

Similarities and differences between energy efficiency and circularity approaches in industrial transition processes targeting manufacturing SME

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Abstract

Several large basic industries and original equipment manufacturers (OEM) have started to develop strategies and measures for a Circular Economy (CE). However, the whole circular potential in the value chain of manufacturing industry can only be seized if small and medium enterprises (SME) are not neglected. SME often do not have a clear perspective when they are asked what they could contribute to and to which extent they could benefit from the transition towards a CE. They often need support in identifying and realising circular potentials.

Therefore, following an action research approach, the project 'Prospektole' has analysed, developed, tested and evaluated concepts and tools supporting SME on their way to a CE. It particularly focuses on manufacturing SME in the state of North Rhine-Westphalia (NRW), Germany, and is carried out in close co-operation of Hochschule Ruhr West (University of Applied Sciences) with Efficiency Agency of NRW, two local economic development agencies (WiN Emscher-Lippe GmbH; City of Bottrop) and the association Prospektole e. V.

The paper analyses, to which extent the development of supporting measures, concepts and tools targeting SME with regard to a CE can learn from the long-term experience in the field of energy efficiency in SME. On the one hand, there are several similarities regarding benefits and opportunities, barriers and obstacles, antecedents, drivers and facilitators, monitoring and evaluation as well as management. In both fields, understanding the situation of the SME, their market situation,

motivations and challenges, and approaching them by personal communication is a key. Therefore, the design of strategies and approaches, concepts and tools, communication, co-operation and networking approaches can learn from relevant measures targeting energy efficiency in SME. On the other hand, while many energy efficiency activities in mostly less energy-intensive SME are cross-cutting measures that hardly touch the company's core value creation processes, a key difference is that several circular strategies directly affect the SME's core business by rethinking the business model, redesigning products and reorganising production, purchasing, logistic, distribution and service processes. For the implementation of these changes, contextual factors are much more important than for energy efficiency activities. Therefore, the focus of CE support activities should be to support the willingness and capability of the SME to implement changes in the core value creation processes of the firm and beyond in co-operation with other actors along the whole value chain.

Introduction

Currently, the economy still largely produces in a "linear" way. In contrast, a Circular Economy (CE) focuses on material cycles that are as closed as possible in order to secure the economic and social benefits of products, components and materials in the long term (Kirchherr et al. 2017). Due to their technical and scalable feasibility, CE strategies like circular and resource-efficient product design, material substitution, longer product life, material efficiency, reuse, refurbishment, remanufacturing and recycling, in a combined energy and material transition strategy, will make it easier and more economical to achieve

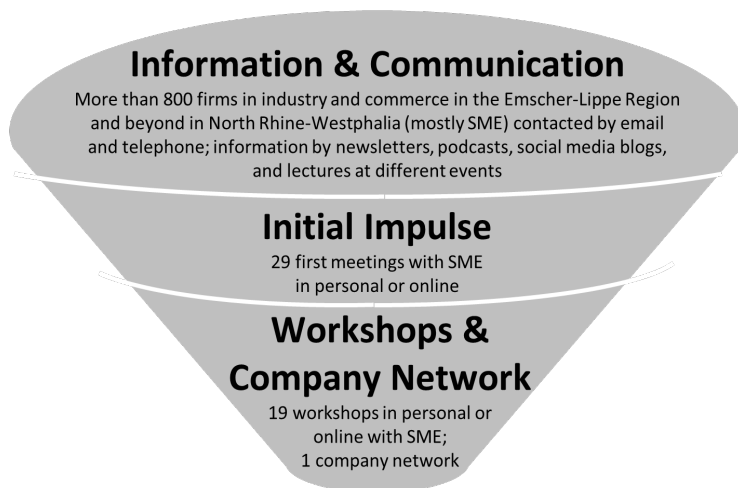


Figure 1. Prosperkolleg project communication, co-operation and networking with SME as of March 2022.

ambitious climate protection targets (Hennicke 2021, based on Günther et al. 2019), with potentials in mitigating greenhouse gas (GHG) emissions summing up to about 50%, depending on the actor, sector, and substance (Material Economics 2019).

Several large basic industries and original equipment manufacturers (OEM) have already set out on the path to a CE. However, respective activities by small and medium enterprises (SME) are still rare. Therefore, the Prosperkolleg project investigating the transformation process towards a CE in the state of North Rhine-Westphalia (NRW) has particularly focused on manufacturing SME in Bottrop and the Emscher-Lippe region in the Ruhr area (www.prosperkolleg.de). The project runs from June 2019 to March 2023 in close cooperation between the Hochschule Ruhr West (University of Applied Sciences), the Efficiency Agency of NRW, two local economic development agencies (WiN Emscher-Lippe GmbH; City of Bottrop) and the association Prosperkolleg e. V. The central research question of the project is: “How does the CE idea get into the heads of those responsible in business and changes the design of products, processes, business models and value creation networks?” The main objective is to derive recommendations for shaping the transformation process. The research approach essentially follows the sequence of analysis, development of an intervention concept, concept testing in practice and evaluation. The aim of the interventions is to provide impulses, offer assistance and ultimately encourage SME to implement CE. By March 2022, the Prosperkolleg project has contacted more than 800 companies, mainly from the manufacturing sector, conducted several initial impulse talks and workshops with SME and established a company network in which companies exchange good practice experiences with each other.

There are approximately 730,600 SMEs in NRW, or 99.3 percent of all companies in the state, which form the economic backbone of the state (Wirtschaft.NRW 2019). This illustrates that the full circular potential in the manufacturing value chain can only be realised if SME actively contribute. The attitude and starting point of SME differs from those of larger organisations, due to numerous competitors, demand-side uncertainties, cash flow problems, lack of standardised business practices, skills

shortages and higher employee turnover. SME tend to focus on their economic performance only rather than on environmental and social aspects (Dey et al. 2020).

Findings from the Prosperkolleg project show that SME are still not familiar with the concept of a CE, despite the fact that more government regulation is expected in the future (European Commission 2020) and although a CE contributes to climate protection. This paper presents a concept on how SME could be supported on their way towards a CE, and analyses to which extent the design of supporting measures in the field of CE could learn from experience with energy efficiency measures for SME. Therefore, after examining the links between energy efficiency, resource efficiency and CE, the paper reviews literature with regard to the situation of and experience with SME in the fields of energy efficiency and CE. It thereby compares benefits and opportunities, barriers and obstacles, antecedents, drivers and moderators, supporting measures, monitoring and evaluation and management systems in both fields. Based on this and the experience with SME in the Prosperkolleg project, the paper develops a concept for a ‘Potential Check CE’ for SME and reports results of its test in practice. Finally, an outlook on the next steps of transition research is given.

Energy efficiency, resource efficiency, circular economy

There is an increasing B2B and B2C customer demand for sustainable products and services. However, there is still a need for political programmes supporting sustainable development (Kirchherr et al. 2017; European Environment Agency 2020). CE aims to ensure the sustainability of the economic system by decoupling growth and resource consumption, as well as preventing materials to be treated as waste. In doing so, resource cycles are slowed down, narrowed or closed (Geissdoerfer et al. 2017). To achieve circularity, a company can apply different strategies, subsumed as R-strategies within a 9R-Framework (Potting et al. 2017). They can be categorised within three supercategories. The first supercategory is the smarter product use or manufacture which can be achieved by making a prod-

uct abundant, intensifying its use or by increasing the efficiency of manufacturing or use of a product. The second supercategory aims to extend the lifespan of products or product parts by reusing still working products or repairing defect ones. If whole parts have to be replaced or even just a few parts can be further used, one can apply the strategy of remanufacturing or refurbishing, and in case of using parts for a different purpose, one is applying repurposing. The last supercategory considers the treatment of products and devices not usable any more, material recycling or incineration for energy recovery (Potting et al. 2017; Kirchherr et al. 2017).

Efficiency strategies form one part of the CE R-strategy concept. The efficiency concept can be divided into resource efficiency and energy efficiency. The basis of efficiency consideration is the ratio of benefit and effort. In this context, benefit is a need that a customer wants to satisfy by purchasing a product or using a service. The effort corresponds to the resources or energy required to produce the product or service. In contrast to other CE strategies, efficiency strategies do not question the benefit of a product or service and the willingness to change it, but aim at minimising the effort required to create the benefit by optimising product design, manufacturing and auxiliary processes or waste management (VDI guideline 4800).

Energy efficiency & SME

There are several benefits and opportunities for SME implementing energy efficiency activities. And there is a large need to realise them and to achieve a substantial reduction in energy consumption as a contribution to climate protection (Kemmler und et al. 2020). While many energy efficiency activities have positive benefit-cost ratios, i. e. reduce life-cycle costs, there is the need to further internalise external costs of climate change into the markets in order to be able to realise even more energy savings in a cost-effective way (Noll und et al. 2021). SME can thus improve their competitiveness by implementing energy efficiency activities. Reduced energy costs, which can be additionally lowered by implementing renewable energies, also mitigate the dependency on volatility of energy prices and on increasing CO₂ prices in the medium to long term. Energy efficiency and energy savings have further multiple benefits (IEA 2014; dena 2015). There can be beneficial side effects like improved efficiency of processes and improved working environment for employees. Moreover, environmental compliance with today's and possible future regulation and green image is strengthened. Finally, firms can promote a green image, which can help to get access to new markets or win new contracts.

BARRIERS AND OBSTACLES

Although often beneficial, a longstanding history of analysis shows that there are various barriers and obstacles that hinder the implementation of energy efficiency measures in SME (cf., e.g., Brüggemann 2005). There are different category systems of barriers and obstacles, e. g. differentiating between information-related, economic, behavioural, organisational and competence-related barriers on the micro and meso level (Neri et al. 2016; cf. also Jalo et al. 2021a; Wohlfarth et al. 2016). Barriers prioritised high in these studies include lack of information or lack of internal competences, lack of skills in identifying opportunities, analysing their cost effective-

ness and tendering, lack of time, lack of financial resources, slim organisation or lack of backing by top management. However, a common denominator of such barriers is the fact that, in contrast to material costs, energy costs usually make only a small percentage of total costs (Statistisches Bundesamt 2022), and thus used to have a lower priority for these firms. Moreover, energy issues are not the core business of most of the SME. A study based on interviews with fourteen manufacturing SME in Sweden, mostly in engineering industry, therefore lists 'other priorities' or 'non-energy related working tasks are prioritized higher' as two of the five highest rated barriers by the firms interviewed (Jalo et al. 2021a; cf. also Wohlfarth et al. 2016). In addition, the economic risk of a longer payback period with high upfront investment, even if the investment results in profitable reduction of life-cycle costs, is still an important barrier to SME. Financially constrained companies do not invest in energy efficiency even if energy audits have been implemented successfully (Jalo et al. 2021b). Lack of governmental support was a barrier ranked high as well. Financial support measures could help to overcome the lack of financial means (Timilsina et al. 2016). Finally, not all energy efficiency investments are economical as long as external costs of climate change are not fully internalised into the market (Wohlfarth et al. 2016).

ANTECEDENTS, DRIVERS AND MODERATORS

There are several influencing factors facilitating or driving the implementation of energy efficiency activities in SME. First, the expectation of further increasing energy and CO₂ prices gives energy efficiency a higher priority. Second, regulation like the EU Ecodesign Directive framework help SME in buying energy-efficient solutions and avoiding technology with high life-cycle costs. Third, recent analysis has shown the importance of contextual factors like the top management's attitude towards climate protection measures, corporate culture or already existing experience by the SME (Eymann und Räber 2013; Neri et al. 2021; Hariyani und Mishra 2022; Hrovatin und et al. 2021). Fourth, firms that are generally more oriented towards innovative technologies and processes would more likely tend to implement energy efficiency activities (Rexhäuser und Löschel 2015).

SUPPORTING MEASURES

Besides such facilitating factors, there is a longstanding history of specific support programmes and services aiming at strengthening energy efficiency in SME. The way policies for SME have to be designed strongly depends on the individual framework conditions and the specific needs and goals of SME in the respective country. There will be no single instrument alone that can overcome all the individual challenges equally well. However, specific types of support have been proven to be successful (Nabitz et al. 2016).

First, there are programmes sensitising and informing SME with regard to the benefits and possibilities and good practice of implementation of energy efficiency activities. These programmes have shown that the personal contact to decision makers (usually the managing directors or technical managers) and docking onto existing challenges and activities of the SME is most successful (Gruber und et al. 2011) for audit programmes.

Second, in several countries, such as Germany, there is already a substantial market for service providers and other agents supporting SME by giving advice and consultation, partly supported by state programmes (cf., e.g., Seefeldt et al. 2020). Some tools exist, e. g. specific technology checks, that help service providers and SME to identify advantageous energy efficiency steps and solutions (cf., e.g., Drivsholm und Maagoe Petersen 2012). Moreover, a systematic energy audit according to EN 16247 helps to reduce the lack of staff awareness, information and competences (Jalo et al. 2021b; Paffard et al. 2021).

Third, financial support programmes have two impacts. They give a signal to the SME that energy-efficient measures could be beneficial, and they mitigate the problem of high upfront investment expenditures (cf., e.g., Wohlfarth et al. 2016). Based on 766 observations, Nabitz et al. (2017) found out that the combination of financial support with the promotion of energy audits would be most effective.

Fourth, in recent years, an active involvement of SME in energy efficiency networks has proven to be a key to a successful implementation of energy efficiency measures (Palm und Backman 2020; Preiß 2021).

AUDITS AND MANAGEMENT SYSTEMS

As already mentioned before, energy audits help companies to overcome the knowledge-related barriers by providing them with useful information on energy saving potentials and how to fulfil them. Such energy audits are often considered as a starting point for a continuous improvement process like it is laid out within management standards like ISO 50001, ISO 14001, or EMAS. However, SME are often too small or just not energy-intensive enough to achieve a positive benefit-cost ratio by the implementation of these management standards. Nevertheless, SME as suppliers or subcontractors in the value chain increasingly have to meet respective requirements set by OEM due to increased market pressure and stronger regulation expected.

MONITORING AND EVALUATION

Monitoring and evaluation is important to measure the output, outcome and impact of energy efficiency programmes targeting SME. While energy savings cannot be exactly measured, their effectiveness can be estimated by standardised energy performance indicators and benchmarks as they are, e.g., explained in ISO 50006 and EN 16231. EN 16212 explains how energy efficiency measures should be evaluated top-down and bottom-up. Moreover, there is a longstanding history of measurement and verification approaches and evaluation guidebooks (cf., e. g., Kristensen und et al. 2001; Schlomann und et al. 2020).

Circular Economy & SME

BENEFITS AND OPPORTUNITIES

There are a number of benefits and opportunities for SME to engage in a CE. Similar to energy efficiency activities, CE activities can help to reduce costs and to mitigate the dependency on price fluctuations in the raw materials sector. New sales markets and customer groups could be opened up by new circular

business models. Moreover, as with energy efficiency, CO₂ is saved in a CE. The less a product needs to be changed during reuse, refurbishment and remanufacturing, and the faster it comes back, the higher the potential savings in the shares of material, labour, energy and capital embedded in the product and the associated backpack of externalities (such as greenhouse gas (GHG) emissions, water, toxicity) (Ellen MacArthur Foundation 2015). Furthermore, SME can expect image gains, business growth and higher productivity when implementing CE activities (Prieto-Sandoval et al. 2018). Finally, environment-friendly SME are likely to have satisfied employees with higher economic performance (Dey et al. 2020).

BARRIERS AND OBSTACLES

Compared to energy efficiency, there is only a short history of analysis on barriers to CE in SME. Dey et al. (2020) conducted a survey on 130 randomly selected SME in the Midlands of the UK. They revealed that SME often are suppliers or subcontractors to OEM and thus often have very little scope to contribute in materials selection and product design, and experience pressure by their OEM in the upstream value chain (Ghisetti und Montresor 2020). Moreover, in contrast to often cost-effective energy efficiency activities, CE activities often are not positively related to economic performance.

In addition, as with energy efficiency, upfront investment is a risk often not accepted to be taken by SME (Ghisetti und Montresor 2020). Lack of governmental support (through the provision of funding, training, effective tax policies, laws and regulations, etc.) is widely recognised as a significant barrier to the uptake of environmental investments. The lack of a concrete, coherent and stringent legal framework often prevents SME from considering the integration of environmentally friendly solutions into their operations (Rizos et al. 2021).

Moreover, in many SME the managing director is the owner of the company and thus has a significant influence on the strategic decisions of the company. Additionally, some of the SME managers responsible or involved in the decision making process play a crucial role in this matter as well. Furthermore, SME owners or managers may have different risk perceptions. Strong risk aversion among managers may hinder the adoption of the CE, even after assessing the benefits associated with its implementation (Rizos et al. 2016).

Common denominators of energy efficiency and CE barriers are lack of information or internal competences and lack of skills in identifying opportunities. While in the field of energy efficiency, these barriers are finally due to lack of energy cost priority, in the field of CE, these barriers are due to just few years of experience with CE.

In addition, conservative attitude of some customers towards recycles slows down the establishment of sustainable, circular product lines. For example, innovative recyclable materials are viewed with a high degree of scepticism and are therefore not accepted in some cases. This would be in line with a certain aversion to innovation and technology in German society (Stiftung Familienunternehmen 2021).

ANTECEDENTS, DRIVERS AND MODERATORS

The introduction of CE measures is driven by company external factors due to changes in the market environment and is linked to the adaptation or re-creation of business models,

which requires company internal factors for implementation. Similar to energy efficiency, external market pressures are driving the adoption of CE measures like an expected increase in customer demand for circular products (Bocken und Geradts 2020). Another aspect to highlight is the existence of political initiatives that promote CE, such as the implementation of the CE Action Plan of the European Union (European Commission 2020).

Furthermore, available corporate resources as well as the corporate strategy are mandatory internal prerequisites. For the introduction of circular business activities, a top management of the SME that is aware of and convinced of the idea of CE is necessary, since CE touches corporate strategy and direction (Popa et al. 2017). The larger a change in the existing business model, the larger the need for resources to be deployed to implement the change. However, SME in particular have very limited resources available. Therefore, an open innovation approach, more precisely an Inbound Open Innovation approach, offers companies the opportunity to internalise and leverage outside knowledge and resources (Gentile-Lüdecke et al. 2020; Hansen und Schmitt 2021). Subsequently, SME that want to implement high-level CE strategies must have a certain degree of openness and dynamic capabilities that enable cross-firm collaborations.

SUPPORTING MEASURES

Compared to energy efficiency, there are currently hardly any financial support programmes for CE besides resource efficiency programmes. Moreover, companies need tools and aids to make the transition to a CE. In this context, some tools and aids have been developed in recent years to master this transition. Stiftung Familienunternehmen has listed the following organisations that offer tools such as platforms and web-based applications: Ellen MacArthur Foundation (Material Circularity Index and Circulytics), WBCSD (Circular Transition Indicators), Cradle to Cradle® NGO (certification), R2Pi (platform with various tools), ResCom (platform with eleven tools), TuDelft (courses on the topic: Circular Product Design Assessment), Self-Check for the Circular Readiness Level® of products and product systems, InChainge (The blue connection) and the Prosperkolleg project (Stiftung Familienunternehmen 2021).

A feasibility study initiated by Handwerkskammer Münster, among others, illustrates the support needed by SME. One of the most important findings of this study was that circular value creation has not yet found much entry into the decision-making and strategy processes in the companies surveyed, and relevant decisions tend to relate to products, but not to management and leadership processes. In this context, 85 % of the SME surveyed consider it necessary to have increased access to improvement strategies in order to be able to operate more circularly in concrete terms. In this context, 40 % of the companies surveyed stated that they felt alone in their intention to transform the company and 60 % stated that they needed external support (HWK 2021).

As the active participation of SME in energy efficiency networks has proven to be a key to the successful implementation of energy efficiency measures, company network approaches can also support SME in the area of CE. Networks can promote the general exchange of information and, for example, bring

different actors along the value chain together (Gandenberger 2021).

AUDIT AND MANAGEMENT SYSTEMS

In order to be able to systematically implement CE-strategies in a company continuously, a CE management approach could be installed (cf. Irrek et al. 2021 for the idea of a CE management scheme). There is no specific standardised CE management system yet, but there are on-going discussions particularly on the international level for a new CE management standard, and on the national level, e. g. in Germany, on integrating CE into existing environmental audit and management approaches like EMAS or ISO 14001. A CE audit could be a good starting point for the implementation of a continuous improvement process. However, standardised CE audit systems for SME are not available yet.

MONITORING AND EVALUATION

To achieve circular transformation targets, Bocken und Geradts (2020) state the urgency of assessing the current state of transformation with well-fitting indicators for both policy and companies. Saidani et al. (2018) describe indicators as enabling factors for CE-performance in terms of “assess[ment], improve[ment], monitor[ing] and communicat[ion]” (p.1). For this reason, discussions regarding appropriate indicators for CE have gained much momentum within the last years and are the subject of an increasing number of research reviews (see, e.g., Saidani et al. 2018; Elia et al. 2017; Kristensen und Mosgaard 2020).

However, the identification of adequate indicators and the development of monitoring and evaluation systems is much more complex than in the field of energy efficiency. While in the field of energy, there is only the type of energy carrier that can differ as input factor, very different materials with complex life-cycle outputs, outcomes and impacts have to be taken into account. Indicators within the methodology of life cycle sustainability assessment can be seen as promising and tested approaches for impact assessments (Valdivia et al. 2011). Other authors as Vanegas et al. (2018) or Franklin-Johnson et al. (2016) consider some indicators that assess an outcome of industrial processes instead of their impact. Therefore, they chose resource duration time and ease of disassembly as appropriate measures for CE. Due to the plurality and multifaceted nature of the CE concept, it has a wide variety of indicators which all are partly able to indicate circular aspects on the levels of input, output, outcome and impact assessment, but there are no generalisable and standardised indicators for CE yet. In order to give a quick insight into the maturity of a CE business model and its improvement potential, Potting et al. (2017) suggest to take the kind of R-strategy implemented as a measure for the level of circularity.

Comparison

The results of the literature review are listed in Table 1, which compares the fields of CE and energy efficiency for SME with respect to its benefits and opportunities, barriers and obstacles, antecedents, drivers and moderators, supporting measures, audit and management systems as well as monitoring and evaluation. As the table shows, there are some differences but also similarities in the area of CE and energy efficiency.

Table 1. Comparison between circularity and energy efficiency aspects for manufacturing SME in Germany.

	Circularity	Energy Efficiency
Benefits and Opportunities		
Mitigating price risks	Lower dependency on volatility of resource prices	Lower dependency on volatility of energy prices
Reduction in supply shortages	Lower dependency on primary resources supply	Lower dependency on energy supply
Net cost savings	Seldomly direct positive net benefits	Often positive benefit-cost ratio
New business models	Several CE strategies might include a change in business model	In general, no change in business model associated
Employment	CE orientation attracts employees with intrinsic motivation and higher performance	Some energy efficiency activities can improve working environment
GHG emissions reductions	Emissions reductions depend on resources and technology used; additional GHG emissions of reverse logistics and rebounds	Direct or indirect emissions reduction depending on energy carriers, technology applied and rebound effects
Barriers and obstacles		
Knowledge and experience	Hardly any CE knowledge or experience, but deep knowledge on core business affected	Already some existing experience; but not core business (lower interest)
Relation to core business	Several CE strategies affect core business or even the whole value chain	Often cross-sectional technology not affecting core business (lower priority)
Investment risks	For several CE strategies, substantial risks have to be taken (new business models)	Short payback periods often required inhibit profitable investments
Antecedents, drivers and moderators		
Market pressure	Growing market pressure (B2C& B2B); material has high share in production costs	Energy market pressure only; energy has just small share in production costs
Regulation	Already some regulation exists; expectation of increase in effective regulation in future	Energy efficiency aspects are subject of several EU and national regulations
Top management	Motivation and backing of top management required, but usually not informed yet	Backing by top management required, but often low interest (not core business)
Innovation capability	Correlation expected between the degree of CE strategy applied and the degree of innovation capability of the firm in general	Correlation between implementation of innovative energy efficiency technology and degree of process innovation
Corporate culture and experience	Contextual factors and an agile and innovative corporate culture important	Contextual factors and an agile and innovative corporate culture helpful
Supporting measures		
Record	Hardly any experience besides support for resource efficiency and waste management	Longstanding experience in political support measures and market services
Information and communication	Personal communication to SME required; some information campaigns on specific R-strategies	Personal communication to SME most successful; several information campaigns
Tools	On-going development of tools	Existing tools (e.g. checks, checklists)
Networks	Hardly any CE networks for SME	Existing energy efficiency networks
Commercial Services	Few existing service providers specialised on the whole set of CE strategies.	Existing service market (advice, contracting or management services)
Financial support	Longstanding support on resource efficiency measures; new additional financial support	Longstanding financial support programmes; continuously improved
Monitoring and evaluation		
Indicators and benchmarks	On-going discussion on adequate circularity indicators and benchmarks	Proven indicators and benchmarks; life-cycle impacts depend on energy carrier
Measurement of savings	Comparability might not be possible due to complex changes in value chain	Energy savings cannot be measured, but proven estimation approaches exist
Standardisation	Requirements for comparability and the mapping of CE are created	Existing measurement and verification standards and evaluation guidebooks
Audits and management systems		
Continuous improvement	Management systems not implemented; kind of CE audit (CE check) as adequate starting point	Hardly any continuous improvement process systematically implemented; energy audits as adequate starting points
Management system standards	Existing ideas for standardisation or integration into ISO 14001 / EMAS	Existing standards ISO 50001, ISO 14001 / EMAS usually not implemented

Prosperkolleg concept for manufacturing SME

The development of support measures, concepts and tools for SME with regard to a CE can learn from the many years of experience in the field of energy efficiency in SME. There are commonalities in terms of benefits and opportunities, barriers and obstacles, precursors, drivers and promoters, monitoring and evaluation, and management. Whether energy efficiency or CE, in both areas it is important to understand the situation of SME, their market situation, motivations and challenges and to address them through face-to-face communication when designing initial impulses, communication, cooperation and networking approaches. This has been confirmed by the Prosperkolleg project's experience with SME (cf. Figure 1).

Since the start of the project, 29 interviews have been conducted with companies on their understanding of a CE. These have confirmed that CE usually is an unwieldy term and that companies have different challenges depending on the industry, business model and customer group. One major difference to the field of energy efficiency is that many circular strategies directly affect the company's core business or even the whole value chain, while many energy efficiency activities are cross-cutting measures that hardly affect the company's central value creation processes. Therefore, for further steps in the development and implementation of CE activities after the initial contact and impulse, the focus of support measures should be on promoting SME readiness and enabling SME to individually identify and implement adequate changes. Since the first step into the large, complex, often opaque subject area of the CE seems to be particularly difficult, the approach developed by the Prosperkolleg project focuses on enabling a low-threshold entry and then approaching the individual potentials of an SME step by step.

As shown in Figure 2, the 'CE Potential Check' includes four steps of approaching SME:

1. An initial discussion to agree on the company's expectations and how to proceed.
2. The application of the Prosperkolleg Circularity Matrix, an Excel tool that functions as a kind of audit and helps to identify the largest CE potentials of a firm in four fields of action: Circular product development, Supply Chains and Purchasing of Recyclable Materials, Resource Efficient Production & Recovery, and Remanufacturing & Product

Service System (cf. Irrek et al. 2021 for an earlier version, based on Konietzko et al. 2020, r2pi project 2021, Evans und Bocken 2014, Vermeulen et al. 2018, Ressourceneffizienz-Zentrum Bayern 2020, Ellen MacArthur Foundation 2015, and Walcher und Leube 2017);

3. The implementation of a CE Workshop, in which the previously identified potentials are analysed and discussed in more detail and concrete steps of implementing CE solutions are derived;
4. Next steps of further cooperation, e.g. with researchers and consultants from the Prosperkolleg network.

Although every SME has to identify its individual CE approach, a firm can benefit from exchange of experience with other companies. Learning from the success of energy efficiency networks, in addition to the CE Potential Check, the Prosperkolleg project has created a company network in which companies exchange ideas.

Moreover, there are some cross-cutting CE issues that can play a role in many SME, for which supporting tools could be developed. For the design and the implementation of such tools, one could learn from experience with energy efficiency cross-sectional technology checks or sector-specific concepts and checklists. As part of a series of expert workshops in the food industry, the Prosperkolleg project has developed and tested an approach for evaluating sustainable food packaging. The evaluation matrix enables a comparison between standard food packaging used in retail and packaging alternatives on the basis of 32 indicators.

Results of first implementation

In order to further develop and test the procedure of the 'CE Potential Check' and to identify concrete CE potentials in SME, the Prosperkolleg project, in close cooperation with the inno-wise GmbH, investigated concrete potentials in four manufacturing companies in NRW. A wide range of instruments was applied in joint workshops with the companies to analyse and develop individual company measures and to initiate their implementation. The tools included a maturity model for gap analysis and a circular business model canvas for developing new business models. The maturity model enables a qualitative and – if the data situation allows – a quantitative assessment of

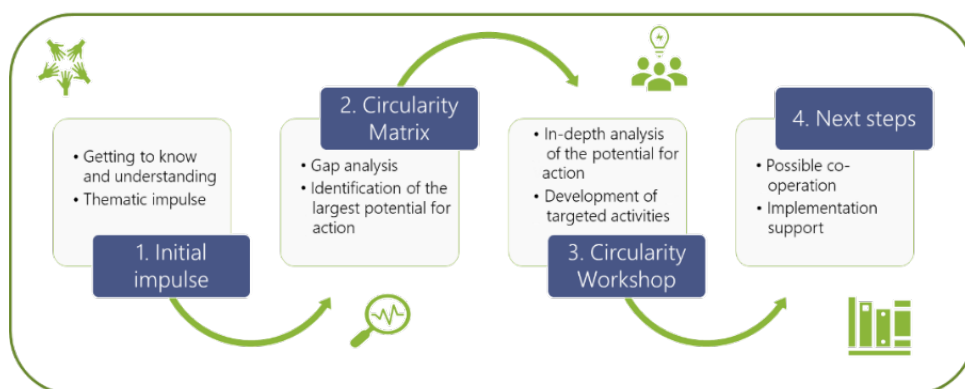


Figure 2. Concept of the 'CE Potential Check' of the Prosperkolleg project.

the status quo, of potentials and of measures in different innovation fields of circular value creation. Based on this, the Circularity Matrix of the 'CE Potential Check' explained before has been further developed.

Two examples of results illustrate that the company workshops can focus on different fields of action depending on the initial situation, position in the value chain and the company's objectives. In one of the companies, the focus was on the procurement of recyclable materials through cooperation with upstream stages of the value chain. Here, concrete product areas were identified and specific procedural standards for initiating and implementing cooperation with suppliers were defined and tested in a pilot area. In parallel, a data structure was set up to record the recycling share of products and make it transparent for those involved. In another company, the focus was on developing a take-back system for its own products in order to recover individual components from returns, process them and bring them back into the manufacturing process as a component of new products.

The study has shown that for the development and implementation of CE activities, the focus of support measures should be on promoting the willingness and ability of SME to implement changes in the company's core value creation processes and beyond, in cooperation with other actors along the entire value chain. In this context, it has turned out to be important to provide an introduction into the CE topic within a face-to-face approach, to analyse individual starting points and to enable the SME themselves to take further steps.

Within the company network established within the Prosperkolleg project as a further mean of support for SME, until March 2022, three meetings have been held, in which (larger) more advanced firms shared their experience. However, the motivation and interest by firms in actively taking part in such a network has turned out to be low so far. One explanation might be that the field of CE is still a comparatively new one for SME, market pressure is still weak and regulative pressure hardly existing so far.

By March 2022, the tool for evaluating food packing, has already been used by 14 companies. The feedback by the companies has shown that cross-sectional tools like this are particularly helpful for SME.

Conclusions and outlook

SME need support in implementing CE measures, as the results so far show. For the development of communication, co-operation and networking approaches, individual support measures, concepts and tools, lessons can be learned from the long-term experience in the field of energy efficiency. In both areas it is important to understand the situation of SME, their market situation, motivations and challenges and to address them through personal communication. A key difference is that many circular strategies directly affect the core business of the company or the whole value chain and therefore depend much more on contextual factors and individual approaches, whereas many energy efficiency activities are cross-cutting ones that hardly touch the company's core value creation processes. Therefore, for the development and implementation of CE support measures, the focus should be on promoting the willingness and ability of SME to implement changes in the company's central value creation processes and in its co-operation along the entire value chain.

In doing so, it should be made easy for SME to take the first steps towards a CE, without being afraid to experiment and rethink their own business processes and to overcome entry barriers to the topic. A face-to-face approach, easy-to-use tools, external impulses and exchange of good practice experience are of great importance.

The Prosperkolleg project has been developing and investigating these impulses in an iterative process. The 'CE Potential Check' is intended to support SME in independently taking the steps towards CE. This approach is continuously tested together with SME. In order to consolidate, deepen and further advance the initial results of the Prosperkolleg project, a quantitative survey of manufacturing companies in NRW will be conducted in summer 2022 on mentality, motivation, challenges and the connection between general innovation orientation and the implementation status of circular value creation strategies.

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