FROM WASTE MANAGEMENT TO STOCK AND FLOW MANAGEMENT: IMPLEMENTING CLOSING THE LOOP STRATEGIES IN THE NORDIC COUNTRIES

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Abstract: The ongoing project "Circular Economy Integration in the Nordic Industry for enhanced sustainability and competitiveness" (CIRCit) aims to identify for companies from five countries in Northern Europe suitable recirculation strategies among options such as reuse, repair, remanufacturing, refurbishment, and material recycling for products and systems. The strategy shall be selected based on technical, market and sustainability characteristics. Moreover, guidance regarding the implementation shall be provided. As a requirement, conditions in the region need to be considered as well as properties of the products, components and materials that have reached the end of a utilization phase.
To consider systems effects occurring on multiple levels and in multiple open and closed loops, a life cycle approach will be adopted. The approach will be further illustrated with cases from the CIRCit project.

1. INTRODUCTION

Circular economy (CE) measures are in general proposed as a means to reach sustainability goals and reduce climate impacts while emphasising the conservation of finite resources, which are circulated economic loops or substituted by renewable and bio-based options where possible [1], [2]. Among the proposed concepts a subset is based on using products, components or materials at the end of a use phase, after a possible transformation and treatment process, for a similar or different purpose. This subset is summarised with the term closing the product cycle and addressed in this paper. Links to other contributions to CE, such as the product development stage that considers already a multitude of loops, and in particular to business models that intensify the utilisation of products, for example by establishing product-service systems or shared use of products, are acknowledged but will not be further elaborated here.

2. BACKGROUND

Economies in the Nordic countries can be considered as performance economies, meaning they are well developed, mature and saturated [3]. Basic demands of the population are widely covered and an inventory of goods and infrastructural facilities (summarized as stock) is built up. Newly produced goods are often meant to replace existing goods. Growth in such markets is limited. That means that a shift to circulation approaches can be particularly beneficial to maximize the utilization of resources. Preconditions within the Nordic countries vary, as an example Finland, Norway and Sweden cover large areas, Iceland has a small population and non-domestic markets for durable goods require long distance transports, whereas Denmark shows similarities to continental European countries regarding population density and distances. Recycling systems for materials are well established in particular in Denmark, Norway and Sweden, and a positive attitude towards recirculation can be expected in all countries. Differences between countries can be used to identify drivers and barriers for particular strategies, for example incineration with energy recovery is well established in Finland, Norway and Sweden with large district heating networks, whereas in Iceland with a high availability of geothermal energy this path is less developed.

Even with a positive attitude towards recirculation, decision makers in industry prefer to identify benefits of recirculation systems in order to consider them.

A basic concept for closed loop strategies is that interventions (resource and energy inputs) to build stock from virgin materials are potentially higher compared to those for recirculation strategies. The embodied primary energy based on raw materials and machining processes in products and components at the end of a use phase should be reclaimed to sufficiently increase material and energy efficiency

together with implementing cutting-edge production technology in order to contribute to sustainable development via recirculation [4], [5].

3. MATERIALS AND METHODS

Industry partners from different Nordic countries and with a wide variety of products for international customers participate in the project to analyse how existing products shall be treated at the end of their service life. The analysis has to consider (1) technical feasibility of recirculation processes, (2) necessary effort for establishing feasible processes, (3) potential market partners and (4) legal implications for producers. All four aspects need to be approved for the implementation of a circular strategy and will be elaborated further in the following sections.

Recirculation strategies require the availability of (technical) processes to identify the state of a good at the end of its serviceable life, and to decide based on the identified state whether a good can be further used "as is" or possibly after an intervention. Goods that are suitable for further use then need to be further analysed to identify whether components can be separated and further used in similar applications, possibly again after treatment. If neither product nor components are suitable for further usage, material recycling after potential disassembly and treatment steps are an option. A follow-up use phase can be very much similar to the previous use phase, but it can also be in a different application or purpose, or after significantly changing shape and composition of a component in an open-loop. All recirculation options have as a common starting point that the content and structure of a product at the end of its service life are still valuable, albeit not for a continued use in the initially intended purpose. If the product or component includes materials that at a later stage after production have been categorized as hazardous or pernicious, they also need to be identified as an initial step for recirculation procedures. As an additional effect, the analysis provides insights from existing products that can be included in guidelines for product design and development. As an example, design for disassembly facilitates recirculation strategies for future products and components. Disassembly time and separation effect can be optimized by using suitable joining techniques [6].

The effort to provide secondary products, components or materials and the effort to adapt established production systems to secondary raw materials has to be taken into account when circular systems are assessed and compared to linear systems. This includes all interventions performed directly on the good, but also collection, storage and reverse logistics [7].

Establishing recirculation processes requires competences; moreover even if reclaiming products, components and materials is feasible, not all producers have an option to use secondary materials due to customer or general quality requirements. A likely outcome is that producers need to find partners with a suitable portfolio of competences to establish recirculation systems.

Among the barriers for establishing recirculation systems are current and potential future legal requirements. Product stewardship for recirculated products in sensitive application areas such as medical products implicates that producers rather have to destroy products at the end of their service life to avoid harm for users of secondary products. Waste directives with an emphasis on polluter-pays-principle also contribute to restrictions if a good or component potentially contains hazardous material. Legal requirements are prohibitive and can prevent the establishment of otherwise feasible and viable recirculation strategies. They are however adaptable to demands and policies.

The analysis of all four aspects will be performed together with participating companies to develop a procedure and tools and guidelines for identifying options to close product cycles and select among various options one that is most suitable to contribute to overarching sustainability goals. The project uses the approach of action research to include practitioners and decision makers in the process of scoping, initial data collection, selection of options, evaluation and further investigation of the most promising alternative where necessary.

A concept for empirical assessment of effects of recirculation systems needs to be based on the potential to contribute to overarching sustainability goals. It is necessary to identify benefits and drawbacks in the system and their relation to core product properties and peripheral activities. Existing indicators to be considered and tested are based on material intensity (MI) and energy intensity (cumulative energy demand CED) [8], [9]. Indicators and metrics will be selected to be generalisable, robust and sensitive when comparing different options, as well as efficient in use of information.

4. OUTLOOK

Initial discussions within the CIRCit project showed that a systematic overview of recirculation options including their potential implications, benefits and drawbacks is necessary for companies to identify what can be done. Available information is incomplete and not suitable for comparing different options.

An important contribution of the project will be the identification of information demand for decision makers to implement recirculation processes that contribute to sustainable development, based on a systematic analysis that includes core aspects related to feasibility and several types of implementation requirements.

Moreover, the results can be used to formulate from practitioners perspective demands for recirculation processes regarding their efficiency, separation effect for valuable and hazardous or pernicious content and energy demand to increase the use of secondary products, components and materials with high quality.

The project will also be used to test evaluation methods for recirculation strategies, and in particular system analysis tools and a life cycle thinking based approach.

Results from the project including results from work packages that are not discussed here such a circular business models, product development for circular strategies and circular product operation, are made available through the website http://circitnord.com/, where also links to publications can be found.

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