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## A methodological approach to development of circular economy options in businesses

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### Abstract

Three types of re-design processes are described in the development of circular economy options in businesses: 1) Re-design of the provided services considering changes in the roles of products, users, service, infrastructure, etc.; 2) Re-design of the value chain relations up-stream to suppliers and down-stream to customers and users; 3) Redesign of internal business organization considering necessary changes in tasks, competences, structures and technologies. These redesign processes have been developed as methodology within a research project based on cooperation with businesses in Denmark about analyses of potentials and barriers to circular economy as part of their business strategies. Circular economy is understood as slowing, narrowing and closing resource flows in order to increase resource effectiveness.

Before the re-design considerations, initial mappings are done of material relations of the business based on an environmental mapping in life cycle perspective and an organizational analysis mapping of value chain relations, competitive position, innovation practices, user practices and relations to regulation and civil society. The article shows that circular economy can be relevant to businesses within many product and service areas, to both start-ups and existing businesses and to businesses with different roles in value chains, including manufacturing, retail and service. The article develops the concept of ‘circular economy journey’, understood as the activities carried out as part of development and analyses of potentials and barriers to circular economy through slowing down, narrowing and closing resource flows in a specific business and its value chains.

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**Keywords:** Circular economy; re-design; value chain; life cycle, social practice, circular economy journey

### 1. Introduction

The linear ‘take-make-dispose’ economic model is reaching its limits, and initiatives to develop alternative economic models are emerging. Circular economy is currently getting a lot of attention, because it promises an industrial system that is restorative by design; and both some businesses and cities are developing circular economy strategies.

However, circular economy is not without shortcomings as strategy for sustainable development, if the focus is merely on closing existing material flows. Instead it is necessary as background for development of circular economy strategies to

understand the dynamics of the present linear economy by questioning:

- Why we produce what?
- What are the challenges of closing material flows from the globalized, outsourced and cheap production?
- When and why products lose value to their users and become waste?

Several alternative social and economic models that aim at circumventing sustainability challenges have been discussed since the Brundtland report was published 30 years ago,

including concepts like industrial ecology and cradle-to-cradle. Recently circular economy (and not least the circular economy framework proposed by the Ellen MacArthur Foundation - see for example [1]) has got a lot of political attention. Ellen MacArthur Foundation [1] refers to some of these and other “schools of thought” as inspiration when describing circular economy as “restorative and regenerative by design”, and aiming at keeping products, components, and materials at highest utility and value at all times and based on the following three principles [1]:

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

Business strategies for circular economy are for finite (non-renewable) resources described as [1]:

- Maintaining products
- Reusing and redistributing products
- Refurbishing and remanufacturing products
- Recycling components and materials from products

For renewable resources the strategies are described as cascading use of waste materials and recycling as feedstock and energy resource. Such changes might need to be accompanied by changes in the business model – for example by changing from product sale to product-service-system [1].

EU’s circular economy package from December 2015 [2] was inspired by the analyses of the Ellen MacArthur Foundation. The European Commission focuses on increasing resource efficiency by closing material loops, and thereby maintaining the value of products, materials and resources in the economy for as long as possible and minimizing waste generation [2].

Bocken et al [3] describe circular economy through the three principles of slowing down, narrowing and closing resource flows:

- Slowing resource loops: Through the design of long-life goods and product-life extension the utilization period of products is extended and/or intensified, resulting in a slowdown of the flow of resources
- Closing resource loops: Through recycling, the loop between post-use and production is closed, resulting in a circular flow of resources
- Increasing resource efficiency by narrowing resource flows by using fewer resources per product.

Analyses by EEB [4] show the risk of low efficiency in recycling of materials and components. Therefore circular economy efforts based on slowing down resources flows – e.g. prolonged life time of products - and narrowing resource flows by using less resources or fewer products enable a bigger increase in resource effectiveness than recycling. This implies that circular economy strategies of businesses, which

are supposed to contribute to substantial reductions of resource extraction and consumption, should include a focus on:

- What is being produced and what are the losses in the production?
- How effective is the product use?
- Why do products lose value to their users – e.g. whether it is due to *technical* obsolescence (not repairable and upgradeable products) or *emotional* obsolescence (e.g. users want a new product model that has been launched)? [3]

The attention to what is produced would for example imply an emphasis on produced types of food products before focusing on reducing food waste. This is a different approach compared to for example the focus on food waste in Ellen MacArthur Foundation’s analyses of circular economy within in Denmark [5]. Since closing resource flows only is one of strategies for increasing resource effectiveness the term ‘circular economy’ could be seen as misleading and strategies for higher resource effectiveness would be a better term.

The article presents an approach, including an in-depth case, to development of circular economy strategies for businesses through so-called ‘circular economy journeys’, based on:

- An environmental and organizational mapping in life cycle perspective of the business
- Analyses of potentials and barriers for circular economy through three types of re-design processes: 1) Re-design of the provided services; 2) Re-design of value chains upstream and down-stream and 3) Internal organizational redesign of the business organization
- Impact of changes on environmental aspects and impacts

The methodology has been developed in a research project at Aalborg University – Sustainable Production 3.0 – aiming at developing experiences with and methods for circular economy in businesses through cooperation with 20 businesses in Denmark with different size, product and service area and geographical belonging. The project findings are systematized and disseminated to other businesses, business associations, business service centers, consultants, waste management companies, authorities and university lecturers through networking, practical guidelines and case reports in cooperation with two regional sustainable business networks.

## 2. Theoretical background

The methodology presented in the article builds upon theories about:

- Network relations of a business, including forces that shape the competition which the business is part of [6,7]
- The interactions between product and service design and users’ social practices with a product or a service [8]

- Aspects which shape the capability of a business to explore and exploit knowledge about environmental problems and solutions [9]

According to Jørgensen and Forman [6] a business is, consciously or unconsciously, part of five types of networks:

- *The value chain* is the flow of capital and information from cradle to grave, and the *product chain* is the resource flows downstream and upstream, between suppliers, customers and users.
- *The innovation network* focuses on the development of new processes, products and services and can include other parts of the value chain, consultants, universities and other types of knowledge institutions.
- *The regulatory networks* include public authorities from the local to the international level, but also civil society organizations that directly or indirectly address how businesses should or ought to act.
- *The local networks* consist of the different local supplies of natural resources, infrastructure, staff, local governmental regulation etc. along the value chain

Porter's concept of five forces [7], which shape the dynamics of the competition of a business, includes the value chain and the bargaining power of suppliers and buyers, but focuses also on rivalry among existing competitors, threats of new entrants, and threats of substitute products or services.

The concept of 'script' and 'de-description' is used as background for understanding the interactions between design of products and services and users' social practices in relation to the products and services [8]. The script is the roles ascribed to a product, services, users, societal infrastructures, etc. during innovation processes. The script can be seen as characterising those intentions which a designer or developer consciously or unconsciously builds ('inscribes') into a technology, product, service, etc. through its material shape, its functions, the user guidelines etc. This includes the future roles, which technologies, user, surrounding infrastructures, etc. are supposed to have. Whether the script afterwards is accepted by the imagined users through their so-called de-description of the script and whether a stable practice is developing, depends on the script, the type of technology, the alternatives, the user and the societal context. Akrich [8] talks about 'negotiations' between the inscribed possibilities and limitations the script gives the user. These negotiations take place in interaction with the economic, knowledge, technical etc. resources which the user has access to when shaping the practice with a product or service. A product is said to be 'hard' if the users cannot change the practice with the product, even if they feel restricted in the shaping of their practices. On the other hand, a product is said to be 'soft' if the users can shape their own practices. The so-called 'prescription' refers to the room for user action, which the script allows.

Lenox and Ehrenfeld [9] distinguish between a business' capability to collect knowledge about environmental problems and solutions (exploration of knowledge) and the business' capacity to translating this knowledge into guidelines for example product design (exploitation of knowledge).

### 3. Environmental and organizational mapping of baseline

As a starting point in the 'circular economy journey' of a business an initial mapping of the social and material relations of the business is made in order to give the researchers and the business some common knowledge about the business and provide a base for development of possible ideas for circular economy that could be analyzed as part of a 'journey'. The circular economy principles like in [2,3] can inspire reflections about potentials and barriers to circular economy but the reflections need to be contextualized and situated within the specific business and its capabilities and its present strategic plans. The environmental mapping in life cycle perspective can be done through a so-called MECO-screening (Materials, Energy, Chemicals, Others) based on a description and assessment of the following aspects of the products and services of a business [10] – both as a baseline and as an assessment of proposed changes in products and services:

- *M*: Materials, including whether the materials are scarce, non-renewable or renewable
- *E*: Energy, including whether the energy sources are fossil or renewable
- *C*: Chemicals, including aspects of environmental toxicology (e.g. risks of carcinogen, reproductive, allergic and neuro-toxic impact) and eco-toxicology (e.g. risks related to persistence and bio-accumulation)
- *O*: Other aspects, like land use, biodiversity, work environment (occupational health and safety (OHS)), etc.

The MECO-screening can be done by filling out a table, like Table 1, with data for types of products and services.

Table1. Matrix for lifecycle screening of Materials, Energy, Chemicals and Other aspects of products and services of a business [10].

Product	Raw material extraction	Production	Use	Waste management
Materials				
Energy				
Chemicals				
Other aspects				

The environmental mapping should include speed (understood as product life time), size and circularity of resource flows, including expected vs actual user practices:

- The extent of use of recycled resources as raw material
- The recyclability of the discarded product, including how pure or clean the resources are and whether they contain hazardous materials, including actual recycling
- The speed and the size of the resource flows, including:
  - Whether and how there is focus on informing users about the right use of the product (through labelling, user manuals etc.)
  - Whether knowledge is collected about the actual use of the products (de-description), and how this use corresponds to the imagined use (script) and whether

and how knowledge from maintenance, service and repair of the products are available and applied in the business trying to obtain longer product life time

Based on the concept of Jørgensen's and Forman's business network relations [6] and Porter's five forces [7] the following aspects are discussed as part of the initial organizational mapping:

- Aspects of power and learning in relation to suppliers, customers, and users and the role of environmental concerns
- The roles of environmental concerns in innovation
- Competitors' environmental strategies
- Threats from new (more environmental friendly) varieties of competing products and services entering the market
- Relations to existing and future environmental regulation – locally, nationally and internationally
- Relations to citizens and non-governmental organizations – locally, nationally and internationally

Knowledge collected in the initial mappings in the project of resource consumption and speed, size and circularity of resource flows in the case businesses show how different dynamics shaping resource flows and resource effectiveness of businesses and their products and services are:

- Big amount of raw material wasted due to quality criteria of the customers in a food company
- No re-use of products despite it could be possible, but the final users lack knowledge about whether and how the product can be re-used
- Use of recycled materials for production of a packaging product, while the used packaging cannot be recycled due to a necessary surface treatment of the packaging
- Different amount of information are given to users about product use and waste management. Complicated user manuals might prevent users from reading and understanding instructions for product use and re-use
- Some start-up businesses are developed around a circular business model with a concern for long product life time (slow resource flows) and/or high degree of circularity, e.g. by only using recycled resources as raw material, offering product take-back or offering repair of products
- Businesses might work with a product-service-system model in some countries, but not in other countries

#### 4. Development of options for analyses of potentials and barriers to higher resource effectiveness

After the initial mapping, potentials and barriers to higher resource effectiveness can be discussed in dialogue between the business and the researchers. Initial options have several times in the research project been developed using a print-out of a circular economy diagram from [1] as inspiration. Such a diagram shows the possibilities of maintaining products, reusing and redistributing products, refurbishing and remanufacturing products, and recycling components and materials from products. For renewable resources the diagram

shows the possibilities of cascading use of waste materials and recycling as feedstock and energy resource. Our experience is that such a diagram can initiate reflections about possibilities for slowing, narrowing or closing resource flows that are relevant to analyze further. Table 2 gives an overview of the different types of businesses, which the project is cooperating with, and the options for higher resource

Table 2. Baseline and options for higher resource effectiveness.

Business and product type	Possibilities and challenges for increased resource effectiveness
Clothing start-up	Product take-back
Clothing start-up	Manufacturing new products of recycled raw material. Sale with product buy-back
Clothing manufacturer	Considering to offer product repair
LED lighting	ESCO business model for exchange of existing lighting. Assessing options for closed loop material recycling
Environmental technology manufacturer	Single-use business model developed into model with re-use of product and components
Pillow manufacturer	Leasing as new business model to enable longer product life time
Manufacturer of furniture	Product take back and refurbishment
Manufacturer of textile for furniture	Material recycling
Building component manufacturer	Re-purposing and multi-purposing of buildings increasing life time and use of buildings
Pump manufacturer	Product-take back and product-service system for professional customers
Manufacturer of furniture	Developing leasing and product-service-system for public procurement
Manufacturer of machines for professional use	Analyzing Total Cost of Ownership as element in increasing customers' resource effectiveness
Food packaging manufacturer	Using recycled raw material. Analysed whether customers recycle used packaging
Manufacturer of water equipment	Refurbishment of used equipment
Retail chain	Development of packaging strategy combining health and circularity and also assessing bioplastic as possible material
Food and agriculture business	Assessing and recycling of plastic from production and retail
Medico-electronic manufacturer	Assessing possibilities for product-service-system as part of public procurement
Integrated urban farming start-up	Assessing resource effectiveness of urban farming using excess energy, water and materials from buildings
Professional laundry and textile service	Increasing resource effectiveness of textiles through optimisation of speed and size of textile flow
Professional laundry and textile service	Increasing resource effectiveness of textile through optimisation of speed and size of textile flow

effectiveness, which are or have been analyzed as part of the cooperation. The table shows that slowing, narrowing and closing of resource flows are relevant and possible within a broad variety of product and service areas and business types.

The identified options for higher resource effectiveness of a business' services are developed further through analyses of the need for three types of re-design processes in order to consider potentials, barriers and prerequisites for implementation of the options, including influence on other environmental impact categories, product quality, etc.. Together the analyses of these re-design processes are part of the circular economy journey of a business:

- 1) Re-design of the provided services, considering necessary changes in the roles of products, users, service, infrastructure, etc.
- 2) Re-design of the value chain relations up-stream to suppliers and down-stream to customers and users
- 3) Redesign of internal business organization considering necessary changes in tasks, competences, structures and technologies related to 1) and 2)

#### 4.1. The enabling role of upcoming strategic decisions

Some of the developed options for higher resource effectiveness in the businesses have been inspired by considerations about future strategic choices, which a business is facing, and where resource effectiveness should be considered together with these choices, either as a further argument or as a concern in order not to reduce resource effectiveness. Examples of such strategic considerations from the case businesses are:

- Whether a public procurement model from another country could be implemented in Denmark and could imply higher resource effectiveness
  - The analysis included interviews with a number of stakeholders from executive management, line management and procurement in the public sector in order to identify the different actors' preferences in relation to an investment model and a service system model based on procurement of number of analyses
- How to include circularity in a new packaging strategy which aims at substituting hazardous substances in metal cans for food?
  - The analysis included assessment of other possible packaging types and their use of recycled material and their recyclability
- Whether a subscription model for an environmental technology product could enable re-use of the product instead of the dominating single-use of the product
  - The analysis showed a need for more knowledge about the present user practices and of the possibilities and barriers to actual re-use of the product
- Whether customers' increasing focus on Total Cost of Ownership (TOC) of machines and facilities as part of a

procurement process can enable higher resource effectiveness in the use of the machines and facilities

- The analysis showed the need for further analysis of the resource flows in an existing customer's facility and some of this customer's important final users in order to get more information about potentials and barriers to slowing down or narrowing resource flows

#### 4.2. Case: a circular economy journey

A circular economy journey in one of the case businesses is presented in the following. In this case the business model of an environmental technology product was changed from a single-use product to re-use of the product. The three re-design processes, which enabled this change, are shown in Table 3. Table 4 describes the circular economy journey: the activities in cooperation between the business and the university during the identification and further development of options for higher resource effectiveness, which led to the longer product life time and the new business model.

Table 3. Case: Redesign for longer product life time.

Types of re-design	Changes through re-design
Re-design of provided services considering changes in roles of products, users, service, infrastructure, etc.:	<ul style="list-style-type: none"> <li>• Business offers to take back product after use instead of product is discarded by customer</li> <li>• Users informed about how to empty used product so that the product can be re-used</li> <li>• Product is re-used after cleaning or refurbishment</li> <li>• Customers buying re-used products are informed that products might be dirty but have same quality as new products</li> </ul>
Re-design of value chain relations up-stream and down-stream:	<ul style="list-style-type: none"> <li>• Customers are offered discount with next purchase of product if they return used products instead of disposing them</li> </ul>
Redesign of internal business organization:	<ul style="list-style-type: none"> <li>• New tasks introduced: Disassembly, refurbishment and cleaning of used products</li> <li>• Development of information for customers about prices and quality of re-used products</li> </ul>

Close cooperation between researchers, university students, the business and interviews and co-design sessions with different actors were important in the identification and development of the possibilities for reuse and recycling into implementable concepts. The changed business model can be seen as co-created by the business and the researchers, students and users. The environmental assessment of the changed business model was based on a comparison of the benefits of product re-use with the impact from cleaning the used product and necessary changes of parts of the product.

Similar dialogues with customers and final users were important in several other cases in order to collect knowledge about the actual user practices and compare them with the

expected practices and thereby identify options for e.g. increased resource effectiveness based on increased product life time. Furthermore, such dialogues have been important in considerations about changes in public procurement models

Table 4. Case: Activities in ‘circular economy journey’ in a business: identification and analyses of options for higher resource effectiveness

Activities	Focus of activities
Mapping of baseline. Initial identification of circular economy options: extension of product lifetime through proper use, product refurbishment, and material recycling	<ul style="list-style-type: none"> <li>• What is proper use of the product?</li> <li>• How are users informed about proper use?</li> <li>• How are the products used compared to the expected use?</li> <li>• What is recommended storage and maintenance of the product?</li> <li>• Is the product designed so that it is repairable?</li> <li>• How are user experiences applied in product re-design?</li> <li>• What are limitations to multiple uses of the product versus single-use?</li> <li>• What are possibilities and limitations for upcycling and downcycling of components of the used products?</li> </ul>
Further analyses of baseline	<ul style="list-style-type: none"> <li>• Mapping details of life cycle, existing user practices with single-use and multiple-use of product and script through meetings and interviews</li> <li>• Environmental assessment of baseline based on MECO assessment</li> <li>• Analyses of user manuals and guidelines and the use hereof</li> <li>• Analyses of importance of product storage facilities and practices</li> </ul>
Exploring possibilities for changes in product and services	<ul style="list-style-type: none"> <li>• Exploring possibilities for product, component and material re-use and recycling</li> </ul>
Redesign of products and services	<ul style="list-style-type: none"> <li>• Developing revised script and concept for use that can enable multiple-use of product</li> <li>• Co-design session with present users about user practice with revised concept</li> </ul>
Implementing changes in products and services, internal organization and value chains	<ul style="list-style-type: none"> <li>• Co-design workshop focusing on possibilities for encouraging more sustainable user practices</li> <li>• Development of and experiences with new business model with product take-back, reuse, refurbishment and recycling of products and components</li> <li>• Introduction of price discount at next purchase of products</li> </ul>

and change in products. Some of the circular economy journeys within the project did not imply changes in the business strategy, but described and analysed the present business strategy from a resource effectiveness perspective,

including practices within slowing down, narrowing and closing resource flows and identified barriers to changes.

## 5. Conclusion

Three types of re-design processes have been described as background for development of circular economy options in businesses: 1) Re-design of services 2) Re-design of value chain relations up-stream and down-stream and 3) Redesign of internal business organization. The concept of ‘circular economy journey’ has been introduced, understood as development and analyses of potentials and barriers to circular economy through slowing down, narrowing and closing resource flows. The experiences show circular economy is relevant to businesses within many product and service areas, to start-ups and existing businesses, and to businesses with different roles in value chains: manufacturing, retail and service. Furthermore the experiences show the importance of an initial mapping of organizational and material relations of the business as background for development of circular economy options. The experiences show that strategic decisions, which a business is considering, can inspire and frame identification of options for circular economy.

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