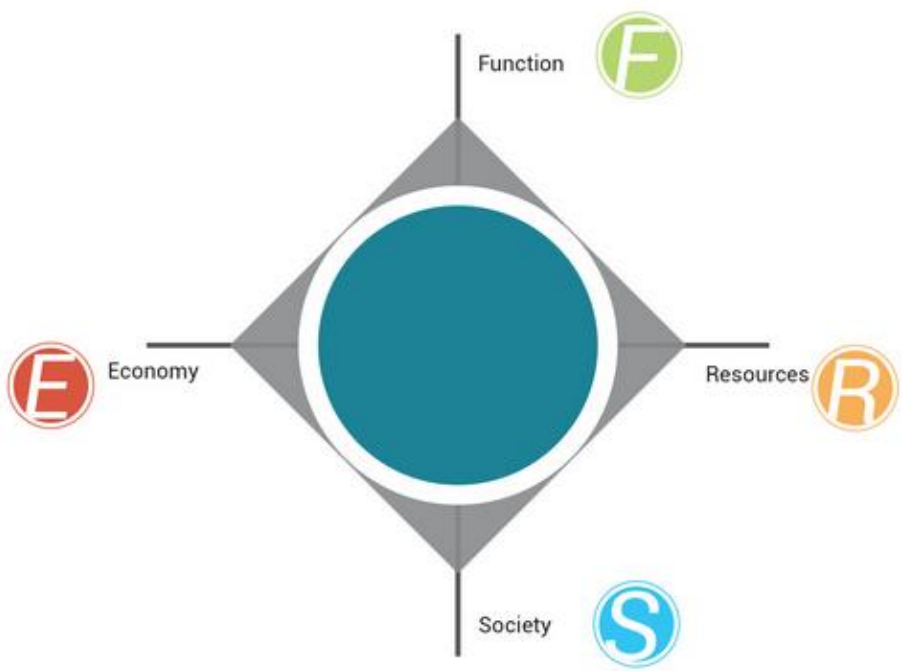
3

The Rounding the vertices concept is based on system optimization to support the transition to circular economy through design. The transformation of a square, which illustrates the linear economy into a circle, relative to circular economy presupposes an optimization at various levels.
Within this project, 4 fundamental dimensions were defined. Economy. Resources, Society and Function.



3.1 At what extent do you agree with the definition of these 4 dimensions in order to support the design process?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

3.2 Relevance of the concept in promoting the transition to circular economy in practice

	1	2	3	4	5	6	
Not relevant	○	○	○	○	○	○	Highly relevant

3.3 Do you have any suggestions for other levels that should be represented in the concept?

Your answer

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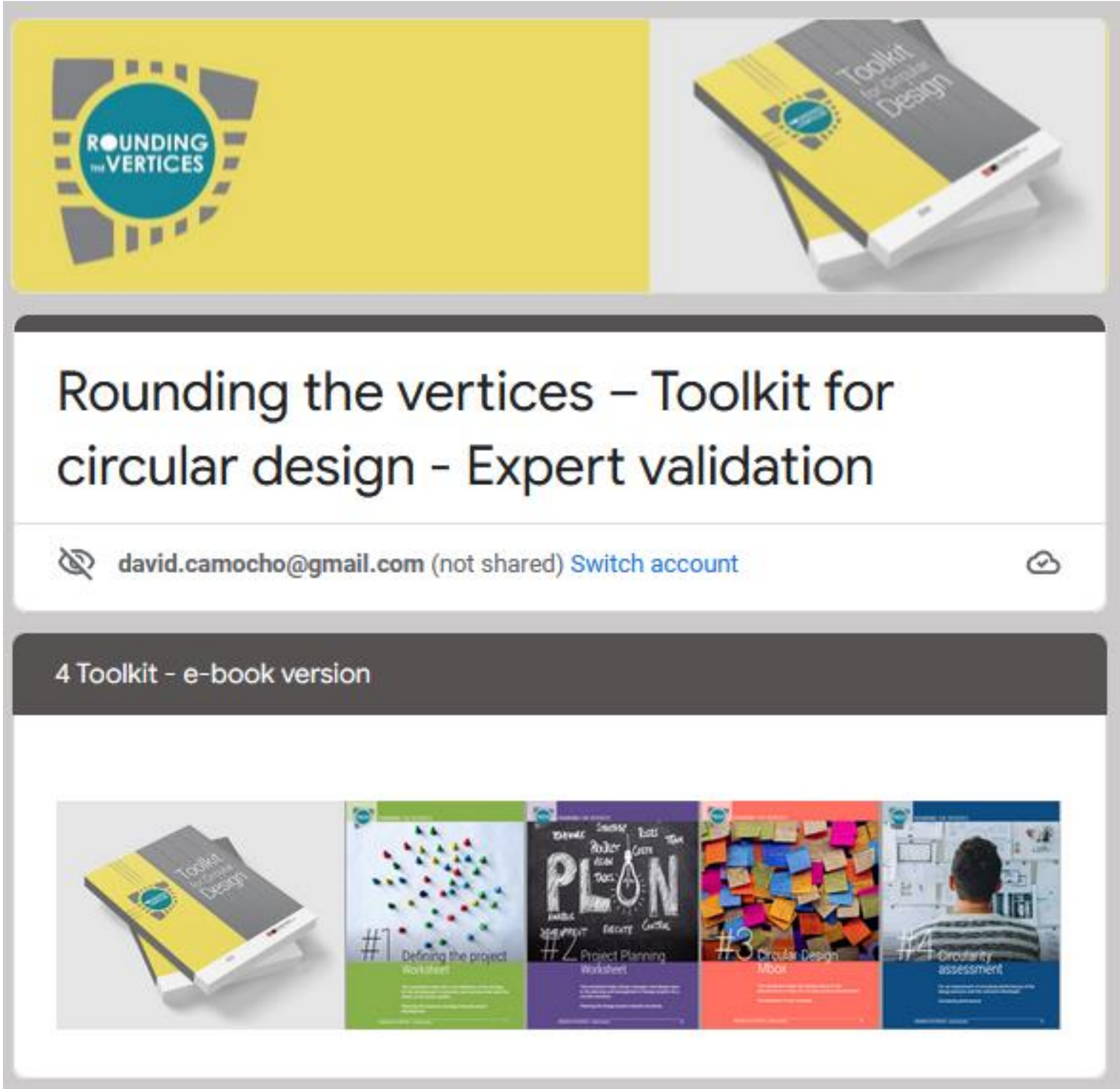
ROUNDING THE VERTICES
Toolkit for Circular Design
Rounding the vertices – Toolkit for circular design - Expert validation
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4 Toolkit - e-book version
#1 Defining the project Worksheet
PLAN
#2 Project Planning Worksheet
#3 Circular Design Mbox
#4 Circularity assessment

4.1 Please evaluate the toolkit according to the different topics:

	Poor	Low	Medium	Good	Very good
4.1.1 Structure	◯	◯	◯	◯	◯
4.1.2 Graphic design	◯	◯	◯	◯	◯
4.1.3 Content	◯	◯	◯	◯	◯
4.1.4 Lenght	◯	◯	◯	◯	◯
4.1.5 Usability	◯	◯	◯	◯	◯
4.1.6 Language	◯	◯	◯	◯	◯
4.1.7 Adequacy to the design professionals	◯	◯	◯	◯	◯

4.2 Based on your analisys of the ebook, wich are the main Weaknesses identifyed?

Your answer

4.3 Based on your analisys of the ebook, which are the main Strengths identifyed?

Your answer

4.2 Based on your analisys of the ebook, wich are the main Weaknesses identifyed?

Your answer

4.3 Based on your analisys of the ebook, which are the main Strengths identifyed?

Your answer

4.4 If you could change something in the toolkit, what would you change? Do you have any ideas on how to improve the toolkit in the excel versions?

Plese insert some ideas about how to improve the toolkit

Your answer

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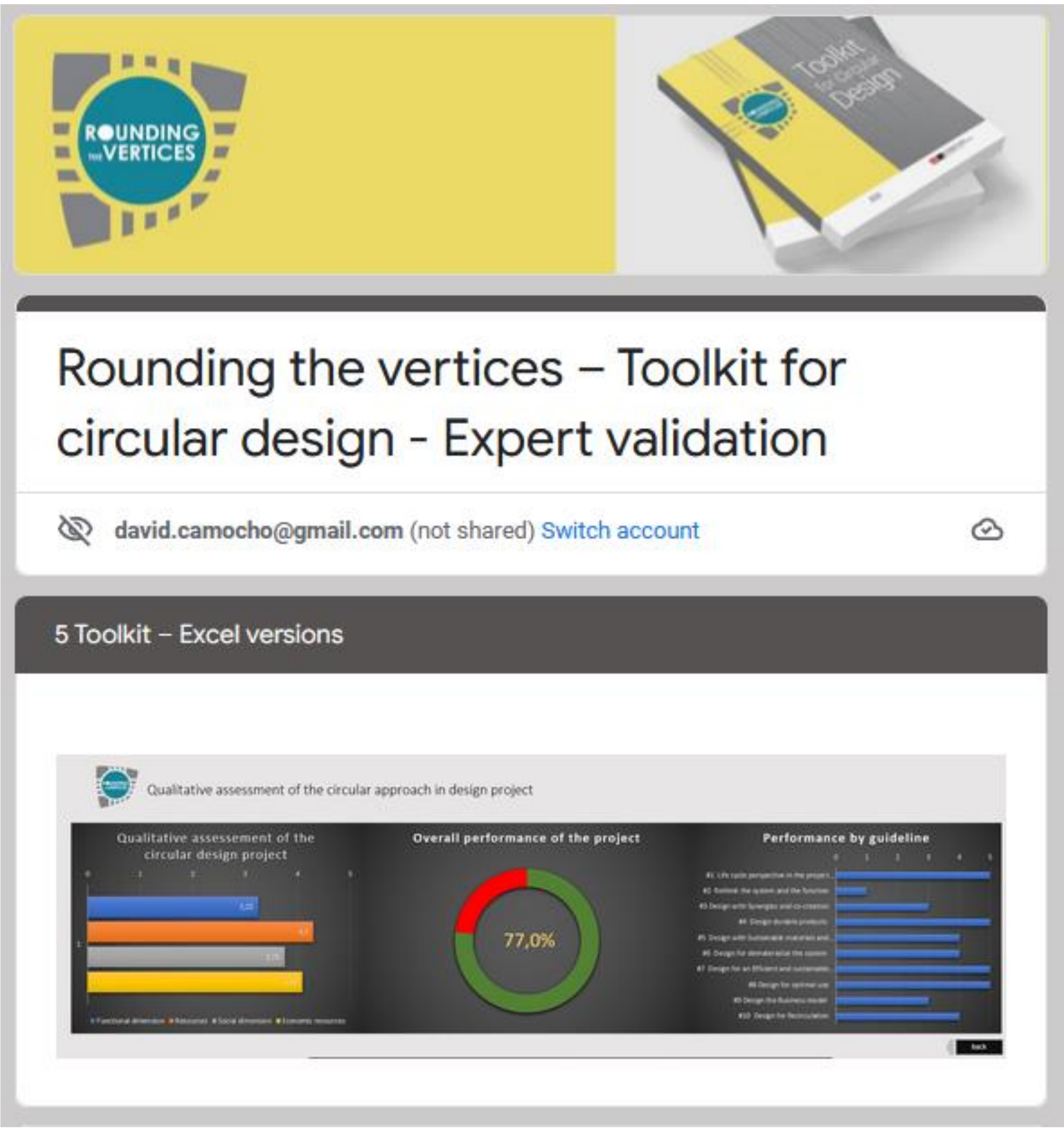
ROUNDING THE VERTICES
Toolkit for Circular Design
Rounding the vertices – Toolkit for circular design - Expert validation
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5 Toolkit – Excel versions
Qualitative assessment of the circular approach in design project
Qualitative assessement of the circular design project
Overall performance of the project
77,0%
Performance by guideline

5.1 Please evaluate the toolkit according to the different topics:

	Poor	Low	Medium	Good	Very good
5.1.1 Adequacy of the Excel versions to practical application	○	○	○	○	○
5.1.2 User friendliness	○	○	○	○	○
5.1.3 Graphic layout	○	○	○	○	○
5.1.4 Lenght	○	○	○	○	○

5.2 Please evaluate the excel versions of the toolkit according to the different topics:

Your answer

5.3 Please add comments to the excel versions of the tools - Strenghts

Your answer

5.4 If you could change something in the toolkit, what would you change? Do you have any ideas on how to improve the toolkit in the excel versions?

Plese insert some ideas about how to improve the toolkit

Your answer

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6. Toolkit - evaluation of individual tools - Ebook

In the following questions, please share you comments, ideas and improvement options related to each tool

6.1 Tool 1 - Defining the project worksheet - ebook version

Your answer

6.2 Tool 2 - Project planning worksheet – ebook version

Your answer

6.3 Tool 3 - Circular design Mbox – ebook version

Your answer

6.3 Tool 3 - Circular design Mbox – ebook version

Your answer

6.4 Tool 4 – Circularity Assessment tool - description in the e-book

Your answer

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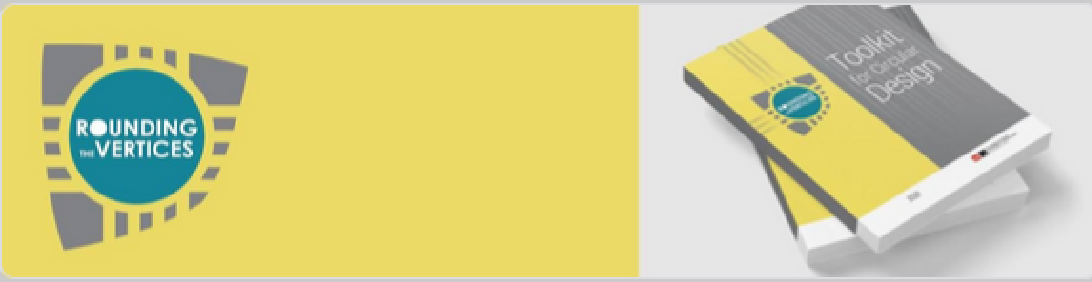

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7. Toolkit - evaluation of individual tools - Excel

In the following questions, please share you comments, ideas and improvement options related to each tool

7.1 Tool 1 -Defining the project worksheet - Excel version

Your answer

7.2 Tool 2 - Project planning worksheet - Excel version

Your answer

7.3. Tool 3 - Circular design Mbox - Excel version

Your answer

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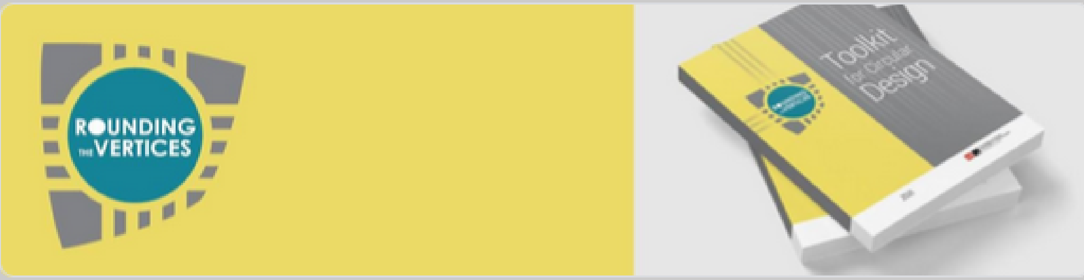

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8. Other comments, suggestions or remarks

8.1 Please use the following field to include other comments, suggestions and remarks not adressed in the above mentioned questions

Your answer

8.2 If you are interested in receiving the results of the questionnaire, please insert your email address.

Your answer

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Annex 17 – Paper_ TRANSition to circular and sustainable economy through design

TRANSition to circular and sustainable economy through design

ABSTRACT

This paper aims to present the research under development whose main objective is to support an effective and practical transition to a more circular and sustainable economy through design.

Currently, circular economy (CE) is gaining attention in Europe and around the world as a potential way for our society to increase prosperity and sustainability by reducing the dependence on primary materials and energy.

In this transition towards CE, numerous research projects and activities have and are being developed at distinct levels of society and design has a crucial role, however, there are still several limitations and barriers in its implementation. To implement the model, designers, product developers and companies need to be able to apply the CE principles and criteria in practice in a simple and efficient way.

The Ph.D. research project that underlies this paper was designed with the objective of supporting the creation of added value for the design professionals and for the society. Focusing on supporting the transition to the CE, the expected results will strengthen the role of design by providing professionals a strategy supported by effective methods and tools for an innovative and effective design practice.

Keywords: Design, Design tools, Design Management, Circular Economy, Sustainability

INTRODUCTION

The concept of sustainability defined in the Brundtland Report in 1987 as a development model that "responds to the needs of the present without compromising the ability of future generations to meet their own needs" has evolved and has been a widely disseminated and exploited strategy (Brundtland, 1987).

The environmental and social concerns in relation with the design activity had already received attention and, as defended by Victor Papanek in his famous publication "Design for the Real World" (Papanek, 1971) design plays a key role in the definition of the environmental profile of products and services. It is at the design stage that about 70 to 80% of the environmental and social impacts of a product are defined (Sinndesign 2016).

The integration of environmental considerations in product development with the objective of reducing products' impacts throughout their life cycle has been subject of methods development, training and implementation in companies since the 1990's. All products have impacts on the environment, which occur at all stages of their lifecycle, from raw material extraction to manufacturing, distribution, use, and end-of-life.

Today, designers and product developers face a new challenge. The design practice has been recognized as a catalyst to transition from the traditional model of take-make-dispose to achieve a more restorative, regenerative and circular economy. To attend the need for Circular Economy, products need to be designed for closed loops and adapted to generate revenues (Moreno, De los Rios, Rowe, & Charnley, 2016). Design for circular economy, as design in general, has the responsibility of responding to product or service problems, integrating various criteria and expertise in problem-solving in an innovative way and adjusted to the needs of users. In the circular economy, the designer has the function of translating the strategies and concepts of circularity in the development of products, services, and systems that promote the transition from a linear model to a circular model focused on closing cycles, on the efficiency and sustainability of the system, however, there is a need to provide design practitioners, business stakeholders and product developers recommendations and practices of how to think and apply particular design strategies for different circular business models (Moreno et al., 2016).

The design of a product directly influences the way a value chain will be managed. Building circular, globally sustainable value chains inevitably implies a fundamental change in the practice of design and despite the importance and recognition of the role of design as an engine and promoter of sustainability, there are still numerous barriers to its implementation in practice within companies and businesses (De los Rios & Charnley, 2017; Prendeville et al., 2013).

Numerous research and development activities have been carried all over the world. However, most of the literature is academic or with industrial examples mostly from business-to-business (B2B) level (De los Rios & Charnley, 2017).

Several research projects resulted in tested and validated methodologies and tools for an application in the development of projects in the companies, however, the adoption of sustainability measures is still seen as an accessory element with little commitment from companies and in most cases, its integration is superficial and poorly substantiated. In most of the cases, it is applied having as main objective the use as a marketing tool to promote the product, the company or in some cases, unfortunately as greenwashing (Alves, Ferreira, & da Silva, 2011). There are also numerous examples of research activities and literature developed to support companies to get started and implement sustainability in their process, however, there are very few examples of literature reporting on success cases of the practical application of the methodology and tools (Dekoninck et al., 2016).

The transition to a more sustainable way of design, produce and consume is a crucial objective for the development of our society (Bhamra & Lofthouse, 2007; Braungart & McDonough, 2009; Manzini & Vezzoli, 2010; MARGOLIN, 2014). In 2015 the European Commission adopted an ambitious Circular Economy Package (European Commission, 2015) to help European businesses and consumers to make the transition to a stronger and more Circular Economy where resources are used in a more sustainable way. The proposed actions will contribute to "closing the loop" of product lifecycles through greater recycling and re-use and bring benefits for both the environment and the economy. The plans will extract the maximum value and use of all raw materials, products, and waste, fostering energy savings and reducing Green House Gas emissions. The proposals cover the full lifecycle: from production and consumption to waste management and the market for secondary raw materials.

In December 2017 the National action plan for the circular economy was published by the Portuguese Council of Ministers (PAEC, 2017). The plan is part of the strategy to be followed up to 2020 and aims to redefine the concept of end-of-life of the linear economy, based on the production and elimination of waste, focusing on the concepts of reuse, repair, and renovation of materials and energy.

It is a strategic model of growth and investment based on efficiency and value of resources and minimization of environmental impacts. This is a document aligned with Portugal's international commitments, such as the Paris Agreement, the Sustainable Development Goals, and the European Union.

One of the instruments to support the implementation of circular economy is the design. The plan includes concrete actions to promote the transition to a circular economy and in these the design plays a crucial role. The design community should seize the momentum to promote and add value to its activity.

Motivation

Changes are taking place worldwide in business strategy and industries face increasing pressures from economic crises, resource scarcity, and pollution (De los Rios & Charnley, 2017). The Circular Economy is gaining attention in Europe and around the world as a potential way for our society to increase prosperity while reducing dependence on primary materials and energy (Ellen MacArthur Foundation, 2015).

Circular Economy is a relatively new concept with a fast development in Europe which is receiving increasing attention worldwide as a way to overcome the current production and consumption models based in so-called "linear economy" or "take, make and dispose model" that depletes natural resources and destroys ecosystems.

In this new transition towards CE, numerous research projects and activities have and are being developed at distinct levels of society and the design has a crucial role, however, there are still various limitations and barriers in its implementation. There is not a systematic approach to its implementation and CE is not already a well-established and mature concept. To implement the model, designers, product developers and companies need to be able to apply the CE principles and criteria in practice in a simple and efficient way.

In the past, sustainability was widely explored, and despite the perception of practitioners and the society of the need to adopt it in the production and consumption of products and services, in practice, sustainability was seen as a complex subject or as an accessory approach, focused on niche markets with low added value (Ferreira, Ana M.,2003). Despite the potential benefits of ecodesign as a way to implement sustainability in the Design practice, and the existence of several tools and techniques for product design, the actual application of ecodesign has not reached companies worldwide, mainly due to difficulties in ecodesign implementation and management (Pigosso, Rozenfeld, & McAloone, 2013).

Objectives

The research under development aims to help the transition to a more sustainable and circular economy through design. The design practice has a crucial role in defining the characteristic of the products and services that fulfill the needs of the society and their impacts in the life cycle are defined in the design and development phase. In order to promote design and the practice of design, it is important to assess the maturity of Portuguese companies and designers in the integration of sustainability criteria related to the development process through the analysis of the current design practice applied in the development of sustainable industrial products available in the market. This broad analysis will allow the identification of the current drivers, barriers, and needs faced by practitioners, which will support the development of strategies, methods and effective tools to support designers in the transition to the circular economy.

Circular economy is seen in the current political context as the potential successful path to achieve a sustainable future, a new economic model operating in closed circuits, catalysed by innovation along the entire value chain, is advocated as an alternative solution to minimize material consumption and energy losses (ECO.NOMIA) and designers should have the knowledge and the tools to leverage the process (Vicente, 2012).

The transition to a circular and sustainable economy requires better knowledge about the links between products, their underlying business model and the societal infrastructure and governance determining their life-cycle, which requires fundamental changes to production and consumption systems, going well beyond resource efficiency and waste recycling. Designing products in a smarter and innovative way, extending their useful lives and changing the role of such products within the system will be crucial to the achievement of that transition (European Environment Agency, 2017). Therefore, a new strategy, supported by improved methods and effective tools for designers, is needed.

Within the research under development, the research team aims to identify, explore and develop an effective strategy supported by improved methods and tools which will be easy to apply in practice, in order to promote the transition to circular economy through design.

Figure 1: Transition from the linear model to circular economy

Circular Economy and Design

Circular economy is an economic system that is restorative or regenerative by intention and design, which actively promotes the efficient use and productivity of resources. It replaces the end-of-life concept with closing, slowing and narrowing the resource flows in production, distribution and consumption processes, extracting economical value and usefulness of materials, equipment and goods for the longest possible time, in cycles energized by renewable sources, with the aim to accomplish the goals of sustainable development. It is enabled by design, innovation, new business models and responsible production and consumption (Ellen MacArthur Foundation, 2013; Kirchherr, Reike, & Hekkert, 2017; Bocken, de Pauw, Bakker, & van der Grinten, 2016)

Inspired by nature in the mechanisms of natural ecosystems, which manage long-term resources in a continuous process of re-absorption and recycling, the circular economy promotes a reorganized economic model through the coordination of production and consumption systems in closed circuits. It is characterized as a dynamic process that requires technical and economic compatibility but also requires a social and institutional framework (ECO.NOMIA).

The circular economy currently is a focus theme on the international political agenda. The necessary revolution requires concerted and strategic alignment as we live in an age of globalization and value systems on a world scale. This change will require a significant effort from all parties, not only from producers and consumers but also from governments themselves (PAEC, 2017).

The CE goes beyond the scope and strict focus of waste management and recycling actions, aiming at a broader action, from the redesign of processes, products and new business models to the optimization of the use of resources. It thus aims to develop new, economically viable and environmentally efficient products and services based on optimally perpetual cycles of reconversion. It materializes in minimizing resource extraction, maximizing reuse, increasing efficiency and developing new business models through design (ECO.NOMIA).

Under this context, the European Commission is engaged in fostering the transition from the largely current linear model and published in 2015 the roadmap: “Closing the loop – An EU action plan for the Circular Economy” (European Commision, 2015). This communitarian sets out initiatives including ecodesign among others.

Design is responsible, to a large extent, for defining the circularity potential of products: i.e., their reparability, longevity, proportion of recycled and renewable materials, and their suitability for refurbishment and remanufacture (European Environment Agency, 2017). It is also necessary to develop maintenance, repairing, reuse and reverse logistics services; as a matter of fact, new business models and service design are required for dematerialization through sharing, leasing and renting services, as well as services that deliver performance (Bocken et al., 2016). Consequently, the role of designers is to meet people’s needs and develop technically and economically feasible products and services (World Design Organization, 2017). Thus, designers are challenged by new environmental, social and economic needs and must adopt a holistic approach to problem-solving (Bocken et al., 2016) taking into account that most of the characteristics of a product entire life cycle are defined in the design stage.

The National Plan for the Circular Economy published by the Portuguese council of ministers in 2017 (PAEC 2017) presents three levels of actions to be introduced and worked over the next three years: national, transversal actions that consolidate some of the actions of several governmental areas for this transition; sectorial agendas, especially for sectors that are more resource-intensive and export-oriented; and regional agendas, which must be adapted to the socio-economic specificities of each region. The Portuguese plan presents instruments to support the implementation of circular economy such as:

- Design: Designing products and services for circularity which requires a systemic view, knowledge, information, and methods.
- Technologies and new business models: technological innovation is of transversal relevance, but the focus has been on strategies of low circularity.
- Reverse cycles (e.g. reverse logistics): a robust, customer-friendly, flexible and efficient reverse logistics to ensure the return of products, components, and materials to the manufacturer for new cycles of use.
- Promotion of favorable context: for an active production in the reduction of impacts, the multiplication of cycles of use, the demand for greater productivity of resources or the valorization of performance (versus the valuation of property) become common, the market will have to have a favorable context.

The plan includes concrete actions to promote the transition to a circular economy and in these the design plays a crucial role. As mentioned before, the design community should seize the momentum to promote and add value to its activity.

Research questions and hypothesis

The research under development intends to answer the following questions and contribute to the increase of knowledge in the fields of design for sustainability and circular economy:

- How design will support the transition from the linear economy to the new model of circular economy?
- Which tools can designers apply to support an effective design practice for a successful transition to circular economy in the real world?
- How can designers overcome the barriers in the implementation of a design practice that effectively result in more sustainable products and services aligned with the European policies for CE?
- How can the design practice and the role of the design professionals be promoted in circular economy context?

Design has the responsibility of responding to product or service problems, integrating criteria and innovative solutions in problem solving, adjusted to the needs of users and the society as whole, which is a key argument of sustainability resulting from the perception that designers must give a more universal and inclusive response and not only depend on the economic interests of companies or focused in niche markets (Ferreira, A.M., 2008).

In the CE, the designer has the function of translating the strategies and concepts of circularity in the development of products, services, and systems that promote the transition from a linear model to a circular model focused on the closing of cycles, the efficiency and sustainability of the systems**. Design, through its specific methods and tools, is an important factor in an effective transition to a circular and sustainable economy** is the hypothesis that will be verified by the research under development. The aim of the research is to promote design and demonstrate to practitioners and companies the key role design has in this process.

The anticipated contributions of the study

The authors are convinced that the study will add value to the design practice in the areas of design, sustainability and circular economy at business and educational levels. Firstly, the study will have an innovative approach in mapping the design practice with sustainability concerns in Portugal by identifying relevant products and the process underlying, having as primary sources of information the designers and companies that were responsible for the development and placement of the products in the market. These professionals are the ones who had dealt with the real challenges of the introduction of sustainability in the design process. Secondly, the study aims to establish a new strategy to promote the effective application of the design practice, supported by methods and tools aligned with the needs of designers and other practitioners. Thirdly, guidelines, supporting a robust and effective design practice will be tested and validated by international experts and by the practical application in pilot projects with companies and workshops with companies and designers. Finally, the results of the research will increase the knowledge and contribute to a more sustainable and circular economy, aligned with the needs of the society, today and in the future.

Research plan and methodology

The methodology presented was designed with the objective of supporting the development of a research plan aiming to the creation of added value for the design professionals and for the society. Focusing on supporting the transition to the CE, the expected results will strengthen the role of design by providing professionals a strategy supported by effective methods and tools for an innovative and effective design practice.

The research plan, established for the next 2 years, is composed of three main methodological moments that correspond to the three main steps in the development process.

<u>In the first methodological moment</u>, which will result in the systematic analysis and identification of the current state of the art by mapping the design and sustainability practices in Portugal and the identification of the main drivers and barriers faced by companies, designers, and practitioners, the plan comprises three main activities:

- Literature Review. A review of the most relevant sources published on the topic;
- Benchmarking of methods and tools. A qualitative analysis of the methods and tools available in the literature, internet, result of international research projects, and other sources. These methods and tools are available, and designers and companies can apply them in the development of new and more sustainable products and services;
- Field research (primary source of information) – Methods and tools applied in practice. At this stage, the research team plans to identify a wide group of products that are produced in Portugal and placed in the market (national or international) as being more sustainable. The products will be identified through internet, magazines, 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 will be gathered in a database of "sustainable" products that will be used to support the research, however, it can be made public, available to all, as a mean to promote sustainability, circular economy, national products, and designers, if perceived useful during the Ph.D. process.

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

  The effectiveness of the current practice will be assessed by a qualitative evaluation of the sustainability profile of the identified products, based on the information available and using a tool previously developed in an international research project. The tool, following a life cycle approach, is a checklist with a set of questions that allow a fast and simple analysis. 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 profiles of products in Portugal.

The identification and characterization of the state-of-the-art will include all the information on how designers are using and applying the methodologies and tools in the development of more sustainable products, which are the motivations and barriers faced in their daily activities and how circular economy is perceived by the practitioners.

<u>The second methodological moment</u> is the phase where the research team, based on the previous analysis will answer the research questions and verify if the hypothesis is valid.

In this step, it is planned to define a new strategy and guidelines to improve the role of design in the transition for a circular and sustainable economy. The strategy for the design practice within CE will be supported by efficient tools and methods that need to be developed, adapted or re-shaped in order to create a toolkit as an experience-based research that can be applied by practitioners in their daily activity to develop innovative and sustainable circular solutions.

An assessment of the proposed Research experiment will be made in workshops with experts from the fields of design, sustainability, and circular economy through the contact with European stakeholders, to discuss, review and validate the results achieved.

In the third methodological moment, related to the test and validation of the previous research work, namely the model of a more sustainable design activity and tools to support it, and in order to guarantee the applicability of the results, it is important to involve the design community and companies from the very beginning of the conception and development phase. The test phase will deliver valuable feedback on meeting the needs and show the practicability, benefits and expected innovation potential of the results.

This activity will be held by the organization of pilot projects in companies and national workshops with designers and companies to discuss, apply and test the result of the research.

The experience gathered from both sides – company representatives and designers – will be transferred into recommendations for further developing.

The interaction with company representatives and designers give an insight on the status and potential for implementing circular economy strategies and should deliver input on how to meet current and future company's needs to support them on the transition towards CE.

Based on the previous moments, the research team will develop the conclusions of the research, which by answering the research questions and validating the hypothesis, will result in an increase of knowledge and contribute to a more sustainable and circular economy, aligned with the needs of designers and companies in Portugal.

Conclusion

This research paper aims to introduce the research work under development by the author within the scope of the doctoral program at IADE and giving continuity to the last 17 years of work in the field of design and sustainability.

The aim of this research is to contribute to society, acting at the level of product design and service design, contributing to the transition to a more circular and sustainable economy.

This research work and the answer to questions such as "How design can effectively contribute to the transition from a traditional and linear economy to a more sustainable and circular model, will result in the definition of a strategy, supported by methods and tools that will support a more efficient design practice aligned with European and national policies and will contribute to a more sustainable future.

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Annex 18 – Paper_ Circular economy – Tools for designers

Circular economy - Tools for designers

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ABSTRACT

The circular economy is seen as a new concept and a new way of responding to the needs of society in a more sustainable and efficient way. The transition from the traditional linear model to a more innovative and circular approach in the development of the economy implies the design of new products, services, and systems, supported, in most cases, by the re-thinking and creation of innovative business models.

To achieve a successful and wide implementation, the concept must be accepted and applied in practice by businesses along the whole value chain and meet the current and future needs of consumers through design.

Several methods, principles, practices, tools, training initiatives, and many resources are being developed globally, but there is still a large gap between what is available to companies and designers, and what is applied in practice on product and service development.

This paper, aligned with a Ph.D. research project focused in the promotion of Circular Economy through design, explores results of an in-deep review of main circular economy tools available that can be used by designers to systematize and guide their development process. The analysis will be a basis for the future development of a toolkit oriented to the practical implementation of the circular economy in the design. (Camocho, Ferreira, & Vicente, 2018)

Keywords: Circular Economy, Tools, Design Practices and Principles, Innovation, Sustainability

INTRODUCTION

The Circular economy approach to the development of the society is seen as a potential solution to attain a sustainable future by increasing prosperity while reducing the critical dependence on primary materials and energy (Ellen MacArthur Foundation, 2015). In the past, during many decades, designers and other professionals have been working to achieve sustainability in the development process, aiming to increase the efficiency and innovation exploring several approaches, from cleaner production, eco-design, design for sustainability through product services systems, however, despite several good examples, mainly linked to niche markets, the results were far from been globalized and integrated widely in the society. Nowadays, Circular Economy claims to be a new path to achieve sustainability and welfare, promoted strongly by governments, research institutions, academia, associations, and many other stakeholders.

This new economic model that aims to work in closed circuits, catalyzed by innovation along the entire value chain, is promoted as an alternative solution to minimize resource consumption and energy losses (Ministério do Ambiente, n.d.) and designers should have the skills, knowledge and the tools to leverage this process (Vicente, 2012).

Today, designers and product development teams face new challenges in their daily practice. The design is recognized as a catalyst to transition from the traditional model of take-make-dispose to achieve a more restorative, regenerative and circular economy(Moreno, De los Rios, Rowe, & Charnley, 2016) and the design of products and services in a smarter and innovative way, extending their useful lives and adjust the function of such products and services within the system will be crucial to the achieve the transition to circularity (European Environment Agency, 2017).

The design practice relies on methods and tools. The evolution of the design profession and the solutions proposed by designers to solve the problems and needs of the society is linked, at some extent, to the evolution of the tools available to designers, (Vasantha G., 2014)(Vicente, 2011). The tools designers use, which have a significant impact on the development process, are changing constantly, new tools appear frequently, especially in the digital environments (Witkowski, 2017), however, and even though tools related to circular economy are starting to appear, it seems that in most of the cases, designers are integrating circular economy strategies in an ad-hoc way, without the support, guidance, and validation of tools at different stages of the process.

CIRCULAR ECONOMY

We can find in literature many definitions of circular economy. The concept has been widely explored and each author or each project tends to develop a definition that best suits their interests. This proliferation and diversity of definitions do not help in the communication and practical implementation of circular economy by businesses.

One of the most known and spread definition is the one developed by the Ellen MacArthur Foundation. However, many others were published. In 2017, an article analysed 114 definitions of circular economy and concluded that there is not one coherent understanding or definition of circular economy (Kirchherr et al., 2017), and from 2017 till now, many other definitions were developed.

Within the KATCH_e EU Project (KATCH_e, 2019) focusing in the reinforcement of the design skills and competences in the field of product-service development for the circular economy and sustainability, the consortium, building on several definitions and concepts from the main key players on circular economy developed a definition that is the definition adopted in the current research by the authors:

"Circular economy is a system that is restorative and regenerative by intention and design, which maximizes ecosystem functioning and human well-being with the aim of accomplishing sustainable development.

It replaces the end-of-life concept with closing, slowing and narrowing the resource flows in production, distribution and consumption processes, extracting economical value and usefulness of materials, equipment and goods for the longest possible time, in cycles energized by renewable sources. It is enabled by design, innovation, new business and organizational models and responsible production and consumption".

DESIGN FOR CIRCULAR ECONOMY

The design plays a key role in the definition of the profile of products and services, and a more sustainable way of design, produce, and consume is a crucial objective for the development of the society (Bhamra & Lofthouse, 2007; Braungart & McDonough, 2009; Manzini & Vezzoli, 2010; MARGOLIN, 2014).

New methods and effective design-oriented tools are needed to support and promote the transition to a circular economy. Designing products in a smarter and innovative way, extending their useful lives and changing the role of such products within the system is crucial to the achievement of a transition to circularity (Camocho et al., 2018; European Environment Agency, 2017) from a society that has been actively seduced by the over-consumption of new and better goods and services, leading to massive consumption of natural resource and the generation of waste and emissions, (Medkova & Fifield, 2016) and this had been promoted globally by industries through design.

The transition to circular economy is not only a design issue but design has a massive role. The potential for design to influence and impact the way that we produce, consume and dispose of products is huge. The Portuguese National action plan to circular economy includes concrete actions to promote the transition to a circular economy and in these the design plays a crucial role (PAEC 2017).

The design practice in circular economy can be seen as more complex, requiring changes in the way of thinking and conduction projects focusing on a shift from product-based solutions to system-based or function-based approaches (RSA. 2014).

Designers need to align their development process with the concept of circular economy in order to replace the conventional end-of-life concept in which the materials and components of a product are disposed after the fulfilling of the function by closing, slowing and narrowing the resource flows in production, distribution and consumption processes (Bocken, 2016) by applying several strategies in the development process.

As for strategies to achieve circularity, several approaches in the literature that are related to design were identified. As an example, the Ellen MacArthur Foundation proposed 3 main principles: (Ellen MacArthur Foundation, 2015)

1. Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows
2. Optimize resource yields by circulating products, components, and materials in use at the highest utility at all times in both technical and biological cycles
3. Foster system effectiveness by revealing and designing out negative externalities

These three principles are then translated into the ReSOLVE framework which considers six actions that should be considered by design.

Regenerate	Shift to renewable energy and materials; Reclaim, retain, and restore the health of ecosystems; Return recovered biological resources to the biosphere
Share	Share assets (e.g. cars, rooms, appliances); Reuse/second hand; Prolong life through maintenance, design for durability, upgradability, etc.
Optimize	Increase performance/efficiency of the product; Remove waste in production and supply chain; Leverage big data, automation, remote sensing and steering
Loop	Remanufacture products or components; Recycle materials; Digest anaerobically; Extract biochemicals from organic waste
Virtualise	Books, music, travel, online shopping, autonomous vehicles, etc.

Exchange	Replace old with advanced non-renewable materials; Apply new technologies; Choose new product/service (e.g. multimodal transport)

Figure 1. Ellen MacArthur Foundation - Growth Within, adapted

METHODOLOGY

The literature review under development aims to identify which tools are available to designers and their adequacy to the design practice for circular economy, having in mind the principle of circular economy and the needs of the design process.

The results of the search resulted in a collection of relevant academic and non-academic resources that are available to be implemented by designers.

Within the current study, only the tools that indicate their relevance to circular economy were selected. Despite the fact that many sustainability and eco-design tools are available in diverse platforms (online, software's, board games, etc) and that their application in circular economy project is relevant (as an example LCA software like SimaPro), the study considers mainly those that were developed and disseminated claiming to be oriented to circular economy.

To perform the analysis of the tools, besides the general information such as the identification, editor/publisher, author, source, availability and short description, a set of variables were used to access the potential for application by designers.

The variables were the following:

- The aim of the tool
- Scope - Circular economy; Eco-design, Design for sustainability, LCA, etc
- Assessment indicators/strategies - how the tool is applied? Which indicators or strategies are applied?
- Life cycle perspective – indication if the tool has an LC perspective or if only focus on a specific stage
- The influence on the design process - How can the tool influence the design?
- The influence in the business model - Can the tool and the results influence the business model?
- Type of inputs - Qualitative or Quantitative
- Inputs - Which inputs are needed to use/apply the tools
- Level of complexity - Level complexity in using the tool by design professionals
- Sectoral focus - sectoral, to which sector the tool is applicable or if it has a generic approach
- Expected results – which type of results are attained with the tool
- Pros and cons – Analysis of the main Pros and cons of the tool related to the design practice in the development of circular products and services

In the next chapter, the authors present eight tools that were analyzed within the research project under development according to the variables explained above. These resources address circularity aspects to develop new products and services and can be applied by design professionals.

TOOLS

Circularity Check

The Circularity Check developed by Ecopreneur, Wesustain, and MVO is a free tool to assist companies to become sustainable and circular or resource-efficient. The tool is primarily intended as an instrument for self-evaluation by companies, based on a questionnaire with about 60 questions that determines a circularity score for a specific product and/or service.

The checklist consists of a free questionnaire that can be filled out online covering five main indicators: Design, procurement, and manufacturing; delivery, use, recovery, and sustainability and the outcome is a total score on circularity (0-100%) and partial scores on the five indicators (0-100%) showing the overall strengths and weaknesses for the product or service.

The tool calculates the score and presents it in a few graphs, and by analyzing and answering the questions, and the scores on each indicator, the design team should identify potential ideas to improve and redesign the product or service (Ecopreneur).

Circular Economy Toolkit

The Circular Economy Toolkit is a free online resource for businesses to find Circular Economy opportunities.

The tool is based on a set of 33 questions related to the strategies and by answering, the analysis will result in the indication of the improvement of potential strategies: Design, Manufacture and Distribute; Repair/Maintenance of the product; Reuse/Redistribution of the product; Remanufacturing/ Refurbishment of product or part; Products as a Service; and Product Recycling at end of life. Besides the assessment features, the tools provide useful information in each strategy.

Based on a simple and user-friendly structure, the results cover the life cycle stages and highlights the potential in each one, and by analyzing the questions and results, the user can identify ideas to improve the product under analysis (circular economy toolkit)

Material circularity indicator

The Material Circularity Indicator (MCI), developed by Ellen MacArthur Foundation and Granta Design, is a tool aiming to measure how restorative the material flows of a product or company are.

By comparing to a similar industry-average product, the MCI for a product measures the extent to which linear flow has been minimized and the restorative flow maximized for its component materials, and how long and intensively the product is used. The tool is built from a combination of three product characteristics: the raw material used in production, the unrecoverable waste that is attributed to the product, and a utility factor that accounts for the length and intensity of the product's use.

The tool is easy to fill in with a user-friendly interface and useful to demonstrate the circularity level of a specific product.

The indicators may be used by designers to analyze a reference product or service and the assessment of potential changes in new designs, as well as for internal reporting, procurement decisions, and the evaluation or rating of companies. (EllenMcArthur)

KATCH_e tools (KATCH_e 2019)

Within the EU research project KATCH_e - Knowledge Alliance on Product-Service Development towards Circular Economy and Sustainability in Higher Education, several tools were developed to support a transition to circular economy.

The following four tools are the ones with a higher potential to be applied in the design practice from the above-mentioned research project under development.

KATCH-Up Board game

This tool is based on a creativity board game and aims to create an idea-value of a new product/service according to the needs of the users and to define the most appropriate circularity design strategies and business models to launch the product/service into the market. The objective of this game is to stimulate the users to generate value ideas from a business challenge, applying circular design and circular business strategies.

Based on six basic steps: a) Defining the problem context; b) Way to the solution focused in the circular economy strategies that can be applied, c) Idea creation, with the development of a solution to meet the needs of the challenge; d) Business model, defining the most appropriate business model; e) Market launch, to define how the solution can be placed on the market and f) Presentation of the results of the exercise, the game acts as a guide to get an idea about an innovative product-service or to solve a real business problem and generate improvement opportunities.

KATCH_e CE Strategist

This tool helps the user to identify for a specific product in a specific context, Circular Business Opportunities and provide ideas and inspiration along the process of defining a Circular Business Model.

The tool starts with an assessment of a product or business to identify circularity strategies that fit best to the predefined circular business strategies.

After assessing the opportunities, the tool proposes several strategies to choose from and shows a definition of each strategy, providing existing business examples and shows how the strategies are connected to specific Design Strategies. The final step is a definition of the Circular Business Model using an adapted version of the Business Model Canvas framework. The Canvas, describing the business model highlights the implications and effects of circular models and guides the user towards circularity.

KATCH_e CE Designer

The CE Designer is a semi-quantitative tool for prioritization, assessment and idea finding of circular solutions for product and/or service design. It consists in a checklist structure organized in 8 strategies that address the most relevant issues a design team needs to consider in the development process of new products or services to support the transition to a more circular society.

The tool, in the first step, starts by asking the user to reflect on each strategy, their adequacy, and relevance for the project under development. In the next phase, the user evaluates the profile of the reference product in each strategy according to to a set of predefined criteria. This step has two objectives, the first is the assessment of the reference products, identifying the hotspots in the product which can be improved, and secondly, by answering the questions in each criterion, the user can identify improvement opportunities that can be implemented in the project.

The identification of the hotspots and opportunities are useful resources to be used as background information to brainstorming and development activities.

In the third phase, the tool is used to compare the reference situation with the new concepts or new products /services resulting from the project.

The tool is simple to be used by designers and development teams and the process and results allow the development of new and innovative circular solutions.

KATCH_e Circular Economy Journey

The tool aims to help the players to assess the overall Product / Service / System journey, in the three stages (uphill, top hill and downhill) according to several factors: materials, producers, stakeholders, and users.

Through a visual canvas, the tool consists in a visual representation of the journey, it aims to identify the touchpoints between the factors identified, providing a model for analysis and identification of opportunities to optimize the journey and to enhance the closing of the loops to develop a more circular solution for a specific problem.

Being a physical tool composed by a printed canvas, cards, pins and color threads, the tool promotes innovation, discussion and brainstorming in creativity sessions.

CONCLUSIONS

Designers have at their disposal numerous tools oriented to support the development of sustainability and eco-design projects, both qualitative and quantitative tools with different levels of complexity, costs, orientation, typologies of results, among others. These tools have been extensively developed, but their use is not as wide as expected and most designers and development teams have not used them in practice in a systematic way.
Currently, the concept of circular economy is gaining attention worldwide and being widely disseminated at various levels of society, and tools with a specific orientation towards the development of circular products and services are beginning to appear.
In order to ensure that the products and services developed are indeed circular, it is necessary to apply several methods and tools that support the development, validation, and communication of their circularity aspects. In order to become widely used tools, it is necessary that these combine the perspectives of circularity with the needs of the design practice.

The seven tools presented address the challenge of integrating circularity in design, however, due to the nature of the tools, which are not mature yet, their characteristics and the needs of the design practice, there is still the need to develop an efficient and innovative tool or a toolkit to support the design of innovative circular products and services. These new or redesigned tools must address the design practice and supply efficient results perceived by all stakeholders as an added value to design projects showing clearly the benefits of their utilization.

FURTHER RESEARCH

The identification, test, and analysis of circularity tools will continue along the project and other relevant activities will be developed such as the analysis of the designers and product developers' perceptions, methods, and approaches on the development of circular products in order to understand how designers translate the user and business needs in product development. The identification of which methodologies and tools are applied in practice by designers and which are the needs, barriers and drivers in their adoption in product/service development will promote the development of the efficient resources to support the transition to circular economy through design.

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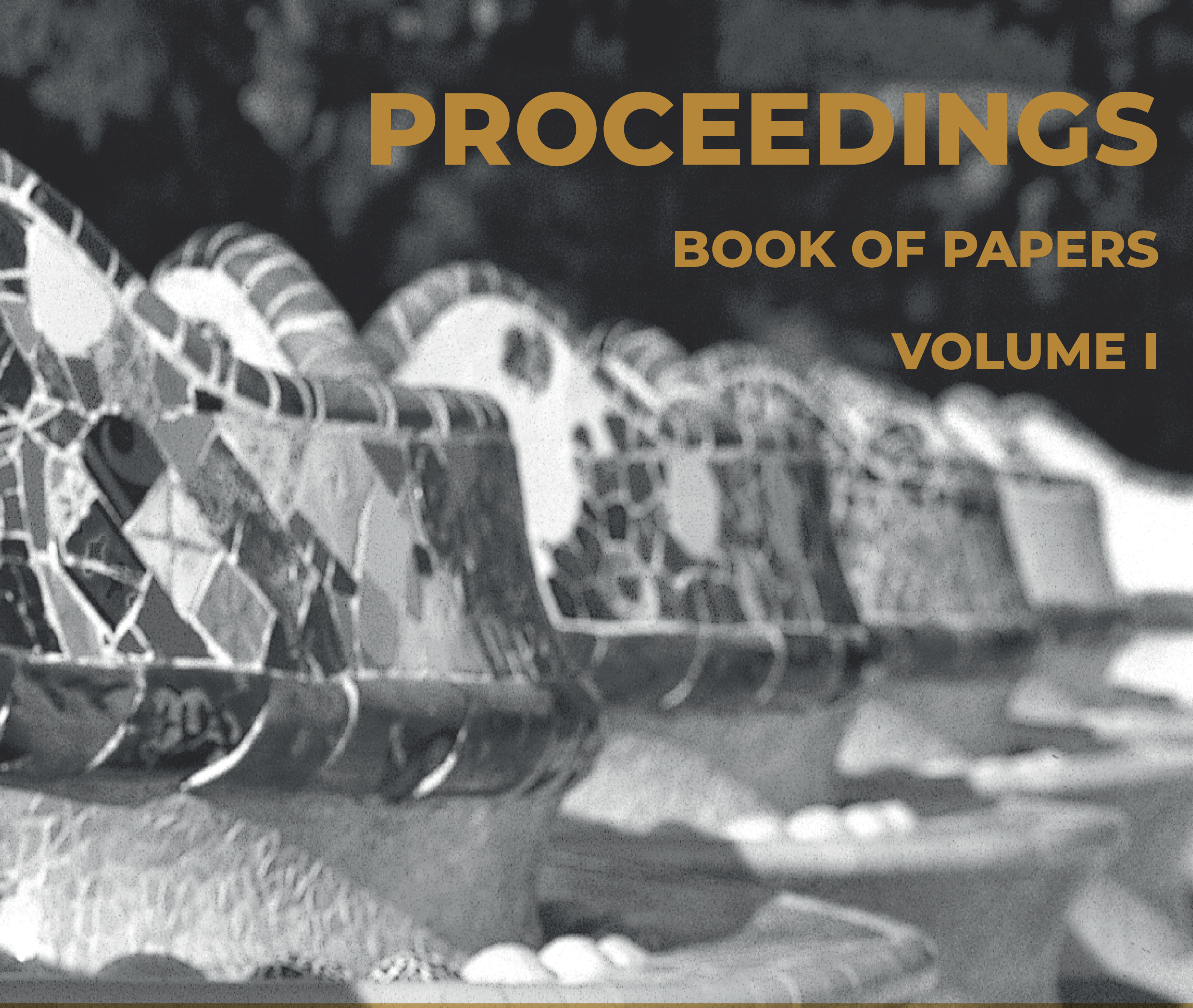
Annex 19 – Paper_ Circular and sustainable products. From theory into practice



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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

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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

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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 strate implemented in the developme process - Methodology applied -Tools applied (related to the desi 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.*

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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 consideratio in the development process	100%
The dimension of the compa	Small company	Large company	Small company
How the product is conside 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 compa certified?	No	Yes (at company level and product level)	No
Certification schemes a labels implemented	n.a	The company has seve certifications and lab 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 speci 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 a relevance of the label
Criteria and strateg 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 principl 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 tl interviewee)	All (according to tl interviewee)	All (according to tl interviewee)
Tools to support the proce known by the deviser/produ developer	None	None	None
Does the company app sustainability tools in tl 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 tl 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 circula 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 tl 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 tl integration of sustainabili and circularity aspects in tl development process?	Difficult collaboration wi suppliers In the subcontracting some parts and componen is difficult to enga suppliers Lack of trust in tl suppliers In some cases, tl 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 to methodologies and process Data and releva information about tl sustainability and circulari profile of materials that ca 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

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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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Annex 20 – Paper_ Meeting the Circular Economy Agenda Supporting Tools for a New Strategic

Meeting the Circular Economy Agenda: Supporting Tools for a New Strategic Design Practice

Rumo aos desafios da economia circular: Ferramentas de apoio a uma nova estratégia na prática de design

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ABSTRACT: The circular economy is a new strategic concept to meet society's needs in a more efficient and sustainable manner based in decoupling the economic growth and welfare from the increase in the consumption of natural resources. It implies the transition from the traditional linear model to a more innovative and circular approach in the development of the economy by designing new products, new services, and new systems, supported, in most cases, by the re-thinking and creation of new business models.

Designers and product developers have an important and crucial role to achieve a successful and wide implementation of the concept which has to be accepted and applied in practice by businesses along the whole value chain and meet the current and future needs of consumers and the society.

Currently, several methods, principles, practices, tools, training initiatives, and many resources are being developed globally as a result of the wide exploitation of the concept, but there is still a large gap between what is available to companies and designers, and what is applied in practice on product and service development.

This paper reflects part of the PhD research project under development by the authors which is based on the promotion of the design practice within Circular Economy. It explores the results of the review of circularity tools available that can be used by design professionals to systematize and guide their development process. The analysis will support the development of a toolkit and guidelines oriented for the practical implementation of the circular economy in the development of innovative and efficient products and services. (Camocho, Ferreira, & Vicente, 2018).

KEYWORDS: Circular Economy, Design Tools, Design Practices and Principles, Innovation, Sustainability.

RESUMO: A economia circular é um novo conceito estratégico que visa responder às necessidades da sociedade de uma forma mais eficiente e sustentável que se baseia na dissociação entre crescimento económico e bem-estar do aumento do consumo de recursos naturais. Esta transição, do modelo linear tradicional para uma abordagem mais inovadora e circular no desenvolvimento da economia implica o desenvolvimento de novos produtos, novos serviços e novos sistemas, apoiados, na maioria dos casos, no repensar e na criação de novos modelos de negócio.

Os designers e os responsáveis pelo desenvolvimento de produtos têm um papel importante e crucial para alcançar uma implementação ampla e bem-sucedida do conceito. Este deve ser aceite e aplicado na prática pelas empresas ao longo de toda a cadeia de valor atendendo às necessidades atuais e futuras dos consumidores e da sociedade.

Atualmente, vários métodos, princípios, práticas, ferramentas, iniciativas de formação e outros recursos têm sido desenvolvidos globalmente como resultado da ampla exploração do conceito, no entanto, ainda existe uma grande lacuna entre o que está disponível para empresas e designers e o que é aplicado na prática no desenvolvimento de produtos e serviços.

Este artigo reflete parte do projeto de investigação de doutoramento em desenvolvimento pelos autores, o qual se baseia na promoção da prática de design no âmbito da Economia Circular. Explora os resultados da revisão de ferramentas de circularidade disponíveis que podem ser aplicadas pelos profissionais de design na sistematização e orientação do processo de desenvolvimento. Esta análise irá apoiar o desenvolvimento de um conjunto de ferramentas e orientações para a implementação prática da economia circular no desenvolvimento de produtos e serviços mais inovadores e mais eficientes. (Camocho, Ferreira & Vicente, 2018).

PALAVRAS-CHAVE: Economia circular, Ferramentas de design, Práticas e princípios de design, Inovação, Sustentabilidade.

1. Introduction

Changes are taking place worldwide in business strategy and industries face increasing pressure from economic crises, resource scarcity, and pollution (De 0los Rios & Charnley, 2017). The Circular Economy approach to the development of the society is seen as a potential solution to attain a sustainable future by increasing prosperity while reducing the critical dependence on primary materials and energy (Ellen MacArthur Foundation, 2015). The concept is receiving increasing attention worldwide as a way to overcome the current production and consumption models based in so-called "linear economy" or "take, make and dispose model" that depletes natural resources and destroys ecosystems. In the past, during many decades, designers and other professionals have been working to achieve sustainability in the development process, aiming to increase the efficiency and innovation exploring several approaches, from cleaner production, eco-design, design for sustainability through product services systems, however, despite several good examples, mainly linked to niche markets with low added value (Ferreira, Ana M.,2003), the results were far from been globalized and integrated widely in the society. Nowadays, Circular Economy claims to be a new path to achieve sustainability and welfare, promoted strongly by governments, research institutions, academia, associations, and many other stakeholders.

This new economic model that aims to work in closed circuits, catalyzed by innovation along the entire value chain, is promoted as an alternative solution to minimize resource consumption and energy losses (Ministério do Ambiente, n.d.) and designers should have the skills, knowledge and the tools to leverage this process (Vicente, 2012).

Today, designers and product development teams face new challenges in their daily practice. The design is recognized as a catalyst to transition from the traditional model of take-make-dispose to achieve a more restorative, regenerative and circular economy(Moreno, De los Rios, Rowe, & Charnley, 2016) and the design of products and services in a smarter and innovative way, extending their useful lives and adjust the function of such products and services within the system will be crucial to the achieve the transition to circularity (European Environment Agency, 2017).

The design practice relies on methods and tools. The evolution of the design profession and the solutions proposed by designers to solve the problems and needs of the society is linked, at some extent, to the evolution of the tools available to designers, (Vasantha G., 2014)(Vicente, 2011). The tools designers use, which have a significant impact on the development process, are changing constantly, new tools appear frequently, especially in the digital environments (Witkowski, 2017), however, and although tools related to circular economy are starting to appear, it seems that in most of the cases, designers are integrating circular economy strategies in an ad-hoc way, without the support, guidance, and validation of tools at different stages of the process. The paper presents part of the research under development which aims to help the transition to a more sustainable and circular economy through design. It explores the results of an in-deep review of circular economy tools available that can be used by designers and product developers to systematize and guide the development process of industrial products and services.

The design practice has a crucial role in defining the characteristics of the products and services that fulfil the needs of society and their impacts in the life cycle are defined in the design and development phase. In order to promote an efficient design and the practice of design, it is important to understand how designers can have a positive and successful impact in this process.

1.1. Circular Economy

The transition to a more sustainable way of design, produce and consume is a crucial objective for the development of our society (Bhamra & Lofthouse, 2007; Braungart & McDonough, 2009; Manzini & Vezzoli, 2010; MARGOLIN, 2014). In 2015 the European Commission adopted an ambitious Circular Economy Package (European Commission, 2015) to help European businesses and consumers to make the transition to a stronger and more Circular Economy where resources are used in a more sustainable way. The proposed actions will contribute to "closing the loop" of product lifecycles through greater recycling and re-use and bring benefits for both the environment and the economy. The plans will extract the maximum value and use of all raw materials, products, and waste, fostering energy savings and reducing greenhouse gas emissions. The proposals cover the full lifecycle: from production and consumption to waste management and the market for secondary raw materials.

In December 2017 the National action plan for the circular economy was published by the Portuguese Council of Ministers (PAEC, 2017). The plan is part of the strategy to be followed up to 2020 and aims to redefine the concept of end-of-life of the linear economy, based on the production and elimination of waste, focusing on the concepts of reuse, repair, and renovation of materials and energy.

It is a strategic model of growth and investment based on efficiency and value of resources and minimization of environmental impacts. This is a document aligned with Portugal's international commitments, such as the Paris Agreement, the Sustainable Development Goals, and the European Union.

We can find in literature many definitions of circular economy. The concept has been widely explored and each author or each project tends to develop a definition that best suits their interests. This proliferation and diversity of definitions do not help in the communication and practical implementation of circular economy by businesses.

One of the most known and spread definition is the one developed by the Ellen MacArthur Foundation. However, many others were published. In 2017, an article analyzed 114 definitions of circular economy and concluded that there is not one coherent understanding or definition of circular economy (Kirchherr et al., 2017), and from 2017 till now, many other definitions were developed.

Within the KATCH_e EU funded Project (KATCH_e, 2019) focusing on the reinforcement of the skills and competences in the field of product-service development for the circular economy and sustainability, the consortium, building on several definitions and concepts from the main key players on circular economy developed a definition that is the definition adopted in the current research by the authors:

> *"Circular economy is a system that is restorative and regenerative by intention and design, which maximizes ecosystem functioning and human well-being with the aim of accomplishing sustainable development.*
>
> *It replaces the end-of-life concept with closing, slowing and narrowing the resource flows in production, distribution and consumption processes, extracting economic value and usefulness of materials, equipment, andgoods for the longest possible time, in cycles energized by renewable sources. It is enabled by design, innovation, new business, and organizational models and responsible production and consumption".*

2. Design For Circular Economy

The design plays a key role in the definition of the profile of products and services, and a more sustainable way of design, produce, and consume is a crucial objective for the development of the society (Bhamra & Lofthouse, 2007; Braungart & McDonough, 2009; Manzini & Vezzoli, 2010; MARGOLIN, 2014).

To develop innovative, efficient and sustainable products, the designers should be able to translate the needs from several actors in the value chain. The needs of the users who will buy and consume the products, the ones from the business, who will develop, produce and place them on the market and the ones from

Society, who will indirectly benefit or suffer with the sustainability impacts of the products

Product design directly influences the way a value chain will be managed and building circular and sustainable value chains inevitably imply a fundamental change in the design practice (centre, 2013; Camocho, 2018; De los Rios, 2017). New methods and effective design-oriented tools are needed to support and promote the transition to a circular economy. Designing products in a smarter and innovative way, extending their useful lives and changing the role of such products within the system is crucial to the achievement of a transition to circularity (Camocho et al., 2018; European Environment Agency, 2017) from a society that has been actively seduced by the over-consumption of new and better goods and services, leading to massive consumption of natural resource and the generation of waste and emissions, (Medkova & Fifield, 2016) and this had been promoted globally by industries through design.

The transition to circular economy is not only a design issue but design has a massive role. The potential for design to influence and impact the way that we produce, consume and dispose of products is huge. The Portuguese National action plan to circular economy includes concrete actions to promote the transition to a circular economy and in these the design plays a crucial role (PAEC 2017).

The design practice in circular economy can be seen as more complex, requiring changes in the way of thinking and conduction projects focusing on a shift from product-based solutions to system-based or function-based approaches (RSA. 2014).

Designers need to align their development process with the concept of circular economy in order to replace the conventional end-of-life concept in which the materials and components of a product are disposed after the fulfilling of the function by closing, slowing and narrowing the resource flows in production, distribution and consumption processes (Bocken, 2016) by applying several strategies in the development process.

As for strategies to achieve circularity, several approaches in the literature that are related to design were identified. As an example, the Ellen MacArthur Foundation proposes 3 main principles: (Ellen MacArthur Foundation, 2015)

1. Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows,
2. Optimize resource yields by circulating products, components, and materials in use at the highest utility at all times in both technical and biological cycles,
3. Foster system effectiveness by revealing and designing out negative externalities.

These three principles are then translated into the ReSOLVE framework which considers six actions that should be considered in the design process (table 1).

Table 1 — ReSOLVE Framework, Ellen MacArthur Foundation

Regenerate	Shift to renewable energy and materials; Reclaim, retain, and restore the health of ecosystems; Return recovered biological resources to the biosphere
Share	Share assets (e.g. cars, rooms, appliances); Reuse/second hand; Prolong life through maintenance, design for durability, upgradability, etc.
Optimize	Increase performance/efficiency of the product; Remove waste in production and supply chain; Leverage big data, automation, remote sensing and steering
Loop	Remanufacture products or components; Recycle materials; Digest anaerobically; Extract biochemicals from organic waste
Virtualise	Books, music, travel, online shopping, autonomous vehicles, etc.
Exchange	Replace old with advanced non-renewable materials; Apply new technologies; Choose new product/service (e.g. multimodal transport)

Source: Growth Within, adapted

3. Methodology

The literature review under development aims to identify which tools are available to designers and their adequacy to the design practice for circular economy, having in mind the principle of circular economy and the needs of the design process.

The results of the search resulted in a collection of relevant academic and non-academic resources that are available to be implemented by designers.

Within the current study, only the tools that indicate their relevance to circular economy were selected. Despite the fact that many sustainability and eco-design tools are available in diverse platforms (online, software's, board games, etc) and that their application in circular economy project is relevant (as an example LCA software like SimaPro), the study considers mainly those that were developed and disseminated claiming to be oriented to circular economy.

To perform the analysis of the tools, besides the general information such as the identification, editor/publisher, author, source, availability and short description, a set of variables were used to access the potential for application by designers.

The variables were the following:

— The aim of the tool

— Scope - Circular economy; Eco-design, Design for sustainability, LCA, etc

— Assessment indicators/strategies - how the tool is applied? Which indicators or strategies are applied?

— Life cycle perspective – indication if the tool has an LC perspective or if only focus on a specific stage

— The influence on the design process - How can the tool influence the design?

— The influence in the business model - Can the tool and the results influence the business model?

— Type of inputs - Qualitative or Quantitative

— Inputs - Which inputs are needed to use/apply the tools

— Level of complexity - Level complexity in using the tool by design professionals

— Sectoral focus - sectoral, to which sector the tool is applicable or if it has a generic approach

— Expected results – which type of results are attained with the tool

— Pros and cons – Analysis of the main Pros and cons of the tool related to the design practice in the development of circular products and services

In the next chapter, the authors present seven tools that were analyzed within the research project under development according to the variables explained above. These resources address circularity aspects to develop new products and services and can be applied by design professionals.

4. Tools

4.1. Circularity Check

The Circularity Check developed by Ecopreneur, Wesustain, and MVO is a free tool to assist companies to become sustainable and circular or resource-efficient. The tool is primarily intended as an instrument for self-evaluation by companies, based on a questionnaire with about 60 questions that determines a circularity score for a specific product and/or service.

The checklist consists of a free questionnaire that can be filled out online covering five main indicators: Design, procurement, and manufacturing; delivery, use, recovery, and sustainability and the outcome is a total score on circularity (0-100%) and partial scores on the five indicators (0-100%) showing the overall strengths and weaknesses for the product or service.

The tool calculates the score and presents it in a few graphs, and by analyzing and answering the questions, and the scores on each indicator, the design team should identify potential ideas to improve and redesign the product or service (Ecopreneur).

4.2. Circular Economy Toolkit

The Circular Economy Toolkit is a free online resource for businesses to find Circular Economy opportunities.

The tool is based on a set of 33 questions related to the strategies and by answering, the analysis will result in the indication of the improvement of potential strategies: Design, Manufacture and Distribute; Repair/Maintenance of the product; Reuse/Redistribution of the product; Remanufacturing/ Refurbishment of product or part; Products as a Service; and Product Recycling at end of life. Besides the assessment features, the tools provide useful information in each strategy.

Based on a simple and user-friendly structure, the results cover the life cycle stages and highlights the potential in each one, and by analyzing the questions and results, the user can identify ideas to improve the product under analysis (circular economy toolkit).

4.3. Material Circularity Indicator

The Material Circularity Indicator (MCI), developed by Ellen MacArthur Foundation and Granta Design, is a tool aiming to measure how restorative the material flows of a product or company are.

By comparing to a similar industry-average product, the MCI for a product measures the extent to which linear flow has been minimized and the restorative flow maximized for its component materials, and how long and intensively the product is used. The tool is built from a combination of three product characteristics: the raw material used in production, the unrecoverable waste that is attributed to the product, and a utility factor that accounts for the length and intensity of the product's use.

The tool is easy to fill in with a user-friendly interface and useful to demonstrate the circularity level of a specific product.

The indicators may be used by designers to analyze a reference product or service and the assessment of potential changes in new designs, as well as for internal reporting, procurement decisions, and the evaluation or rating of companies (Ellen McArthur).

4.4. KATCH_e tools (KATCH_e 2019)

Within the EU research project KATCH_e - Knowledge Alliance on Product-Service Development towards Circular Economy and Sustainability in Higher Education, several tools were developed to support a transition to a circular economy.

The following four tools are the ones with a higher potential to be applied in the design practice from the above-mentioned research project under development.

4.5. KATCH-Up Board game

This tool is based on a creativity board game and aims to create an idea-value of a new product/service according to the needs of the users and to define the most appropriate circularity design strategies and business models to launch the product/service into the market. The objective of this game is to stimulate the users to generate valuable ideas from a business challenge, applying circular design and circular business strategies.

Based on six basic steps: a) Defining the problem context; b) Way to the solution-focused in the circular economy strategies that can be applied, c) Idea creation, with the development of a solution to meet the needs of the challenge; d) Business model, defining the most appropriate business model; e) Market launch, to define how the solution can be placed on the market and f) Presentation of the results of the exercise, the game acts as a guide to get an idea about an innovative product-service or to solve a real business problem and generate improvement opportunities.

4.6. KATCH_e CE Strategist

This tool helps the user to identify for a specific product in a specific context, Circular Business Opportunities and provide ideas and inspiration along the process of defining a Circular Business Model.

The tool starts with an assessment of a product or business to identify circularity strategies that fit best to the predefined circular business strategies.

After assessing the opportunities, the tool proposes several strategies to choose from and shows a definition of each strategy, providing existing business examples and shows how the strategies are connected to specific Design Strategies. The final step is a definition of the Circular Business Model using an adapted version of the Business Model Canvas framework. The Canvas, describing the business model highlights the implications and effects of circular models and guides the user towards circularity.

4.7. KATCH_e CE Designer

The CE Designer is a semi-quantitative tool for prioritization, assessment and idea finding of circular solutions for product and/or service design. It consists in a checklist structure organized in 8 strategies that address the most relevant issues a design team needs to consider in the development process of new products or services to support the transition to a more circular society.

The tool, in the first step, starts by asking the user to reflect on each strategy, their adequacy, and relevance for the project under development. In the next phase, the user evaluates the profile of the reference product in each strategy according to a set of predefined criteria. This step has two objectives, the first is the assessment of the reference products, identifying the hotspots in the product which can be improved, and secondly, by answering the questions in each criterion, the user can identify improvement opportunities that can be implemented in the project.

The identification of the hotspots and opportunities are useful resources to be used as background information to brainstorming sessions and development activities.

In the third phase, the tool is used to compare the reference situation with the new concepts or new products /services resulting from the project.

The tool is simple to be used by designers and development teams and the process and results allow the development of new and innovative circular solutions.

4.8. KATCH_e Circular Economy Journey

The tool aims to help the players to assess the overall Product / Service / System journey, in the three stages (uphill, top hill and downhill) according to several factors: materials, producers, stakeholders, and users.

Through a visual canvas, the tool consists in a visual representation of the journey, it aims to identify the touchpoints between the factors identified, providing a model for analysis and identification of opportunities to optimize the journey and to enhance the closing of the loops to develop a more circular solution for a specific problem.

Being a physical tool composed by a printed canvas, cards, pins and colour threads, the tool promotes innovation, discussion and brainstorming in creativity sessions.

5. Conclusions

Designers have at their disposal numerous tools oriented to support the development of sustainability and eco-design projects, both qualitative and quantitative tools with different levels of complexity, costs, orientation, typologies of results, among others. These tools have been extensively developed, but their use is not as wide as expected and most designers and development teams have not used them in practice in a systematic way.
Currently, the concept of circular economy is gaining attention worldwide and being widely disseminated at various levels of society, and tools with a specific orientation towards the development of circular products and services are beginning to appear.
In order to ensure that the products and services developed are indeed circular, it is necessary to apply several methods and tools that support the development, validation, and communication of their circularity aspects. In order to become widely used tools, it is necessary that these combine the perspectives of circularity with the needs of the design practice.

The seven tools presented address the challenge of integrating circularity in design, however, due to the nature of the tools, which are not mature yet, their characteristics and the needs of the design practice, there is still the need to develop an efficient and innovative tool or a toolkit to support the design of innovative circular products and services. These new or redesigned tools must address the design practice and supply efficient results perceived by all stakeholders as an added value to design projects showing clearly the benefits of their utilization.

6. Further Research

The identification, test, and analysis of circularity tools will continue along the project and other relevant activities will be developed such as the analysis of the designers and product developers' perceptions, methods, and approaches on the development of circular products in order to understand how designers translate the user and business needs in product development. The identification of which methodologies and tools are applied in practice by designers and which are the needs, barriers and drivers in their adoption in product/service development will promote the development of the efficient resources to support the transition to circular economy through design.

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Annex 21- Paper_ The Common-Sense Assessment

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The Common-Sense Assessment of Sustainability

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Abstract. Products claiming sustainability benefits have been spreading all over the world in response, manly, to the consumer's behavior change towards a healthier and more sustainable way of life.

However, what guarantee do consumers have that the products they are consuming are in fact more sustainable? Apart from certified products, the consumer believes in a common-sense assessment of sustainability supported in part by self-declarations and allegations from designers, producers, and retailers focusing only in few aspects of the life cycle, and in some cases, misleading consumers through greenwashing approaches.

This paper is part of a Ph.D. research aiming to support a transition to circular economy and sustainability through design. The authors explore in this article the consumer perceptions of sustainability in products and communication strategies adopted. The results will support the development of guidelines to promote a more effective design practice for the development of sustainable and circular economy-based products.

Keywords: Design · Circular economy · Consumer perception · Common-sense assessment · Sustainability assessment · Sustainability

1 Introduction

The paper presents the research under development which aims to help the transition to a more sustainable and circular economy through design. The authors believe that design practice has a crucial role in defining the characteristic of the products and services that fulfill the needs of society. Also, that their impacts in the life cycle are defined in the design and development phase. In order to promote design and the practice of design, it is important to understand how eco and sustainable products and services are developed and placed on the market, how they communicate to users their

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profile; how consumers understand that information; and which are their perceptions about the profile of products. To integrate successfully circular economy, a holistic approach is fundamental considering all aspects from the production to consumption. In this paper, the authors look to one part of the process related to the communication on products and the consumer perceptions of sustainability aspects.

Today, designers and product developers face a new challenge. The design practice has been recognized as a catalyst to transition from the traditional model of take-make-dispose to achieve a more restorative, regenerative and circular economy. To attend the needs for circular economy, products need to be designed for closed loops and adapted to generate revenues [1].

Design for circular economy, like design in general, has the responsibility of responding to product-service system problems, integrating various criteria and expertise in problem-solving in an innovative way adjusted to the needs of users, businesses, and society's dynamics as a whole [2]. In the circular economy approach, the designer has the function of translating the strategies and concepts of circularity in the development of products, services, and systems that promote an efficiency and sustainable transition from the current linear model to a circular model focused on narrowing, slowing and closing resources cycles [3], in the efficiency and sustainability of the entire system [4], however, there is a need to provide design practitioners, business stakeholders, and other product developers guidelines and practices of how to apply particular design strategies for different circular business models [1, 3].

Product design directly influences the way a value chain will be managed. Building circular and sustainable value chains inevitably imply a fundamental change in the design practice [5–7].

To develop innovative, efficient and sustainable products, the designers should be able to translate the needs from several actors in the value chain. The needs of the users who will buy and consume the products, the ones from the business, who will develop, produce and place them on the market and the ones from Society, who will indirectly benefit or suffer with the sustainability impacts of the products. These processes and concerns have been influencing the design practice since many decades along the development of the eco-design, and design for sustainability with relative success in some niche markets, but not in a large scale as expected.

Nowadays, a new approach is being developed on a global scale based on a circular economic model. Yet, in order to be practical and successful, our society needs innovative products and services that supply the needs of consumers and businesses complemented by a more informed and accurate sustainable consumption behavior.

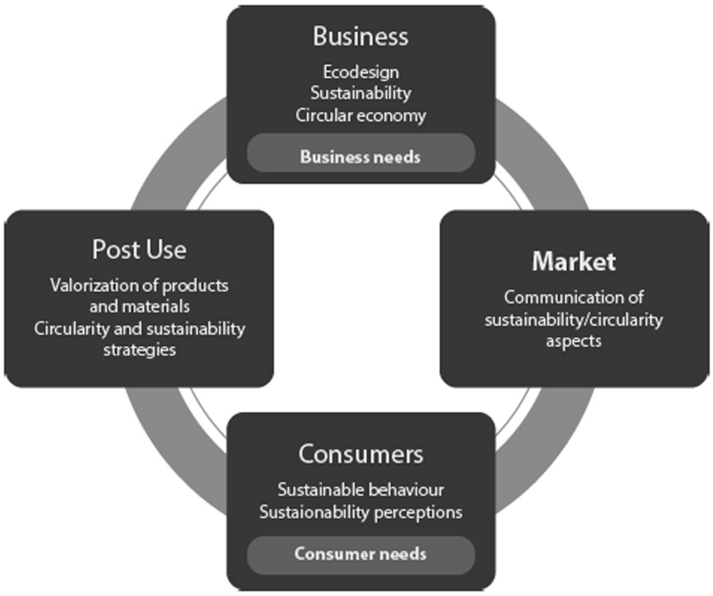

Fig. 1. Four pillars to circular production and consumption

For a successful transition to a circular economy through the design of products and services, it is essential to have a holistic vision based on an approach that integrates four fundamental pillars (Fig. 1):

– The business of the companies responsible for placing the products on the market. In this context, it is important to understand which the needs of companies are, and how they can generate wealth and growth. Many of the sustainability projects developed, despite presenting innovative concepts and sustainable solutions, did not respond to the needs of the business and failed to penetrate the market, thus leaving behind solutions that could have had significant impacts. It is in this pillar that designers must be able to implement methodologies and tools (eco-design, design for sustainability, design for the circular economy, etc.) for the development of innovative and efficient solutions.
– In the second pillar, it is important to provide the products with direct and indirect information that allows the consumers to perceive the message conveyed. In this regard, labels, certification and other intrinsic characteristics that products must contain in order to communicate with consumers.
– The third pillar is related to the importance of knowing the consumer. Relatively little is known about consumer perceptions as a pre-decision mechanism that impact their preferences and choice behaviors [8]. Which are the behaviors of consumers and their needs? It is fundamental to be able to effectively translate these needs into the design project. On the other hand, although there is already a growing awareness, the way consumers perceive sustainability issues is not always the right way, or they are influenced by socio-economic factors that divert the focus. There is a gap between attitudes and behaviors. The levels of concern and awareness of the need to

change consumption styles are high in general. However, this is not accompanied by the adoption of more sustainable consumption styles [9].
– In a fourth moment, in order to close the cycles of products and materials in line with the concept of circular economy, it is necessary to adopt an approach that integrates circular economy strategies aiming to close resource cycles through the valorization of products and materials. A holistic approach, focused on the role of design, adopting various methodologies and tools at a strategic level, could allow the transition to a more efficient, healthier and more circular economy.

In the next section, is explored how sustainable products are placed in the market.

2 Eco/Sustainable Products

There are several terminologies to define products with improved profiles. Eco products, green products, sustainable products, circular products, and many other terms. Within this research, the authors aim to explore products that have a better sustainability performance considering their life cycle and products that are placed on the market claiming those features. Therefore, it was decided to use the term "Sustainable products" which is a more comprehensive term that includes all the other concepts.

2.1 Types of Products

According to the specificities of the product and to the strategies of the producers, distributors and other stakeholders, within the current research, the products were defined according to four different typologies:

2.2 Type A: Silent Products

These are more eco-efficient and sustainable products that were developed considering sustainability aspects in their process, however, these aspects are not communicated to the user/client.

The sustainability aspects (environmental, social and economic) can be important factors for the innovation of the product, their efficiency, quality, etc. However, the company does not communicate it as part of their strategy.

2.3 Type B: Naturally Sustainable

These products due to their characteristics, materials, production process, etc., have a good sustainability profile. In their development process, sustainability measures and tools were not considered, but, in the end, the result is a sustainable product.

2.4 Type C: Eco/Sustainable Products

These are the products that were developed with sustainability objectives. In their development, methodologies and tools were applied to support the creation of products with reduced impacts in the product lifecycle compared to previous products of the same type.

2.5 Type D: Sustainability Influencers

These are products that *per se* are not sustainable, but when included in a system they have a positive influence on the overall performance of the system. This type of products includes also the ones that influence users to have a more sustainable behavior.

In our society today, we face several gaps that may jeopardize the future success of circular economy approaches. One important topic is the gap between what producers and business place on the market and how the consumer perceives the sustainability features and information. Many products include certification labels and information that the consumer does not recognize and do not appreciate it.

Another gap is the difference between what consumers say and what they actually do. Several studies show this problem [10, 11].

How the information on the sustainability profile of products reaches the consumers is presented next.

3 Sustainability Communication in Products

To promote the information and awareness of consumers about the sustainability profile of products, several methods have been used, such as campaigns, green marketing initiatives, and claims. The most adopted and successful ones seem to be eco-labeling schemes which rely on credible informative instruments.

Environmental labeling or eco-labels are important tools that companies can and are using to communicate and guarantee that their products and services comply with environmental requirements beyond what is established by law. The use of labels as part of an effort to make green claims more trustworthy, providing the consumer with clear and homogeneous information on the environmental aspects of products and services, avoiding confusing information and influencing greener consumer choices is emphasized by the European Commission in its Action Plan for the Circular Economy [12].

Companies have at their disposal many environmental labeling possibilities, some of them are regulated under International Standards, based on the ISO 14020 family standard, while others, do not meet this requirement. According to ISO, there are three types of environmental labels:

- Type I labels (ISO 14024): "third party" labels that indicate voluntary conformance to pre-determined, multi-attribute criteria that identify environmentally preferable products within a particular product category, based upon life cycle considerations.
- Type II labels (ISO 14021): self-declarations made by manufacturers, importers, distributors, retailers, etc., focusing on environmental improvement of some specific aspect of their products, such as energy consumption, compostable, degradable indoor air quality, recycled content, etc.
- Type III labels (ISO 14020 and 14025): These labels, often referred to as Environmental Product Declarations (EPDs), present comprehensive product information based on quantitative validated Life Cycle Assessment (LCA)

As said before, there is a wide and growing range of possibilities to inform about sustainability criteria or content. Nonetheless, companies will have to be proactive and assure that their messages do not get lost or fall victim to incorrect perceptions [8].

Although, do consumers perceive the information included in product communication conveyed by companies and it influences, in fact, their choice? These concerns were subject of a survey carried out to consumers in Portugal.

4 Consumer Perceptions

Production and consumption have a symbiotic relationship that must be nurtured, educated and promoted with a sustainability perspective.

The market is shaped and reshaped continuously by the consumers through the messages/information about consumption, purchasing choices and practices they send, directly and indirectly, in a conscious or unconscious manner to decision makers in governments, industries, business, designers and other stakeholders in the value chain. Companies also create needs and demands by placing more and more products on the market. Thus, the way our society consume will determine supply and the way production is organized will influence demand in a complex and symbiotic relation.

Several studies demonstrate that the sustainable behavior is changing, and the awareness is high and increasing in most consumers segments. There has been a growing trend in informing consumers about the environmental aspects to take into account when buying products [13].

If a consumer wants to buy a more sustainable product, it is difficult to have sound comparative information. The data consumers need to compare impacts in products is usually missing, incomplete, or even, not reliable. Apart from products with certified labels, consumers only have access to information regarding the features of the product in terms of price, technical characteristics, and marketing information [14]. Even products that claim to be sustainable do not have often clear and trustful information.

The consumer believes in a common-sense assessment of sustainability supported in part by self-declarations and allegations from designers, producers, and retailers focusing only in few aspects of the life cycle, and in some cases, misleading consumers through greenwashing approaches. In this sense, it is important to understand which the consumer's perception of the sustainability profile is and what are the physical attributes of corresponding artifacts.

Making informed decisions about what to buy also helps in achieving a more sustainable approach [15]. The information gap between producers and consumers is still a huge flaw in our society. The ignorance and lack of information hinder the efficiency of the market while sound and reliable information let consumers make a smarter and conscious choice [14].

Another important aspect to consider is the lack of consumer awareness regarding the link between their personal behavior and the direct impact on the environment or society [10]. In this regard, we must define the type of consumers with sustainability concerns. According to the study "Identifying the green consumer" by Arminda Finisterra do Paço, we can define three main types of users [16]:

Type 1 – **The uncommitted**, composed mainly by young people with high educational levels, and living in urban environments. This group claims to have knowledge about the issue; however, this segment has very negative behaviors in relation to environmental aspects.
Type 2 – **'The green activists',** composed by individuals with the highest education levels, have a favorable position in relation to all environmental aspects, particularly towards perceived efficiency, environmentally friendly buying behavior, recycling, sensitivity to the economic factor and resource saving. The segment tends to be sceptical about the promotional and advertising claims made by firms.
Type 3 – '**The undefined**' consider that their individual action does not contribute to the improvement of the environment. This segment includes individuals with lower educational levels than the other segments and has very negative positions towards environmental issues. Claiming to have little knowledge about environmental issues, they have a positive attitude towards recycling and are highly sceptical about the promotional and advertising claims made by companies. However, the environment does not occupy a prominent position among their concerns.

By knowing the types of products defined above, the types of consumers and their perceptions, the design teams can manage the design practice in a more effective and more successful way.

4.1 Method to Assess Consumer's Perception of Sustainability in Products

To better understand consumer habits, perceptions and general knowledge regarding the sustainability aspects of products and their knowledge on communication elements of a product such as labels, certifications, self-declarations, etc., was applied a survey in January 2019 to collect data from Portuguese consumers, using two different approaches: (*a*) an online questionnaire built with google forms with potential survey respondents contacted through social media and email databases to participate by filling in the form online; (*b*) a paper version of the questionnaire, aiming to broader dissemination and a collection of feedback. The questionnaire was composed of 5 sections and was based in a trade-off between the complexity/length and the amount of data to collect.

After the introduction, aims and objectives of the survey, the first section of the questionnaire included basic questions regarding the demographic characteristics of the interviewee. The second section was built to access the knowledge regarding eco-design, design, sustainability, and circular economy.

Section 3 included questions to evaluate consumer habits and the influence of environmental labeling on products.

In Sect. 4, through images of products, the aim was to understand if the sustainability perception of the consumer corresponds to the reality and how consumer rate sustainable products based only in perception.

To end the survey, Sect. 5 included an area to add remarks, suggestions, ideas and the indication to follow the research.

5 Findings/Analysis

With the main objective of identifying the consumer perceptions regarding sustainable products placed on the Portuguese market, the authors did a study, understood as a pre-test, based on a sample of 105 individuals aged over 18. Since the questionnaires were sent by social media, and the respondents were asked to share the questionnaire with other consumers, it is difficult to have concrete numbers of the scope of the research. However, it is estimated that around 500 individuals were sent questionnaires, representing a response rate of around 20%.

The sample, composed by 105 individuals includes 55% women and 45% man with different educational levels, 36% graduation, 31% 12° year, 24% master, 5% less than 12° year, 3% Ph.D. and 1% with a professional degree, with a diversified professional activity. From the total number of questionnaires, 75% consider having a sustainable behavior in daily activities, which also is a clear indication of the gap between what consumer say and what they really do. When analyzing this data by gender, between male and female respondent we do not identify a significant difference, 70% male and 78% female consider having a sustainable behavior. The difference in behavior according to education is also not relevant, 73% in respondents with higher education and 79% in lower education respondents. This is in line with several consumer surveys like for instance, the sustainable consumption paradox referred by Vringer Kees when studying the Dutch consumers [11].

5.1 General Knowledge in the Field

To access the knowledge in the topic, respondents were asked to express their perception of knowledge regarding Design, Ecodesign, sustainability and Circular economy.

The majority of the respondents claim to have basic notions about the 4 concepts (in average, around 78% consider to have basic notions or above), and in general, the concepts with a higher knowledge level is sustainability (49% have basic notions, 30% high level of knowledge and 6% are experts in the field) and Design (51% have basic notions, 22% high level of knowledge and 12% are experts in the field) and the less knowledgeable level is circular economy (18% do not know the concept and 24% have heard about it, which is understandable, since it's a new concept for the majority of respondents.

5.2 Sustainability Attitudes and Practices

When questioned about their practices, only 7% do not make a waste separation for recycling, 2% do not apply water saving measures, 9% do not buy organic products and 9% do not buy sustainable products.

As shown in Fig. 2, consumers claim to have sustainability considerations in their day-to-day life, especially in the separation of waste for recycling. The purchase of sustainable products, in general, is one that has a lower application rate.

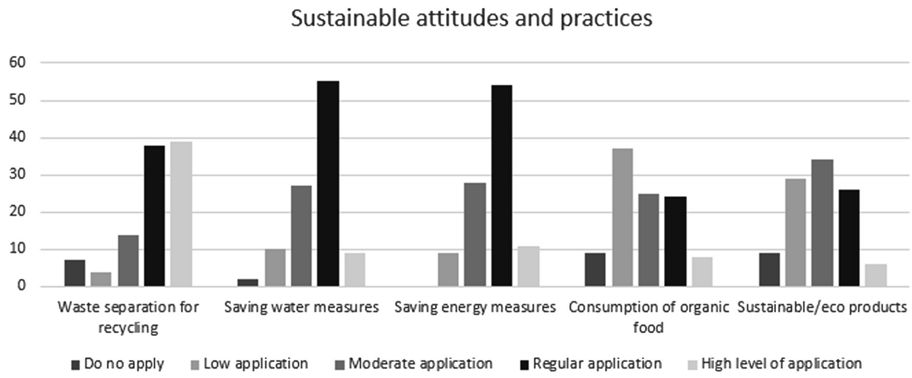

Fig. 2. Sustainability attitudes and practices

5.3 Influence of Ecological and Sustainability Factors in the Acquisition of Products

The influence of these factors is considered moderate to high in most of the cases. In all types of products included in the survey, only less than 30% consider that sustainability criteria do not influence their choice.

5.4 Influence of Labels and Environmental Certification in Purchasing Decision and Related Trust in the Allegations

Most consumers (76%) indicate that labels and certification influence the selection of products. However, only 18% have a high level of confidence in the allegations, 62% have a medium level of confidence, 19% a low level and only 1% do not trust in the allegations form producers.

5.5 Knowledge About Labels

To access the knowledge about products' label included, a selection of 10 units was displayed and consumers were asked to express if: (*a*) they know the label and its meaning; (*b*) they recognize it but do not know what it is, or; (*c*) they do not recognize the label at all. From the analysis, was possible to conclude that in most of the examples, the consumer do not know the labels or do not know the meaning of it. In the case of the European eco-label - only 26% know the label and the meaning, 32% recognize it and 42% do not know it. Regarding Cradle to Cradle, 65% do not know the label and only 13% know it.

The more known labels are the Green Dot Society symbol (EoL packaging management system in Portugal), the Energy efficiency label and the recycling symbol. These are known by more than 90% of the consumers.

The labels that are less known are the Cradle to Cradle, the European eco-label, the Fair-trade label, and the Euro leaf.

5.6 Perception of the Sustainability Profile of Products

To access the perception of consumers, the questionnaire presented 3 products to serve coffee, a ceramic cup, a paper cup, and a polystyrene cup. Based on the images and indication of the material, consumers were asked to indicate which one they consider more sustainable and less sustainable.

The examples in the questionnaire were selected form the LCA study Disposable Cups vs. Reusable Cups developed by Carbon Clear [17].

The product considered more sustainable was the Ceramic cup (75%), followed by the paper solution (23%). The polystyrene was indicated as the more sustainable by 2% of the sample.

When asking about the more sustainable solution, despite the fact that the majority have selected the ceramic, a relatively high percentage of consumers considered the paper as more sustainable. This asymmetry can be explained by the absence of the indication of the functional unit. Some consider the ceramic artifact because it can be used several times, while the others may have considered only one unit of each product, not considering the number of paper cups that are necessary for long-term use.

However, when asked to select the less sustainable, 90% of the consumers selected the polystyrene product and 2% the ceramic product.

According to the LCA study performed by Carbon Clear, based on the energy and emissions required per 2,000 servings for paper, polystyrene and ceramic cups the ceramic is the more efficient solution and the paper is the less efficient one.

This means that the perceptions of most consumers regarding the more efficient solution were correct. However, their perceptions regarding the less sustainable solution were wrong in 90% of the cases.

6 Conclusions

Our society is changing along with the way we produce and consume. Nevertheless, to have a positive impact under the sustainability framework we need to change radically our approach and the business models from the past. Despite all the efforts being done, *Our world is only 9% circular* [18], and the changes implemented still don't have a positive impact on our society.

The availability and dissemination of products and services with sustainability considerations is increasing worldwide, though sustainability in most cases, is still a marketing flag or a greenwashing tool.

In the current approach on the transition to a circular economy aligned with the European and national objectives, it is fundamental to understand where we have failed and learn with the errors from the past to define an effective approach based in the relation between production and consumption and the translation of the needs from the consumers, the needs of the business and the needs of society in the development of new products, services and systems.

Regarding consumers, which were the main focus of this paper, we are facing remarkable changes in the sustainable behavior. In general, consumers, are more aware of the societal and environmental problems and challenges and demand for new and better products and services. Yet, the gap between what is placed in the market by producers and what the consumer perceives is an important issue to overcome. The communication on products, the inefficiency of labels for the most users who do not understand these topics needs to be designed in a more efficient way.

The survey undertaken indicates that consumer believes in a common-sense assessment of sustainability based on their perceptions, which are not always correct and are partially supported in part by self-declarations and allegations from designers, producers, and retailers focusing only in few aspects of the life cycle, and in some cases, misleading consumers through greenwashing approaches.

For an effective transition to a more circular and sustainable economy, the market and consumers perspective has to be integrated into a holistic approach through the design practice.

7 Further Research

For the above-mentioned holistic approach, the next steps in the current research will be the analysis of the designers and product developers' perceptions, methods, and approaches on the development of sustainable and circular products. How designers translate the user and business needs in product development, which methodologies and tools are applied in practice to integrate sustainability and circular design strategies, will be some topics addressed and under scrutiny.

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Annex 22 – Paper_ Circular and Sustainable Design A systemic design model for the transition to a circular and sustainable economy

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Circular and Sustainable Design: A systemic design model for the transition to a circular and sustainable economy

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Abstract
Successful and innovative design practices towards the development of more circular and sustainable products and services that are aligned with the current and future needs of our society rely on efficient practices that combine three main levels in the design and development process. The design management level which is responsible for establishing, planning and managing the development of design projects. The business level, which is focused on the feasibility and effectiveness of the project and its results in the short and long term. Lastly, the design level that is responsible for the implementation and development of circular design projects. This paper is part of a PhD research focused on supporting an innovative and efficient transition to a circular economy and sustainability through design. It describes the basis of a design model under development based on the design thinking process and an expert's survey carried at an international level and the research activities undertaken. It integrates the three levels in a systemic perspective, guiding the process and establishing the link between the needs of the design and development teams in terms of the definition of circularity and sustainability considerations and strategies, objectives and the activities, resources and practical tools needed to support the circular design projects.

Keywords: Design, Circular economy, Sustainability, Design systemic model

Introduction
To achieve sustainability and the transition to a Circular Economy (CE), we need to shift to a more innovative and effective way to fulfil the needs of the society and change the paradigm of production and consumption of products and services. The way we design, produce, use, distribute and discard products has a strong impact on the economy, the society and the environment (European Commission, 2019) and design practice are seen as a catalyst to shift from the traditional model of take-make-dispose to achieve a more restorative, regenerative and circular economy (Moreno, De los Rios, Rowe & Charnley, 2016). However, the approaches proposed so far in the field of design and innovation have not addressed and promoted significant changes at the system level (Idil Gaziulusoy, 2015) and designers who have the function of translating the strategies and concepts of circularity in the development of products and services that promote the closing of cycles, the efficiency, and sustainability of the systems, are challenged by new environmental, social and economic needs must adopt a holistic approach to problem-solving (Bocken, de Pauw, Bakker & van der Grinten, 2016) taking into account that most of the characteristics of the entire life cycle of a product are defined in the design stage.

As part of a doctoral research project under development which aims to promote and demonstrate to practitioners and companies the key role of design in this process, and to increase the knowledge in the fields of design for sustainability and circular economy, as well as support the design practice and the practitioners with guidelines and resources to develop sustainable solutions to current and future needs, the project addresses four main research questions:

- How can design support the transition from the linear economy to the new model of a circular and sustainable economy?
- What tools and methods can designers apply to support an effective design practice for a successful transition to CE in the real world?
- How can designers overcome the barriers to the implementation of a design practice that effectively results in more sustainable products and services aligned with the European policies for CE?
- And, how can design practice and the role of the design professionals be promoted in the CE context?

To support the design practice and to reduce the gaps that exist between what is being developed and investigated in CE and its practical application in the development of more circular, sustainable and innovative projects, products and services, and to promote good practices, this paper presents a systemic model that is under development to meet the needs of designers in the integration of circularity aspects in their practice. The model aims to establish the connection of the design process, the business strategy and the design management towards circularity and integrates the inputs derived from the research undertaken and will be further tested and validated to ensure its adequacy and efficiency to support the process.

Design for a circular economy

In the transition from the traditional linear approach to the circular economy, design makes a huge contribution. Design plays a key role in the definition of the features and the profile of products and services. A more sustainable way to design, produce, and consume is a crucial objective for the development of our society (Bhamra & Lofthouse, 2007; Braungart & McDonough, 2009; Manzini & Vezzoli, 2010; Margolin, 2014) that, according to recent studies, is only 9% circular (De Wit, Hoogzaad, Ramkumar, Friedl & Douma, 2019). With the responsibility of responding to product-service system problems, designers must integrate circularity criteria and expertise in problem-solving innovatively, adjusted to the needs of users, businesses, and society's dynamics (Ferreira, 2008).

The circular design process and the underlying practice can be seen as more challenging and complex, requiring changes in the way of thinking and conducting projects focusing on a shift from product-based solutions to more sustainable and innovative system-based or function-based approaches. Designers need to align their development process with the CE approach to replace the conventional end-of-life concept in which the materials and components of a product are disposed of after fulfilling the initial function, through closing solutions, slowing and narrowing the resource flows in production, distribution and consumption processes (Bocken, de Pauw, Bakker & van der Grinten, 2016). They need to apply several strategies in the development process focusing on the efficiency and sustainability of the entire system (Rocha, Camocho & Alexandre, 2019).

To foster an efficient design practice, there is a need to provide practitioners, business stakeholders, and other product developers with guidelines, resources and practices to apply design strategies for different circular business models (Moreno, De los Rios, Rowe & Charnley, 2016; Bocken, 2016), and influencing and managing the value chains. Building circular and sustainable value chains that are highly influenced by product and service design, inevitably imply a fundamental change in design practice (Camocho, Ferreira & Vicente, 2018; Prendeville et al., 2013; De los Rios & Charnley, 2017).

New or updated and upgraded methods and effective design-oriented tools are needed to support and promote design in the transition to a CE. The over-consumption of goods and services have actively seduced society, leading to excessive consumption of natural resources and the generation of huge amounts of waste and emissions (Medkova & Fifield, 2016). Designing products more smartly and innovatively, extending their useful lives and changing the role of such products within the system is crucial to the achievement circularity and sustainability (Camocho, Ferreira & Vicente, 2018; European Environment Agency, 2017).

Currently, and given the post-COVID19 scenario in which we are, the effects of the pandemic have further reinforced this need to create a more ecological and resilient society. Europe needs to be revitalized. Companies, businesses and society must adapt to a new reality, and new revitalization mechanisms must be adopted. The European Union recently launched the Europe recovery plan (European Commision, 2020) in which measures to revitalize and support organisations will be put into practice. In this context, the design is a fundamental element in adapting to new needs and must respond with integrated solutions that enhance innovation, sustainability, employment and the creation of value for all stakeholders.

Basis and rationale for the development of the design model for a CE

The integration of sustainability principles in product development has been a concern of many professionals since the 70s, having, in a way, an important influence of Vitor Papanek's book "Design for the real world" (1970). The authors called into question the practice of design and the relationship of this professional activity with the environmental and social impact associated with product development. From green design to design for the circular economy, we have witnessed an evolution in design, in the concepts, practice and growth in complexity by integrating a larger scope of sustainability criteria (Vicente, Frazão & Silva, 2012). Numerous projects and initiatives have been developed, numerous examples of success are available in the market, however, this practice has never become mainstream. These approaches have always been related to niche markets and in general (Hassi & Wever, 2010) never managed to demonstrate the real benefits of being sustainable, taking into account, the environmental, social and economic pillars of sustainability.

The CE can be considered as another step in the evolution of a necessary and fundamental demand for a more sustainable future and presents itself as a possible path in this direction, and in this way, the scientific, academic and business communities are highly motivated and committed in this respect. However, as mentioned above, despite the numerous developments in terms of methodologies, practices, tools, funding, etc., there is still a huge gap between theory and practice (Camocho, Ferreira & Vicente, 2019), between what is being developed in research and development projects and what is applied in practice for new solutions that reach the market.

It is essential to narrow this gap and provide designers, who have a fundamental and irrefutable role in the development of new products, sustainable services and systems, with interdisciplinary practices supported by synthetic methods, tools and guidelines that result in sustainable solutions that contribute towards an environmentally efficient future, fair from a social point of view and that creates value and wealth for business and the society.

In this sense, this research project intends to develop a synthetic method that supports this practice and that integrates the project development, the management and orientation of the design project and the perspective of the business, as presented in Figure 01, implementing these considerations in early phases of the project (Hassi & Wever, 2010) with high innovation potential.

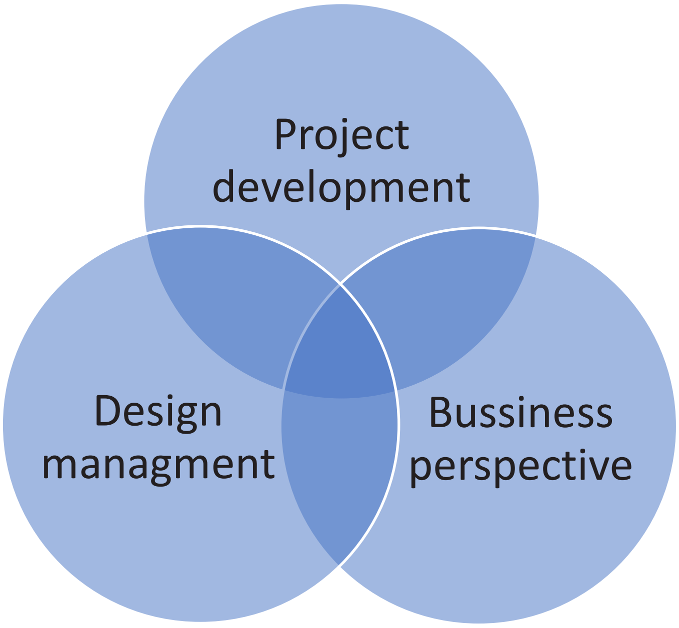

Figure 1: The 3 dimensions of the circular design model.

This model results from the work and research carried out and aims to systematize and guide the design process by integrating aspects of circularity and sustainability that respect the intrinsic needs of the design process and activities. The model is based on four main sources of information. An extensive literature review, the national practices applied in Portuguese products that are available in the market, the perspective of consumers and the perspectives of a group of international experts that were consulted within the process (Figure 2).

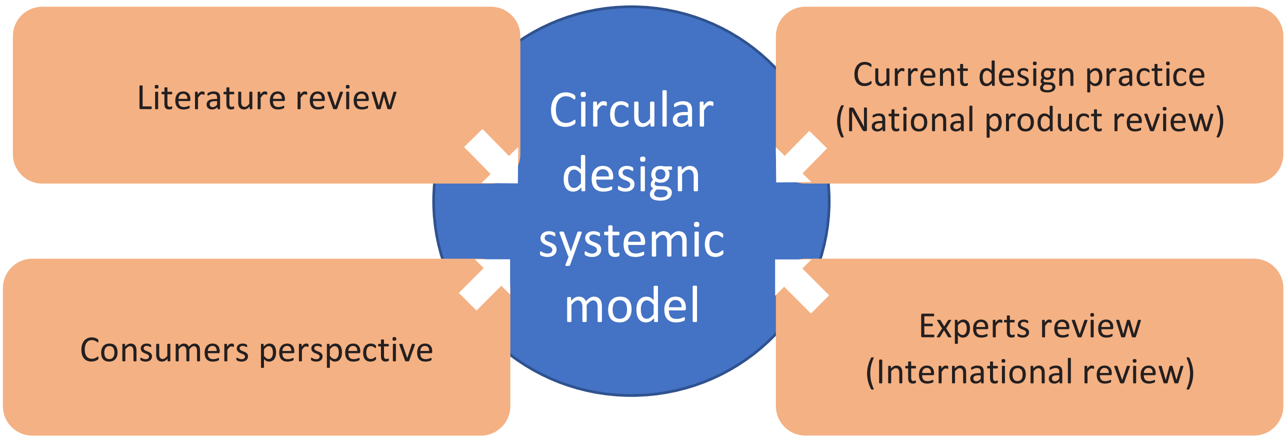

Figure 2: Circular design systemic model – sources.

Literature review

For the development of the design model, the literature review that aimed to identify and analyze the main sources at a national and international level provided a clear picture of the state-of-the-art and knowledge in the field of design, sustainability and CE with a special focus in identifying methodologies, tools, definitions and case studies of development and implementation of design projects oriented towards CE and sustainability (Camocho, 2018). Within the research project, several resources were collected and analysed. The CE is a current topic, and a vast number of activities and publications are being released frequently. These have been considered in the project and integrated as possible.

Besides the support in the development of the project and the design model, the collected information, with a brief analysis of each resource will be systematized and made available in the form of a database of resources oriented towards the design process aiming to provide designers and product developers with a source of relevant knowledge that is available and can be used as reference and inspiration to support innovative projects.

Identification of national products with sustainability criteria

To map sustainable and circular design practices in Portugal and to analyze how the sustainability and circularity aspects are being integrated into product development and communicated to the user, within the research project, relevant industrial products that are available in the market which have been developed with sustainability and/or circularity criteria and are placed in the market with sustainability allegations were identified and collected in a database of Portuguese products. This will be made available to be used by the design community as a source of inspiration, collection of good practices and promotion of the sustainability and circularity concepts and their background.

The collection of national examples was done to support the identification of the design professionals and companies linked to the products identified and, through interviews, the research aimed to identify and analyze how sustainable and circular products were developed and which are the needs, drivers, barriers and more information on the design practice towards a CE to support the development on the resources that will result from this project.

The search and collection of Portuguese examples demonstrated that despite all the efforts that are being done by research institutions, the Portuguese government, academia, associations, organizations, NGO’s, etc., there is still a lack of national products developed and placed in the market. There are, however, several examples of products available, but the majority are imported from abroad.

Analysis of consumer perspectives

The availability and dissemination of products and services with sustainability considerations is increasing worldwide. There has been a growing trend in informing consumers about the environmental aspects to take into account when buying products (Young, Kumju, Seonaidh & Caroline, 2008). In general, consumers, are more aware of the societal and environmental problems and challenges and demand new and improved products and services. Yet, the gap between what is placed in the market by producers and what the consumer perceives is an important issue to overcome. The communication of products, the inefficiency of labels for most users who do not understand these topics, need to be designed in a more efficient way (Camocho, 2019).

For an efficient transition to CE through design, it is important to have a holistic and integrated approach. On the one hand, we need to supply innovative and sustainable products that meet the needs of consumers, and on the other, we need to have a sustainable consumption behaviour and features related to products and services that allow an informed choice and efficient use by consumers. Within the development of design projects for CE, designers need to better understand the consumer habits, perceptions and general knowledge regarding the sustainability aspects of products and services, and in this regard, within the research project, a consumers analysis was developed.

The survey undertaken indicates that consumer believes in a common-sense assessment of sustainability based on their perceptions, which are not always correct and are partially supported by self-declarations and allegations from designers, producers, and retailers focusing only in few aspects of the life cycle, and in some cases, misleading consumers through greenwashing approaches (Camocho, Ferreira & Vicente 2019). These findings and concerns should be translated into criteria to guide the development process and must be considered in the design model under development.

Survey of experts

Despite the evolution of the CE approach and wide dissemination and engagement at many levels of our society, which lead to the development of new business opportunities, new business models and developing new markets, is CE the solution to attain a sustainable society? To answer this question, the current research conducted an international survey, in which a group of international experts were contacted and invited to collaborate by sharing their experiences and perspectives about the current and future status of CE in practice.

To develop an efficient survey, the purpose, goals and the sample were clearly defined to ensure focus, concise and provide useful data. The collected information allows the definition of an international overview of the practice, motivations and barriers in the transition to CE through design, and supports the research and development of methods, tools and guidelines to promote an improved design practice.

To involve an effective and relevant sample, before the development of the survey, a database of international experts was developed as well as a questionnaire based on the compromise between the length and time needed to complete it and the need for data to support the analysis. Through the questions, the research aims to understand the views and perspectives of the experts in the field on what concerns the practical implementation of CE, in what sense the experts consider that CE is the way to achieve a sustainable society in the future, what is considered the novelty that the concept and approach can bring to society, what are the main drivers and motivations to adopt CE in practice, what are the main barriers, how should we overcome the current obstacles and promote the design practice towards innovative and sustainable solutions, and what lessons can we learn from the past.

The analysis of the data gives an overview of the perceptions of the experts that are working in the field and are facing the real challenges in the circularity path. From the expert's inputs to the survey, more than 80% consider that CE is the way to attain sustainability. The around 20% that do not consider CE as the way for sustainability consider that CE is one important strategy, but many other must be integrated and considered in the development of our society and the future patterns for production and consumption.

From the overall perceptions, CE can be seen as a change of mindset for consumers and industries, leading to the development of different ways of production and consumption, focusing on the real needs of the users, business and the society by adopting new development paths and new business models which can lead to a more dematerialized and efficient ways to fulfil the needs of all stakeholders in the value chain.

The results of the survey which include also a set of motivation, barriers for the implementation of CE in practice, ideas on how to overcome the obstacles and promote the design practice towards innovative and sustainable solutions and other relevant aspects will support the development and adequacy of the design model and the related resources.

Development of the Circular Design Model and toolkit

Aiming to support and promote the design practice, a design model is developed. Bild upon the results of the research, the above-mentioned review, the analysis of strategies, tools and methods, and other relevant information collected and analyzed, the structure of the model (Figure 3) derives from the six main stages of a design project and relates the activities of the process with three levels that complement each other resulting in a robust model to support the design practice towards circularity and sustainability:

- The Project management level to support an efficient integration of circularity in the different phases and aspects of Design management
- The business level to align the development with the strategy and considerations of the business, promoting the efficiency and sustainability of the system.
- The design team level, to support the practice and the integration of the circularity and sustainability considerations, methods and tools in the development of new and innovative products, services and systems.

The model establishes the relation of the design thinking process with the goals of the CE to define how the resources can guide the design process to promote sustainability and circularity in processes.

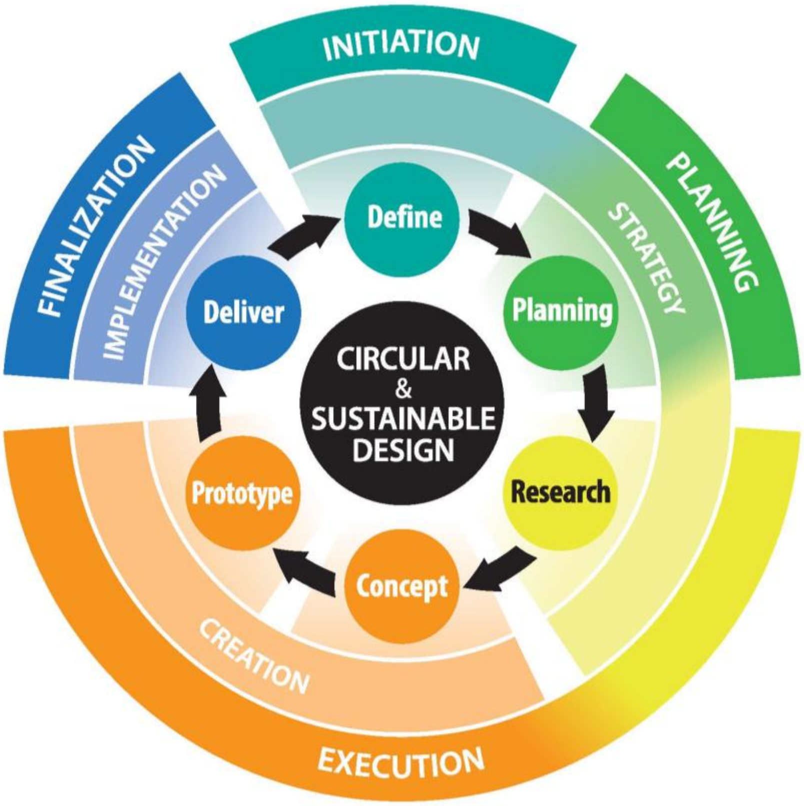

Figure 3. Circular and sustainable design model.

The description of each step in Figure 3 are the goals and objectives of each phase, how circularity should be addressed, which sub-activities are included in each step of the model and which are the inputs (resources, time, human resources, etc) and the outputs needed, will allow a systemic definition, the planning and the development of the design for a CE project.

The strategy for the design practice within CE will be supported by relevant tools, methods and guidelines that can be applied by practitioners in their daily activity to develop innovative and sustainable circular solutions. The translation of the model into the practice will be done through a design for circularity and sustainability toolkit. The toolkit to improve the role of design in the transition towards a circular and sustainable economy is being developed and will support the development of new projects that will result in new products and services with more potential for innovation, sustainability and circularity.

Conclusions and further development

The circular design systemic model, structured in three interlinked layers that integrate the project development perspective, the design management approach, and the business perspective, will promote the adoption and implementation of circular design in practice. The model provides guidance and support to designers, project developers, project managers and business strategists engaged in this typology of projects, integrating circularity considerations, tools and methodologies as core activities in the development of new and efficient products and services. These align the current and future needs of consumers with improvements and benefits in the circularity profile of products and services with an added value for the business and the society. This model aims to reduce the gap between theory and practice, developed with an orientation towards the project, respecting the needs of the various stakeholders and aligned with the characteristics and needs of project management and development.

The result, integrating a set of guidelines and different types of resources for project development, will be tested and validated by a focus group and will be disseminated and promoted to design communities, product developers and businesses, in a collaborative approach, creating synergies and sharing the knowledge, thus contributing to an effective improvement of society towards a more circular and sustainable future through design.

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