Pathways towards a German Circular Economy

Circular Economy Initiative Deutschland

Lessons from European Strategies
Preliminary Study

Thomas Weber and Martin Stuchtey (Eds.)

acatech
DEUTSCHE AKADEMIE DER TECHNIKWISSENSCHAFTEN

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Preface

The preliminary study „Pathways Towards a German Circular Economy" has been compiled in preparation for the *Circular Economy Initiative Deutschland*. The initiative, carried out under the guidance of acatech – National Academy of Science and Engineering, is funded by the German Federal Ministry of Education and Research (BMBF). The *Circular Economy Initiative Deutschland* aims to initiate a dialogue as to how the economy can be systemically transformed from a linear to a circular model. Various working groups will develop specific approaches for implementing circularity and identify solutions to existing barriers. A further objective of the initiative is to provide more precise estimates of the potential of a Circular Economy in Germany. The insights developed in the initiative will result in a roadmap which outlines a transition pathway for Germany towards a Circular Economy.

In order to set the course for the *Circular Economy Initiative Deutschland* and get it off to the best possible start, the present preliminary study analysed and discussed key conditions for a successful implementation. The preliminary study builds on the experience gained by European countries which have been moving towards a Circular Economy by developing roadmaps or similar Circular Economy strategies. The lessons learned and best practices established by these countries were investigated and evaluated for their applicability to a German context. This preliminary study provides a comprehensive basis for the discussions and analyses planned for the *Circular Economy Initiative Deutschland*.

This groundwork was led by acatech – National Academy of Science and Engineering (Vice-President Thomas Weber and the team in the *Circular Economy Initiative Deutschland* Office) in cooperation with SYSTEMIQ (Martin Stuchtey and the Material-Platform-Team). As an independent, non-profit organization, acatech provides a forum for the scientific, engineering and business communities and society at large to debate future issues of science, engineering and technology policy. In line with its two-pillar model, acatech combines the expertise of prominent scientists from different disciplines with the expert knowledge of representatives of technology companies and associations. Set up as a B Corporation, SYSTEMIQ sees itself as a catalyst for good disruption in critical economic systems with the aim of achieving the Paris Agreement's 1.5-degree target and the UN Sustainable Development Goals. SYSTEMIQ builds and supports coalitions, advises pioneering businesses and policy makers, invests in promising solutions and itself forms companies to fill gaps in the market.

The authors would like to thank Stiftung Mercator and the European Climate Foundation whose funding enabled this preliminary study and who have thus significantly added to an understanding of how a transformation to a Circular Economy can be designed.

Prof. Dr.-Ing. Thomas Weber
Vice-President acatech –
National Academy of Science and Engineering

Prof. Dr. Martin R. Stuchtey
Co-Founder and Managing Partner of SYSTEMIQ

Executive Summary

The European Union and many member states have developed strategic plans for a transition to a resource-efficient economy based on the principles of a Circular Economy. Countries outside Europe, such as China, Japan and Canada, have also been following these guiding principles. There is currently no such plan for Germany.

This preliminary study is a contribution to the growing public debate around a Circular Economy in Germany. Enabled by funding from Stiftung Mercator and the European Climate Foundation, this publication provides the basis for the *Circular Economy Initiative Deutschland* initiated by acatech – National Academy of Science and Engineering – and SYSTEMIQ.

The initiative, which was launched at the beginning of 2019, has a political mandate and funding from the German Federal Ministry of Education and Research (BMBF). It brings together business, science and societal stakeholders with the intention of developing a shared vision for a Circular Economy in Germany, investigating specific applications and supporting their implementation while also identifying conditions favourable to a Circular Economy.

The literature reviews and expert surveys carried out by acatech and SYSTEMIQ consolidate the experience of European countries which have already developed roadmaps or comparable Circular Economy strategies. The resultant insights thus form the basis for the more detailed analyses and discussions within the *Circular Economy Initiative Deutschland*.

A Circular Economy in Germany

The Circular Economy is increasingly perceived as an important concept with which ecological and economic goals can be reconciled. Policy makers, business, science and civil society have, however, only just started a dialogue around its potential. Initial calculations indicate that implementing a Circular Economy has considerable positive potential. In Europe, for instance, it might be possible to cut emissions from material-intensive industries and value chains by up to 50 per cent or to generate net social benefits of 900 billion euro per year by 2030. However, these numbers have not yet been scientifically confirmed.

At the same time, there are also barriers to a successful transformation to circularity. These are encountered at virtually all levels and are often interdependent. They include not only fiscal barriers but also operational and technical challenges at the corporate level.

Assuming that Germany can also benefit from a Circular Economy as a way of reconciling environmental goals with greater productivity, innovative capability, competitiveness and employment, there is a need for action. Germany must use its existing skills and structural strengths to show that decoupling economic growth from resource consumption is a competitive advantage. Compared to some other European countries, discussion of this issue is only just beginning in Germany. It is indeed true that there are major policy instruments providing targeted support for the transition to a Circular Economy, an increasing number of initiatives and stakeholders are addressing the issue and a comprehensive public funding strategy is in place. However, what is still lacking among society as a whole is a joint vision of the transition to a Circular Economy which describes the fundamental motivation for systemic change, links it to existing political goals in other policy areas, and develops a narrative which emphasizes the overarching relevance of a Circular Economy.

This paper is intended to initiate a debate which will lead toward this vision. It develops various proposals as to how this vision can be systematically developed and implemented jointly between all relevant stakeholders. These proposals will then be addressed in greater detail in the *Circular Economy Initiative Deutschland* working groups and the outcomes of the initiative will be synthesized into a Circular Economy Roadmap for Germany.

Circular Economy Strategies in European Countries

A series of European countries have already developed Circular Economy roadmaps and strategies, some of which have been implemented. This preliminary study is based on an analysis of these Circular Economy roadmaps and strategies as well as expert interviews with the relevant political stakeholders.

List of analysed countries/regions:

- Denmark
- Finland
- France
- Italy
- England – London
- Luxembourg
- The Netherlands
- The Netherlands – Friesland
- Portugal
- Scotland
- Slovakia
- Slovenia

The team of authors has summarized the results of the analysis in chapter 4 in the form of 24 essential insights which show:

- The **impetus** for change originated from different parts of society. For instance, in the Netherlands it was the Parliament, in Slovenia a non-profit organization and in Luxembourg individual companies which approached the Ministry of the Economy. At a political level, various ministries, recognizing the cross-sectoral nature of a Circular Economy, often worked together in devising national strategies.

- The **motivation** for the transformation to a Circular Economy is to achieve various national and international goals such as competitiveness, minimized dependency on raw material imports, climate protection, etc. Economic goals are the primary focus here. A Circular Economy is thus not an end in itself but a means for achieving higher-level goals.

- Linking a Circular Economy to higher-level goals has meant that, with the exception of the Netherlands, none of the countries has defined a specific **circularity target**. Within the higher-level goals, the countries did nevertheless use indicators to measure the impact of their actions for fostering a Circular Economy. There is agreement that the **indicators** used are insufficient for measuring the impact of actions which are intended to support a transition to a Circular Economy. Effort is being put into further development, taking account of the EU Monitoring Framework.

- Two **types of strategy** can be identified from an analysis of the countries' strategies. Some are stated in very general terms and aim to create a common understanding of a Circular Economy (inclusive, non-mandatory *approach*). Others examine the effects of various circularity policy levers in detail and derive specific activities and responsibilities (explicit approach). Which strategy is selected depends to a great extent on pre-existing Circular Economy activities.

- Generally, **key themes** were not systematically derived from a science-based analysis of potential and options, but were instead, directed by current **political goals** (e.g. hundred-percent recycling rates for plastics waste in France), **strategic relevance** to the country as a location for industry (e.g. forestry in Finland) or were intended to **harmonize** different national goals with a Circular Economy strategy.

- All countries identified **inclusion in pre-existing activities and a broad stakeholder base** to be vital for generating momentum and making good use of resources. In almost all countries, **businesses** were included not only as drivers but also as the most important target audience. The **scientific** community was primarily included in order to investigate specific issues. Some countries actively included representatives of civil society, for example by means of multi-stakeholder workshops and working groups (France, Slovenia and Luxembourg). While deriving specific strategic conclusions from the processes did prove complicated, it had an educational effect.

- Close **interaction between national and regional governments** played a part in many countries, allowing better account to be taken of regional differences.

- The **measures** defined in the strategies encompass negative and positive economic incentives, regulatory instruments, information tools, education and research. Although a number of measures are already being implemented, it is not yet possible to assess their overall effect.

- Given the impact of a Circular Economy on society as a whole, the **measures are directed at business, science and civil society**. In relation to business, the emphasis is often on providing incentives and promoting networking. The scientific community receives targeted support to investigate issues of relevance to a Circular Economy. The responsibility of consumers, on the other hand, is not addressed at all by many roadmaps (Denmark) while others are very clear about consumer responsibility (Italy and France).

Conclusions for a Circular Economy Initiative in Germany

The analysis of other countries' experience and the major insights obtained provide valuable lessons, highlighted in text boxes in chapter 4, which can help to shape a Circular Economy strategy for Germany. In the concluding chapter 5, the team of authors has taken these insights and the lessons learned from them and set them out in ten propositions which can be viewed as a foundation for further dialogue to develop a German Circular Economy strategy. The ten propositions are shown in figure 1 below.

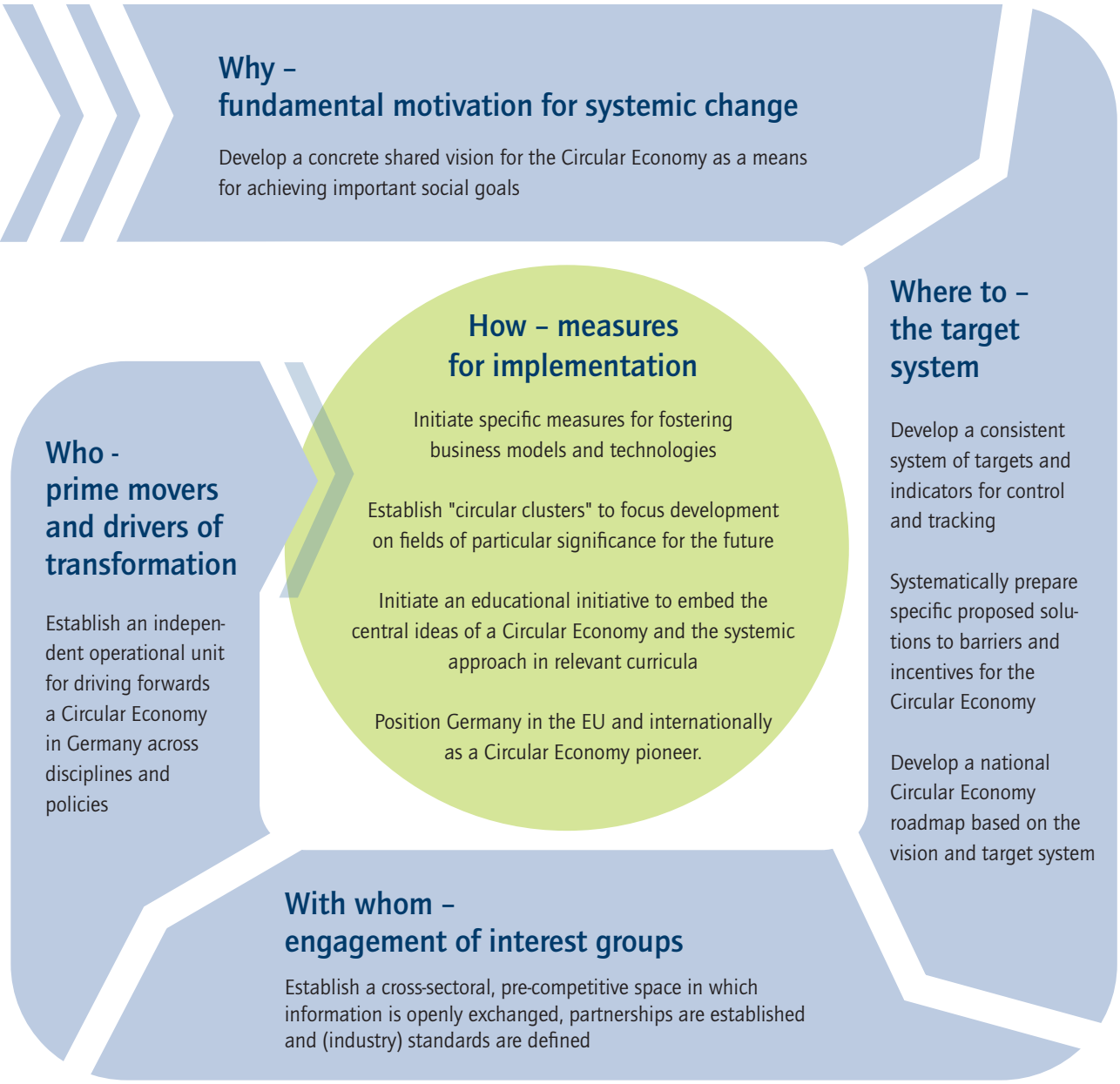

Figure 1: Options for shaping the transition to a Circular Economy in Germany (Source: own presentation).

This preliminary study is a contribution to the growing public debate around a Circular Economy in Germany. Specifically, it will be the starting point for discussions in the *Circular Economy Initiative Deutschland,* which will build on these insights in the course of its work and investigate individual elements in greater detail in the planned working groups. With its political mandate, the initiative will bring together business, science and societal stakeholders to (1) develop a shared vision for Germany, (2) investigate specific applications and support their implementation and (3) identify enabling factors for a Circular Economy. The *Circular Economy Initiative Deutschland* is funded by the German Federal Ministry of Education and Research and is led by acatech in cooperation with SYSTEMIQ.

Project

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- Prof. Dr. Martin Stuchtey, SYSTEMIQ

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- Barbora Bondorová, Ministry of Environment of the Slovak Republic
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- Callum Blackburn, Zero Waste Scotland
- Milan Chrenko, Ministry of Environment of the Slovak Republic
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1 Introduction

A paradigm shift away from a resource-intensive linear economy towards a resource-efficient, productive Circular Economy (CE) is currently under discussion. As an industrial and exporting nation, the stakes are thus high for Germany, because this change would entail a complete reinterpretation of the "Made in Germany" model.

Based on the assumption that a CE can be the key to a resource-productive economy, **this preliminary study,** derived from the experience of other European countries, **offers suggestions for shaping Germany's path towards a** CE. The study therefore starts by outlining the European context and initial situation in Germany (chapters 2 and 3). Building on this foundation, it then analyses relevant activities in other European countries in order to obtain insights for Germany (chapter 4). This analysis was based on interviews, carried out between December 2018 and February 2019, with the ‚architects' of existing roadmaps[1] for EU countries. The key insights from this analysis are summarized in the form of ten propositions which describe essential elements for shaping a transition to a CE (chapter 5).

This **preliminary study provides the knowledge base and basis for discussion for the *Circular Economy Initiative Deutschland***. While the initiative has set itself the goal of providing a thorough analysis of specific issues relevant to the implementation of a CE in Germany, this preliminary study would like at this early stage to give some space to the experiences of other countries. This analysis of the strategies in ten European countries and regions has led to ten propositions for shaping the transition to an optimized CE in Germany.

By involving politics, science, business and civil society, the ***Circular Economy Initiative Deutschland,*** which is funded by the **German Federal Ministry of Education and Research,** would like to initiate a dialogue about how the economic system can be transformed from a linear to a circular model. Various working groups will develop specific approaches for implementing circularity and identify solutions to existing barriers. A further aim is to put more precise figures on the potential for a CE in Germany.

1 | „Roadmapping" is a project management term describing an analytical method which involves analysing, projecting and visualizing the future development pathways of products, services and technologies. Key elements here are the compilation and evaluation of expert knowledge with the aim of deriving specific options for action in the form of a roadmap. In the cases investigated here, the roadmaps describe elements for shaping a transition to a CE.

2 Circular Economy – Decoupling Economic Growth from Resource Consumption

2.1. Need for Action and Concept of a Circular Economy

Ever since the publication of *The Limits to Growth* by the Club of Rome in 1972, there has been a global debate around the extent to which global population growth, increasing affluence and the associated consumption behaviour are compatible with the Earth's limited resources.[2] While the debate was initially limited to the availability of non-renewable resources, its scope has since widened.

It is increasingly being recognized that **human activity is destabilizing the Earth system and as a result "planetary boundaries"[3] may be exceeded.** These changes are apparent from issues such as the distinct increase in pace of climate change,[4, 5] the rapid decline in global biodiversity[6, 7] or rising pressure on the remaining areas of natural land.[8] Scientists are therefore already referring to the "Anthropocene"[9, 10, 11] - a geological era in which humans have a major and sometimes irreversible impact on the geological, atmospheric and biophysical processes of the planet.

The resulting **implications for the productivity of existing value creation systems have not yet been thoroughly investigated** and understood. Nevertheless, supply chains have been interrupted and prices have spiked as a result of extreme weather phenomena, as can be expected to occur as climate change progresses. The acceptable maximum usable quantity of various raw materials is also being called into question, for example leakage of nitrogen and phosphorus from agriculture.

To elaborate the idea of economic activity continuing within planetary boundaries in more detail, scientists, civil society and business are currently developing "science-based targets" for various Earth systems which are vital to sustaining life.[12] At present, these still have a strong climate focus and are directed towards making efforts to reduce greenhouse gases at the business, sector or city level consistent with the Paris Agreement and to limit the rise in global average temperatures to well below two degrees Celsius above preindustrial levels.[13]

At the same time, **human economic activity is having far-reaching effects on the environment and human health**, without necessarily reaching planetary boundaries. For instance, the extraction of metals and minerals for manufacturing often results in severe environmental damage, social upheaval and human rights abuses.[14, 15] Apart from these ethical considerations, it can often make business and economic sense to reduce dependency on critical primary raw materials. Using resource-efficient production processes and business models can accordingly reduce dependency on volatile raw materials markets. This can provide businesses with incentives to manage their use of natural resources more efficiently and to take account of social and environmental impacts.[16]

Solutions to the outlined challenges can take various forms: many are based on the **principle of efficiency,** which has the goal of minimizing the consumption of resources for providing products or services. A key concept here is raw material productivity, which is used as an indicator of the efficiency of a system and expresses the amount of economic output (GDP) per amount of resource consumed.[17]

Efficiency approaches are an important first step towards cutting resource consumption and the associated negative environmental impacts because they reduce the use of resources per unit output. However, more fundamental measures are required, building on the extensive experience in boosting efficiency and productivity. Ultimately, the actual potential of efficiency approaches is limited in the light of rising consumer demand.[18] Moreover, **rebound effects** may prevent efficiency improvements from reducing resource consumption in absolute terms.[19, 20] In addition, while efficiency

2 | See Meadows et al. 1972.
3 | See Rockström et al. 2009.
4 | See IPCC 2014.
5 | See IPCC 2018.
6 | See IPBES 2019.
7 | See WWF 2018.
8 | See Steffen et al. 2015.
9 | See Subcommission on Quaternary Stratigraphy 2019.
10 | See Crutzen 2002.
11 | See Waters et al. 2016.
12 | ee IIASA 2019.
13 | See SBTi 2019.
14 | See Angerer et al. 2016.
15 | See OECD 2019.
16 | See acatech et al. 2017.
17 | See BMUB 2016.
18 | See Allwood et al. 2017.
19 | See IRP 2011.
20 | See IRP 2017.

can mitigate the business risks arising from a dependency on primary materials obtained from volatile global raw materials markets, it cannot completely eliminate them.

To this end, the Circular Economy (CE) concept goes beyond the resource efficiency and productivity approaches and is positioned between pure efficiency approaches and the **schools of thought of sufficiency and post-growth economics.** The latter call for an absolute limit to the use of raw materials and a move away from economic growth.[21] A **CE, in contrast, is a consistency strategy which promotes environmentally sound economic systems** and is based on well-established scientific disciplines such as industrial ecology and ecological economics.[22, 23, 24, 25] It endeavours to minimize negative environmental impact by a qualitative transformation and by closing and slowing resource loops. The implementation of CE practices is accordingly intended to decouple the rate of economic growth from an increase in environmental impact.[26]

In the debate around **decoupling economic output and well-being from resource use and externalities,** a distinction is drawn between relative and absolute decoupling. Relative decoupling occurs if economic growth rises faster than the associated environmental and social consequences. Absolute decoupling does not occur until resource use and externalities decrease while economic growth continues (see Figure 2).[27] In order to meet demand for further economic growth from less prosperous countries, the International Resource Panel (IRP) acknowledges, however, that these countries should still have the opportunity just to pursue relative resource decoupling (although here too plans for appropriate infrastructure should be made with an eye to the future in order to enable subsequent absolute decoupling).[28]

CE approaches can apply in the different stages of a product's life cycle: the choice of material and design should permit durability, remanufacturing and repairability or alternatively biodegradability. The use phase should be intensified and extended. This could for example be achieved by technical products being shared by means of digital services, so substantially boosting utilization, or being completely replaced by digital services. At the end of their service life, the various valuable materials should as far as possible be separated by sorting and disassembly and reprocessed to be put to renewed use.

The **Ellen MacArthur Foundation (EMF)** and the **McKinsey Center for Business and Environment** developed a **conceptual framework for the CE** in 2013. The resultant framework, known as the butterfly diagram (see Figure 3), has struck a strong chord not only in business and civil society but also in political dialogue and is often referred to as a central framework for a CE. Even if this idealized representation cannot be put into practice in this form, this widely used diagram will be used as a reference point for the discussions planned in the context of the *Circular Economy Initiative Deutschland (CEID)*.

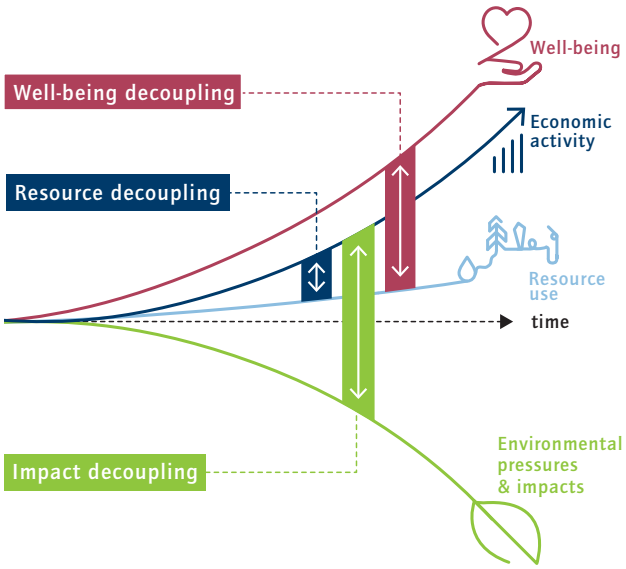


Figure 2: Decoupling concept (Source: IRP, 2019)

On the basis of the cradle-to-cradle approach, the diagram **distinguishes** between the **biosphere and technosphere.**[29] The consumables circulating in the biosphere should be produced from renewable natural raw materials which cause no harm when returned to the environment. The durables circulating in the technosphere, in contrast, are of synthetic or inorganic origin and should accordingly be kept within a closed loop. According to this idealized concept, the intention is to minimize leakage and negative externalities by paying greater attention to making productive use of resources along the value chain and endeavouring, as far as possible, to close loops. Foodstuffs packaging is one example which reveals the advantage of drawing this distinction because in this case large quantities of packaging material and additives often limit closed-loop circulation of food waste.[30] At the same time, it should be noted that in practice it is not possible to draw an absolute distinction between the two cycles. Examples

21 | See Paech 2012.
22 | See Huber 2000.
23 | See Schmidt 2008.
24 | See Bruel et al. 2018.
25 | See Ghisellini et al. 2016.
26 | See IRP 2018.
27 | See IRP 2019.
28 | See IRP 2017.
29 | See Ellen MacArthur Foundation 2013.
30 | See Ellen MacArthur Foundation 2019.

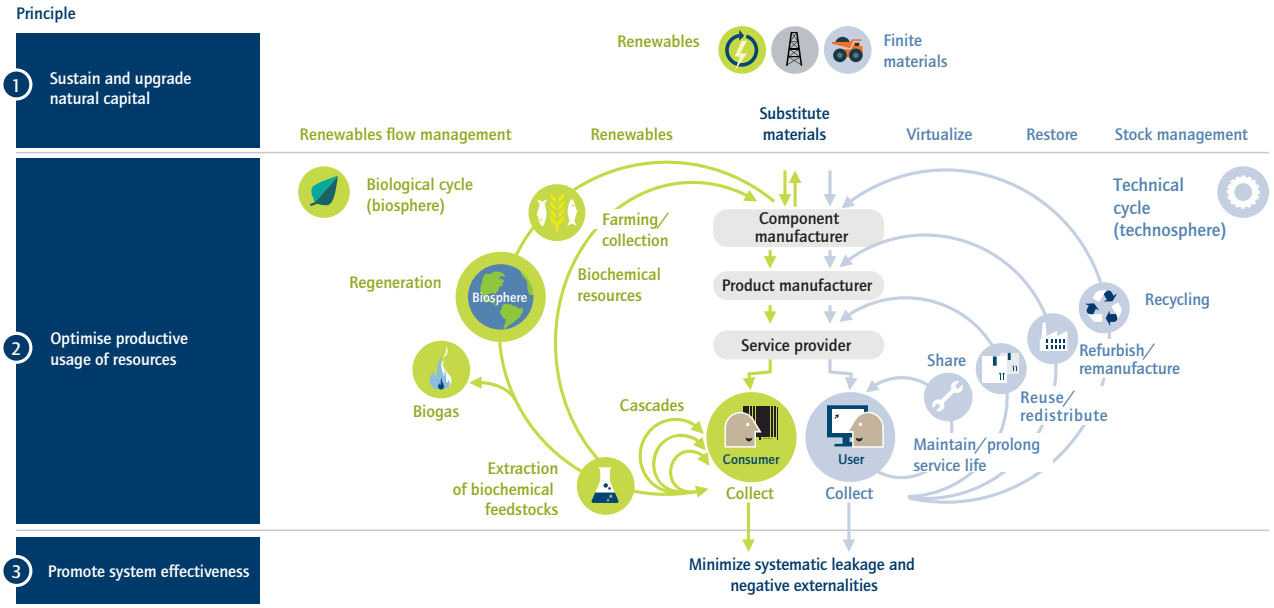


Figure 3: Diagram of separate biological and technical loops and cascading use.
The diagram serves as a reference point for the discussions planned in the context of the CEID to develop a conceptual framework for the Circular Economy (Source: own presentation based on Ellen MacArthur Foundation and McKinsey, 2013)

which might be mentioned are, on the one hand, biopolymers which are not biodegradable and, on the other, synthetic fertilizers: in both cases an exchange of substances occurs between biosphere and technosphere.

With a view to the implementation of a CE, the EMF and the McKinsey Center for Business and Environment developed the ReSOLVE framework which identifies and describes examples of individual levers (see figure 4) including: making increased use of renewable resources or replacing materials with resource-efficient alternatives, better utilization of products by the "sharing economy", optimizing processes, largely closing material and product loops and dematerializing processes and products by virtualization (e.g. the digital twin in manufacturing processes).[31, 32]

This should enable the CE to create the conditions for the types of decoupling envisaged by the IRP: impact decoupling by requiring biodegradability of materials which return to ecosystems (Re); resource decoupling by intensifying use and, ultimately, reusing-materials (SOL); and well-being decoupling by requiring dematerialized forms of meeting demand (VE).

A number of these **ReSOLVE levers are reflected in existing strategies** which have been identified for example in the context of the Resource Efficiency Programme ProgRess II from the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.[33] However, increasing significance is being attached to the role of innovative business models and digital technologies, in particular in relation to the comprehensive implementation of the levers such as "Exchange" (e.g. for product-service business models)[34] or "Virtualize" (e.g. for collaboration in digital platforms).[35, 36] Accordingly, particular attention is paid to these aspects in the German Federal Ministry of Education and Research's newly established "resource-efficient circular economy" research plan[37], with two of its research priorities being focused on business models and digital technologies. Taken together, these developments help to develop a systemic view of resource use and to broaden the understanding of the term "closed-loop resource management" which, at least in Germany, is often viewed in narrow terms just to mean recycling.

31 | See Material Economics 2018.
32 | See Wang/Wang 2018.
33 | See BMUB 2016.
34 | See Antikainen et al. 2018.
35 | See Michelini et al. 2018.
36 | See Pagoropoulos et al. 2017.

REGENERATE	Approach: using renewable resources Greater inclusion of biological cycles in production Advantage: natural capital and ecosystems maintained, dependency reduced
SHARE	Approach: expanding user group for products and assets Creation of greater incentives for durability, preventive maintenance, updatability Advantage: greater utilization of the materials and value used in goods
OPTIMIZE	Approach: reducing waste in production and logistics, increasing energy/material efficiency "Conventional" improvement processes, Industry 4.0 has major potential for growth Advantage: greater material efficiency and reduced costs
LOOP	Approach: designing materials, components and products to be recyclable Optimization of technical cycle in design, production, use and logistics Advantage: minimal loss of material value
VIRTUALIZE	Approach: replacing physical products and processes by digitalization and virtualization Possible application in planning processes, media and communications, etc. Advantage: lower material requirements
EXCHANGE	Approach: replacing materials and technologies by resource-efficient alternatives Redefinition of products as services, use of remanufacturable materials Advantage: increased raw material productivity, continuous loops enabled

Figure 4: ReSOLVE levers of the Circular Economy (Regenerate, Share, Optimize, Loop, Virtualize, Exchange) (Source: own presentation based on Ellen MacArthur Foundation and McKinsey 2013)

The following **limitations of the presented CE concepts and implementation strategies** should be taken into account when considering the implementation of a CE. In thermodynamic terms, completely closed-loop circulation of natural raw materials will be fundamentally impossible. Firstly, it is virtually impossible to locate all every last bit of a raw material to be recycled and feed it into the recycling process and, secondly, any process requires additional energy, the generation of which in turn results in externalities. In addition, extracting secondary raw materials, if they are present in low concentration, may be costlier in economic and energy terms than primary extraction.[38, 39, 40]

Moreover, **countervailing effects** must also be considered **when implementing CE principles**. For instance, the expansion of digital technologies can result in rising demand, higher energy and resource consumption and disposal problems in the form of electrical waste.[41, 42] Even within a CE, strategies may be antagonistic: product modularity and dismantlability may conflict with extending service life and may tend to increase resource requirements. A careful evaluation of raw material requirements, performance requirements and externalities is thus required at each stage of the value chain.

A conclusive and precise definition of a CE cannot at present be provided, since the field is broad and fragmented.[43] High-profile proponents of a CE include Michael Braungart and William McDonough, who have been promoting the cradle-to-cradle principle (which focuses more strongly on chemical toxicology and product design) since the late nineties[44], the Ellen MacArthur Foundation[45] in an international context and the European Union since the recent launch of the Circular Economy Package.[46] In order to ensure conceptual continuity, this preliminary study is therefore based on these approaches and uses the term CE. A sensible first step and contribution by the *CEID* would nevertheless appear to be to discuss and clarify terminology. In addition to assisting with a productive dialogue regarding the development of specific measures towards a CE, a further *CEID* task will be to identify specific aims and corresponding indicators[47] for evaluating effectiveness and progress.

Finally, it must be emphasized that a **CE is not an end in itself**. It is a concept which provides an organizing principle and vision for economic activity because it allows various challenges to be tackled. Goals can be of environmental (climate protection and resource conservation), economic (competitiveness, independence

37 | See BMBF 2018a.
38 | See Allwood 2014.
39 | See Korhonen et al. 2018.
40 | See Wellmer/Becker-Platen 2001.
41 | See Hilty 2008.
42 | See WBGU 2019.
43 | See Kirchherr et al. 2017.
44 | See Braungart/McDonough 2002.
45 | See CIRAIG 2015.
46 | See European Commission 2015.
47 | See for example Moraga et al. 2019.

from raw material imports) or social (employment, local value creation) nature. Sometimes, prioritization between the goals is required. The CE concept can nevertheless help to achieve some of the UN Sustainable Development Goals and create synergies between some of the goals.[48]

2.2 Development of a Circular Economy in Europe

The **public and political debate around the Circular Economy (CE) in the EU primarily originated from the further development of waste management** in the eighties and nineties. The aim was to improve environmental protection and human health. The introduction of a broader "polluter pays" principle (extended producer responsibility) in the early nineties was intended to inspire improved waste management; mandatory waste sorting and regulation of landfilling were intended to improve recyclability and reduce the waste sector's climate footprint.[49, 50]

In the early noughties, the EU addressed two particularly critical elements of the waste management sector with the End-of-Life-Vehicles Directive and the E-Waste Directive which in particular took account of the impact of material flows arising from global exports.[51] Finally, in 2008, the EU Waste Directive smoothed the way to EU-wide harmonization of waste and recyclables management. All these regulations were reformed by the 2015 Circular Economy Package.[52]

From 2010 onwards, **contributions to the debate from civil society** added momentum to the further development of CE, both conceptually and in implementation terms. One central contribution is the establishment of the Ellen MacArthur Foundation (EMF) in 2010. With the publication of the *Towards a Circular Economy* report in 2013, based on the analytical and conceptual work of the McKinsey Center for Business and Environment, EMF brought major contemporary schools of thought such as the performance economy, cradle-to-cradle, biomimicry, industrial ecology and renewable design together under the new, systemic CE approach. While the EMF is commonly viewed globally to be the prime mover behind the modern concept of a CE and to lead the world in its commitment to this approach[53], other economic and civil society organizations are now also driving the CE forwards, for instance the World Economic Forum[54], the World Wide Fund for Nature (WWF) [55], the Organisation for Economic Co-operation and Development (OECD)[56] or the United Nations Environment Programme (UNEP)[57].

In addition to the mentioned publications, from 2010 onwards two consultation processes were carried out within the **EU institutions.** These were initiated by the EU Environment Commissioner at that time, Janez Poto nik. Consultation involved various EU Directorates General, economic players, unions and further interest groups. The participation of a total of 1,500 individuals and institutions in the first consultation revealed the great interest and central relevance of the issue at a European level.[58]

The issue has been firmly politically rooted in the European Union since the publication of the action plan **Closing the Loop – an EU Action Plan for the Circular Economy** in 2015. The Circular Economy Action Plan is the conclusion of the second consultation which was introduced by the then Vice-President of the EU Commission Frans Timmermans[59] and was strongly supported by industry and many EU Member States.

It sets out the objectives of a CE and implementation measures intended to accelerate Europe's transition to a CE while simultaneously strengthening competitiveness and creating economic growth and jobs.[60] It is thus a consistent further development of the original CE activities during the nineties and early noughties. Financial support for this transition is provided by various EU funding mechanisms, including the European Structural and Investment Fund, Horizon 2020, the European Fund for Strategic Investments and the LIFE Programme. The Circular Economy Action Plan explicitly requires close cooperation between Member States, regions and local authorities, companies, research institutions, citizens and other stakeholders in CE.[61]

The **Circular Economy Package** has since served as a framework for further measures, such as most recently in 2018 for the Monitoring Framework for the Circular Economy and EU Strategy for Plastics in the Circular Economy packages. The Circular Economy Action Plan and the legislative package are increasingly putting in place the systemic view which is often viewed as the cornerstone of a CE.[62]

48 | See Schroeder et al. 2018.
49 | See EPRS/Bourguignon 2016.
50 | See CIRAIG 2015.
51 | See European Commission 2005.
52 | See Kauffmann/Dodick 2017.
53 | See CIRAIG 2015.
54 | See WEF 2019.
55 | See WWF 2017.
56 | See OECD 2018.
57 | See UNEP and IRP 2018.
58 | See Potočnik 2018. Personal correspondence.
59 | See Vella, 2015.
60 | See European Commission 2015.
61 | See ibid.
62 | See Kirchherr et al. 2017.

2.3 Potential for an Ambitious Transformation Based on Circular Principles

Proponents of a Circular Economy (CE) approach view the corresponding transformation of economic thinking and structures to be a major step towards achieving the above-described economic, environmental and societal goals. For instance, the fundamental principles of a CE can directly and indirectly lead to **reduced natural capital costs and emission reductions.** For example, in many cases the consumption of water (as natural capital) is much lower for the production of one tonne of secondary raw materials from recycled material than for the extraction of primary raw materials – approximately by a factor of up to 7.5 for magnesium and a factor of up to 20 for cobalt. Moreover, at present, less energy need also on average be used – up to approximately 23 times less for magnesium and 15 times less for cobalt.[63, 64] According to some calculations, consistently applying CE principles in line with the ReSOLVE framework in material-intensive industries and value chains may cut emissions by up to 56 per cent.[65] The CE's large climate protection potential is increasingly being acknowledged, for instance in the European Commission's long-term climate protection strategy published in late 2018.[66]

The **effect on the natural capital water** is revealed *inter alia* by drinking water prices. According to the German Environment Agency, prices could rise by up to 45 per cent primarily due to nutrient loads from agriculture.[67] A CE can also reduce health costs, for instance due to lower fine particulate pollution by atmospheric ammonia emissions, 45 per cent of which are still attributed to agriculture in Germany. Both challenges could often be distinctly reduced for instance by improved handling of animal slurry or optimized fertilizer use, both of which are measures advocated in the context of a CE.[68] A CE also holds great potential for avoiding health costs arising from pesticide use: estimates from the Ellen MacArthur Foundation (EMF), suggest that consumption changes in cities alone could generate global cost reductions of 550 billion dollars per year.[69]

In addition to potential savings, a CE also offers significant **potential for innovation and growth**. Classic areas of closed-loop resource management such as environmental technology and resource efficiency, which will also in future be core elements of a CE, are of particular interest here. According to the Roland Berger business consultancy, in 2016 the market volume for the use of environmental and efficiency technologies for products, processes and services (including renewable energy sources and sustainable mobility) was 350 billion euro in Germany alone and over three trillion euro worldwide.[70] Furthermore, these "green future markets" are forecast to see annual market growth of 6.9 per cent in the period to 2025.

According to the EMF, the potential for growth and innovation could give rise to profitable investment opportunities of 320 billion euro for Europe in the period to 2030.[71] A major part of these earnings would be enabled or boosted by digital business models, for instance due to the expansion of "Mobility as a Service" in the mobility sector.

Macroeconomic assessments from the OECD support these analyses: the great majority of studies evaluating the macroeconomic effects of a CE identify positive, or at least neutral, economic effects with a simultaneous reduction in the use of primary raw materials and thus an improved total-cost calculation towards a net-positive economy.[72] On the basis of a study from Cambridge Econometrics, even a distinct increase in raw material productivity of up to 2.5 per cent per year to 2030 would have a net-positive impact on EU 28 gross domestic product.[73]

In addition to the first quantitative assessments of the potential of a CE, its implementation can also **address existing opportunities or challenges in other areas**. Although this kind of potential can still only be described in qualitative terms, it can contribute to strengthening Germany's competitiveness. An example: numerous new CE business models are very compatible with other central developments in climate protection or digitalization and will thus in future probably experience large global demand. The potential of digital solutions is magnified by reduced costs for data collection and processing and for transactions, and enables new processes and business models which were previously impossible or uneconomic in this form (e.g. material passports for tracking raw materials). There is thus strong synergy between a CE and digitalization, the latter already being a recognized driver of growth, as is apparent from the high market capitalization of companies with digital business models.

At the same time, a **CE can reduce dependency on imported primary materials.** Since an ever smaller number of countries and companies are in control of ever greater proportions of sup-

63 | See European Commission 2018a.
64 | See SYSTEMIQ, own analysis 2019.
65 | See Material Economics 2018.
66 | See European Commission 2018b.
67 | See UBA 2017a.
68 | See Max-Planck-Institut für Chemie 2019.
69 | See Ellen MacArthur Foundation 2019.
70 | See BMU 2018a.
71 | See Ellen MacArthur Foundation et al. 2017.
72 | See McCarthy et al. 2018.
73 | See Cambridge Econometrics 2014.

plies of critical raw materials, a dependency on imports is associated with geopolitical risks.[74] Fluctuations in the market availability of primary raw materials can, as a result of abrupt and extreme spikes in prices, have negative effects which can go as far as supply bottlenecks. The market for cobalt is one example of a monopolized raw materials market with over 55 per cent of the world's cobalt output originating from the Democratic Republic of the Congo. China is furthermore investing massively in cobalt projects and holds over 50 per cent of the world's further processing capacity, the refineries. The price for cobalt has risen by 200 per cent since 2016 and a forecast supply shortage is expected to cause further price increases from 2020 onwards.[75] The resultant economic risks can be significant in particular for high-tech industries. While technologies for recovering cobalt salts do already exist,[76] just the collection of used products generally involves major losses and high-quality recovery is technically complex and costly due to the process used. Good logistical systems for returning used devices and laws which promote recycling together with intensive research for alternatives can make Europe independent of cobalt imports.[77]

The UN International Resource Panel (IRP) has shown that a **CE also has the potential to have positive effects on labour markets**. Reprocessing activities are often not only relatively labour-intensive but are also frequently tied to a locality and so relatively well protected from the consequences of globalization. And, not least, they generally require complex, flexible skills and are thus more difficult to automate[78]. A study commissioned by the European Commission forecast the creation of up to two million additional jobs due to the implementation of ambitious measures for increasing raw material productivity.[79] Some features of a CE thus have the potential at least partially to offset some of the changes to the labour market concomitant with automation and globalized markets and so mitigate the associated concerns and political consequences.

The potential of a CE which has so far been quantified can be viewed as a framework of incentives to encourage a turnaround in thinking and action. This is backed up by various kinds of CE potential which have been qualitatively described and are in principle capable of contributing to Germany's competitiveness and to achieving Sustainable Development Goals (SDGs) (such as SDG 6 – Clean Water and Sanitation, SDG 7 – Affordable and Clean Energy, SDG 8 – Decent Work and Economic Growth, SDG 12 – Responsible Consumption and Production, SDG 15 – Life on Land).[80] All in all, there are many indications that there could be many and varied advantages to applying a CE in Germany. However, as the following sub-heading explains, there are also many barriers standing in the way of a CE.

2.4 Barriers to a Circular Economy

Transformation to a Circular Economy (CE) requires disruptive change and radical innovation because it often also entails new business models and product design. This raises many and varied challenges for practical implementation. The structure set out below (cognition, culture, knowledge, regulations and standards, market, finance, technology and business operation) is drawn from general innovation theory and relevant literature about the barriers to a CE.[81, 82, 83, 84]

Figure 5 is a conceptual presentation of the various analytical levels. The innermost part of the diagram shows barriers at the microlevel, such as for example limiting technology. These can be overcome at the corporate level. The further out a category is located, the more stakeholders it involves and the more difficult it is for a company to have any direct effect on the obstacles.[85] There are also cognitive obstacles which act on individuals at all levels.

The generic **list of barriers within the categories is a major simplification,** since the barriers interrelate and in some cases are mutually dependent. For example, the relatively high taxation of labour in contrast with resources (obstacle in regulations and standards) results in high costs for remanufacturing and repairing products (obstacle in finance) and thus leads to low customer acceptance if the additional costs are reflected in higher prices (obstacle in market).

Some obstacles are addressed below **by way of example.**

Numerous **technical challenges,** both for the design of production processes and remanufacturing and of the products themselves, stand in the way of a CE. Product design should accordingly as far as possible take account of repairability and complete separability of the constituent materials, which is a challenge for complex products such as electronic devices.[86, 87, 88, 89] Furthermore, there is often a conflict in goals between technical possibilities,

74 | See Angerer et al. 2016.
75 | See NPE 2018.
76 | See Hagelüken 2018.
77 | See Angerer et al. 2016.
78 | See Nasr et al. 2018.
79 | See European Commission et al. 2014.
80 | See Schroeder et al. 2018.
81 | See de Jesus/Mendonça 2018.
82 | See Pheifer 2017.
83 | See Ritzén/Sandström 2017.
84 | See Kirchherr et al. 2018.
85 | Based on a presentation by Kirchherr et al. 2018.

economic viability, environmental factors (e.g. energy input) and quality requirements.[90, 91, 92, 93]

The implementation of CE business models means that **operational structures** within and between companies must change and new capabilities be established. This requires resources, expertise and broad acceptance by staff. This is a major challenge, in particular for established companies, since it is accompanied by changes to organizational structures.[94, 95, 96]

The **financial evaluation of CE business models** is often too conservative, since conventional valuation and risk models and operational financing indicators are incapable of modelling central concepts of CE business models. For example, current business model valuation methods are generally based on conventional data points such as fixed assets which are reflected in indicators such as Return on Capital Employed (ROCE). It can be assumed for CE business models that corporate value will no longer be generated, or at least to a lesser extent, via the fixed assets. Current valuation indicators would thus also not reflect the corporate value of a CE business model. The valuation of CE business models thus entails an approach to valuation which is more strongly based on cash flow than on market value. [97, 98]

Low user acceptance is an **obstacle in the market category.** Lack of demand for circular products and services means there is no incentive for a company to develop them.[99]

Each stakeholder involved in value creation must make their own contribution to a transformation to a CE, which means that conflicts of interest between companies must be overcome. For example, the party redesigning a **product** in line with circular principles often does not gain the direct benefit. Some way of transferring value must thus be created.[100, 101]

Current **regulations and standards** provide inadequate incentives for circularity. From a CE standpoint, it is a fiscal policy mistake to apply high taxation to labour and low taxation to resources. Applying low taxation to resources encourages overconsumption, while high wage taxation is a disadvantage for labour-intensive business models such as repairs.[102, 103] Taxation of individual resources has been a repeated subject of discussion since as long ago as the nineties.[104] In addition, there is a lack of purely regulatory provisions from legislators, definitions and standards for enabling closed-loop circulation.

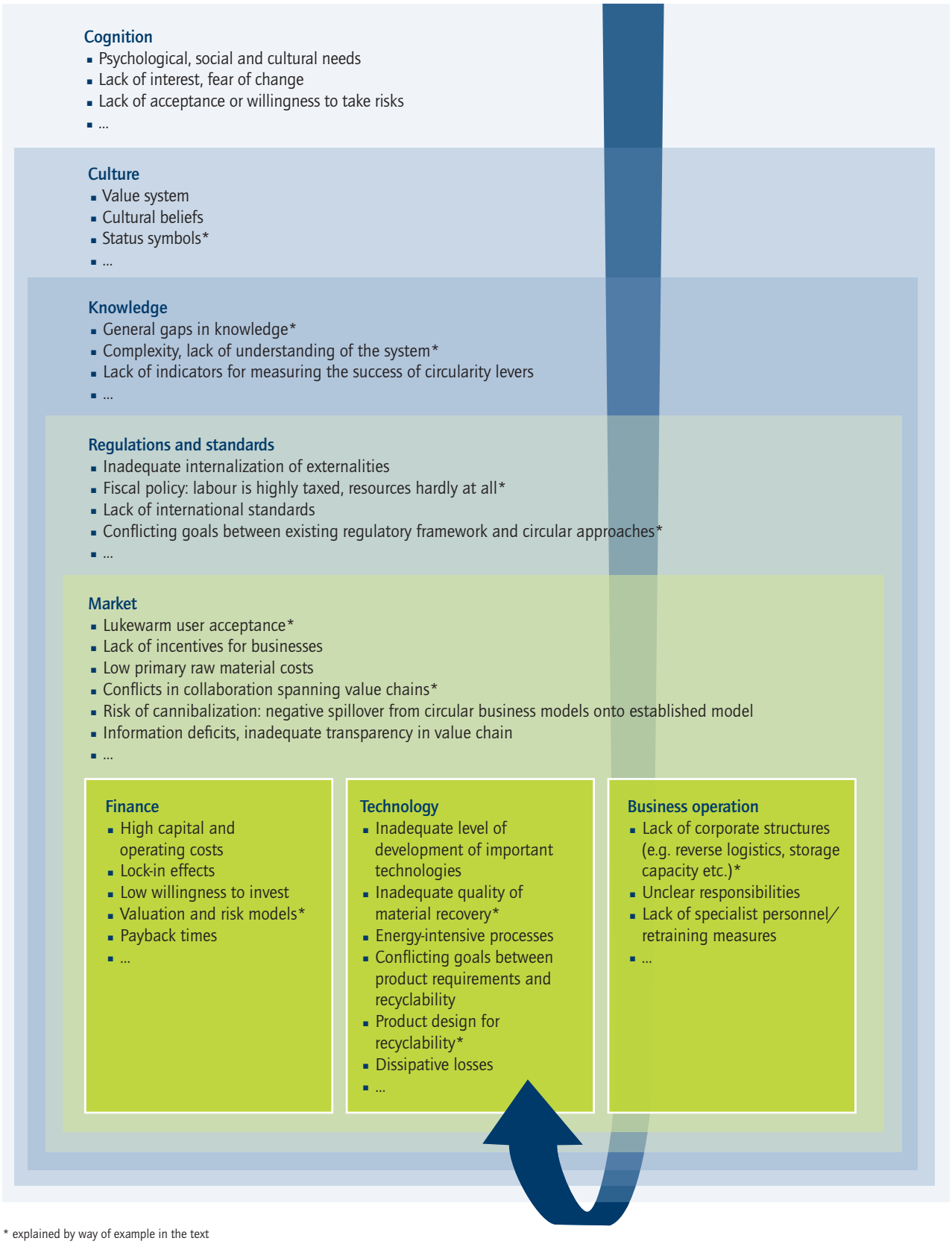
Regulations at the product or material level can also inhibit a CE, for example, if conflicting values are to be protected. One such example is the strict hygiene regulations in the packaging sector and the goal of increasing the use of secondary raw materials. Identifying and resolving these conflicts while weighing up sometimes contradictory goals is often very complex as they are many and varied and can rarely be conclusively delimited.[105]

Outside the legislative framework too, there is in many cases an absence of widely accepted (industrial) standards which enable reliable application of CE business models, in particular across sectors. For instance, there are thus far no generally applicable standards for fertilizers and soil improvers obtained from biowaste, despite suggestions by organizations such as the European Compost Network.[106]

There are **many gaps in knowledge** about the CE concept in theory and in practice and existing knowledge is insufficiently widely known in society. Given the complexity of the CE approach, many levers for optimization and interdependencies are yet to be discovered or have not been adequately investigated. In addition, until knowledge about the CE approach is more widely disseminated in society, there will be no improvement in system conditions and theoretical discussions will not be put into practice.[107]

Status symbols are a strong **cultural barrier** to a CE.[108] There must therefore be a shift in values towards sustainable consumption patterns which are compatible with a sharing economy and are accompanied by a new understanding of quality (in which "new" does not necessarily equate to quality). There are also very simple examples of cultural barriers: at least in Germany, separating rubbish is a fact of everyday life and is already fairly deeply

86 | See Bakker et al. 2014.
87 | See Wilts/von Gries 2017.
88 | See Sawanishi et al. 2015.
89 | See Du et al. 2012.
90 | See Allwood 2014.
91 | See Dobos/Richter 2006.
92 | See Peters et al. 2018.
93 | See Fennemann et al. 2017.
94 | See Ritzén/Sandström 2017.
95 | See March 1991.
96 | See Amit/Zott 2010.
97 | See Hieminga 2015.
98 | See FinanCE 2016.
99 | See LE Europe et al. 2018.
100 | See Vanner et al. 2014.
101 | See Ritzén/Sandström 2017.
102 | See Vanner et al. 2014.
103 | See Ex'tax Project et al. 2016.
104 | See acatech et al. 2017.
105 | See Technopolis Group et al. 2016.
106 | See ECN 2015.
107 | See Stahel 2016.
108 | See Hood 2016.



* explained by way of example in the text

Figure 5: Obstacles to the transformation to a CE, own analysis (Source: own presentation based on Kirchherr 2018)

rooted in the culture. Old electrical devices, however, still linger for years untouched in drawers despite containing valuable materials for reuse.[109]

A systemic transformation towards a CE holds many and varied challenges which apply on numerous different levels. Not only within Germany, these range from cognitive barriers among consumers through operational barriers in businesses to regulatory barriers at the macroeconomic level. There are also obstacles within international trading networks, such as the lack of standards, which cannot be addressed by domestic businesses or the government acting alone. This chapter has addressed existing barriers by way of example and described them in the light of the regulatory framework in Germany in order to provide an initial overview of the range of these obstacles. A more in-depth assessment of the most significant obstacles, their effects on one another and of the issues involved in overcoming them will be carried out in the course of the *Circular Economy Initiative Deutschland (CEID)*.

2.5 Synopsis

Chapter 2 of this preliminary study has provided an overview of the major challenges such as climate change, biodiversity loss and land use associated with the current linear economic system. These challenges are now so wide-ranging that they are also raising questions about the future handling of natural resources at the corporate level.

A comprehensively thought-out Circular Economy (CE) which builds on previous efficiency and recycling approaches and combines them with the necessary systemic changes regarding design and use of materials and products, can offer a response to these challenges. For instance, lower consumption of primary raw materials can curtail the negative externalities associated with extracting and producing the raw materials and reduce dependency on imports. Applying circular principles to the agricultural sector could likewise help to cut the health costs arising from the widespread use of fertilizers and pesticides. Ultimately, a transition to a CE has extensive potential for innovation and growth, much of which will arise from the use of new digital technologies and materials. However, as with any kind of innovation, and most particularly in the context of a CE, attention must always be paid to its systemic effects in order to guard against any possible negative effects, externalities, rebound effects etc.

Despite this extensive potential, a transition to a CE faces numerous obstacles which can be cognitive, cultural, regulatory, financial or operational. In addition, the profusion of different definitions of a CE makes it difficult to state clear goals for its implementation and to identify indicators for measuring the effectiveness of any measures which are taken. These challenges will be discussed in greater depth in the *Circular Economy Initiative Deutschland (CEID)*.

The information compiled in this chapter provides an initial overview of the individual elements of the debate around a CE. Against this background, the following chapter focuses on the situation in Germany and throws some light on the significance and potential a CE can offer to Germany.

109 | See Totzauer 2016.

3 Looking Inwards: The Significance of a Circular Economy for Germany

Chapter 2 has described how moving more strongly towards a Circular Economy (CE) can bring about economic, environmental and social advantages. In addition to the economic potential arising from the application of circular business models and a suitable regulatory framework, a CE can also make a positive contribution to the environmental challenges which Germany currently faces.

Resource consumption in Germany is at present still far above an environmentally compatible level. Depending on the reference source, annual raw material consumption (RMC) for 2010 is stated to be around 15.3 tonnes.[110] Almost half of this is accounted for by non-metallic minerals, one third by fossil energy carriers and about one fifth by biomass. If the materials influenced but not directly used worldwide for consumption (such as mining overburden) are included, total material consumption (TMC) came to 43 tonnes in 2010.[111] This is in contrast to the 5.6[112] to 10[113] tonnes per year which scientists consider to be sustainable.[114]

Each German citizen moreover requires an area equivalent to five hectares for his/her consumption which is almost three times the average available biocapacity[115]. These existing challenges are also part of the reason why Germany will not achieve the goal it set itself in 2002 in the context of the National Sustainable Development Strategy[116]. Instead of doubling raw material productivity over the period from 1994 to 2020 as planned, progress of just 48.8 per cent was achieved up until 2014 (see also "CE indicators" text box, page 30 ff.).[117]

The climate policy targets which have been set are also likely to be missed. At present, Germans have an average footprint of 9.6 tonnes CO_2 per year, which is twice the international average. Meeting a two-degree target by 2100 would mean reducing the global average to below two tonnes per capita per year.[118] According to the Paris Climate Agreement, Germany should largely achieve greenhouse gas neutrality by 2050. Germany therefore set out to cut its greenhouse gas emissions by at least 40 per cent by 2020 and by 55 per cent by 2030 over the reference year 1990.[119] At current levels of effort, Germany will fail to meet its self-imposed, short-term targets.[120]

Over and above these self-imposed commitments, Germany is obliged under the EU's Effort Sharing Decision to reduce greenhouse gas emissions by up to 14 per cent by 2020 in comparison with 2005 (in the sectors transport, construction, agriculture and some parts of industry which are not covered by EU emissions trading). From 2020, Germany is likely to face costs for the first time in this context since it is likely to miss these targets and will most probably have to offset by purchasing emission rights. The think-tanks Agora Energiewende and Agora Verkehrswende estimate the costs at up to two billion euro. Unless Germany implements some decisive climate protection measures, the 2030 targets set under the EU Climate Action Regulation are already calculated to result in a burden on the German budget of 30 to 60 billion euro.[121]

Implementing CE principles could thus contribute to stronger resource conservation and climate protection and is therefore also being discussed in existing German and international climate protection initiatives.[122, 123, 124] So how are things looking for a CE in Germany?

The Legacy of Germany's Pioneering Role

Germany took the first significant steps towards a CE in the context of closed-loop resource management. These steps in particular include developments in waste management, moving on from viewing waste as a valuable resource to the implementation of the waste hierarchy. Germany assumed a pioneering role in waste legislation with the Closed Substance Cycle and Waste Management Act (KrW-/AbfG) of 1996. By enshrining manufacturer liability for the first time in legislation, despite the Green Dot symbol having already been in place since 1990, this Act served as a model for European environmental legislation.[125] Germany thus laid foundation stones for environmental protection which are still deeply rooted in the industrial landscape: Germany

110 | See UBA 2016a.
111 | 2010 was the most recent year that Germany's total material consumption (TMC) was also surveyed. The most recent survey of RMC was in 2014 and, at 16.1 tonnes per capita, revealed an increase, see UBA 2018b.
112 | See Schmidt-Bleek 1994.
113 | See Bringezu/Schütz 2014.
114 | See Wuppertal Institut n.d..
115 | See Global Footprint Network 2018.
116 | See Bundesregierung 2002.
117 | BMUB 2016
118 | See BMU 2018b.
119 | See BMU 2016.
120 | See BMU 2019a.
121 | See Agora Energiewende/Agora Verkehrswende 2018.
122 | See Wirtschaft macht Klimaschutz n.d.
123 | See European Commission 2018b.
124 | See UN 2018.
125 | See Fraunhofer UMSICHT 2017.

has a strong waste management sector, ultra-modern refuse incinerators, is a pioneer in environmental engineering such as refuse sorting, waste2energy, pre-treatment of waste for landfill and other sectors such as hydroelectric power, the bio-based economy, etc.[126] There is great entrepreneurial interest in implementing resource efficiency measures[127] and industrial symbiosis across the most varied sectors is characteristic of German industry.[128]

Germany's long-term involvement with these issues from the outset means that **availability of data about material flows in the country is very good.** Institutions such as the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), the German Environment Agency (UBA) and the German Mineral Resources Agency (DERA) collect and analyse data sets which form the analytical backbone for environmental policy and enable quantitatively based decision-making. Raw material productivity, enshrined in the German Resource Efficiency Programme ProgRess II, has accordingly been the German government's explicit goal as the driver of economic development and environmental protection since 2002.[129]

Technology and Innovation

Germany has **excellent technical infrastructure** in fields which are key to success such as transport, energy and water supply combined with outstanding **social infrastructure** such as its education and health systems. Germany furthermore has an **engine of innovation** which is required for a systemic transformation towards a CE, namely the close interaction between a stable flow of (corporate) venture capital[130, 131], government think-tanks and industrial innovation. Internationally, Germany is therefore one of the most highly innovative countries (in fourth place according to one innovation indicator).[132] Germany is equal third with Luxembourg in the **Eco-Innovation Index**, behind Sweden (first place) and Finland (second place).[133]

Regulatory Framework in Germany

Thus far, there is no explicit institutional framework for a CE but merely various items of legislation and directives which are intended to guide the transformation. The regulatory framework under discussion in connection with a CE is set out below.

The Waste Management Act (KrWG 2012) implements the EU Waste Framework Directive (EU Directive 2008/98/EC, as amended by EU Directive 2018/851) in Germany. The central pillar of the Waste Management Act is the waste hierarchy: the prioritization in descending order of prevention, preparation for reuse, recycling, recovery and disposal of waste materials.[134] The Waste Management Act also sets a recycling target: 65 per cent of all municipal waste is to be recycled in 2020. This target was exceeded back in 2016.[135]

Another text which is closely linked to a CE is the EU Ecodesign Directive (2009/125/EC), which is implemented in Germany as the Energy-related Products Act (EVPG). The goal of the Ecodesign Directive is to mitigate the environmental impact of energy-related products over their entire lifetime.[136]

Adjustments to the Ecodesign Directive are planned by 2021 which will make requirements for resource efficiency and durability more central to the directive. A first example which has already been agreed by the EU Commission and EU Member States are specifications for improved repairability of electrical appliances. For instance, a manufacturer will in future have to make spare parts available for a defined period.[137]

The higher-level legislation is also accompanied by secondary regulations relating to the Waste Management Act which specify details of waste recovery and control, for example a landfill ordinance.[138] These also include waste stream-specific ordinances and acts for different product groups. These are based on EU Directives, for example for packaging and packaging waste (EU: Directive 94/62/EC, Germany: Packaging Act since 01.01.2019, previously Packaging Ordinance), end-of-life vehicles (EU: Directive 2000/53/EC, Germany: End-of-life Vehicle Ordinance), batteries (EU: Directive 2006/66/EC, Germany: Battery Ordinance) and waste electrical and electronic equipment (EU: Directive 2012/19/EU, Germany: Electrical and Electronic Equipment Act). ›

126 | See FES 2016.
127 | See Schmidt et al., 2019.
128 | See BAFU/ERA-NET ECO-INNOVERA 2014.
129 | BMUB 2016
130 | See KPMG International 2017.
131 | See Roland Berger/BVK/IE.F 2018.
132 | See Frietsch et al. 2018.
133 | See Eurostat 2018.
134 | See BMJV 2012, Article 6 waste hierarchy.
135 | See UBA 2018a.
136 | See UBA 2016b.
138 | See UBA 2016c.

One aspect of the EU Circular Economy Action Plan was a tightening up of these EU Directives in line with CE principles. July 2018 saw a Waste Package come into force which comprises four amended directives intended to tighten up both the Waste Framework Directive and the EU Directives for the above-stated product groups and the Landfill Directive. Measures include, for example, increasing recycling rates and defining minimum requirements for extended manufacturer liability systems.[139]

Connecting Factors with Existing Initiatives

Some aspects of the CE narrative are reflected in the Federal government's current strategic policy position. Examples include: the Federal government's raw materials strategy[140] (security of supply for Germany as a business location), Germany's National Sustainable Development Strategy[141] (SDGs 8 and 12), the Integrated Environmental Programme 2030[142] (planetary boundaries), the National Programme on Sustainable Consumption[143] (social transformation), the German Hightech-Strategy[144] (innovation for increasing total raw material productivity), the Federal government's Action Plan on the Material Usage of Renewable Raw Materials[145] or the National Research Strategy BioEconomy 2030[146] (bio-based economy), the Environmental Innovation Programme[147] and the GreenTech made in Germany programme[148] (environmental engineering as a driver of growth).

At the organizational level too, there are **many and varied multi-stakeholder platforms and initiatives in Germany** which address sub-aspects of the CE narrative, for example the National Resource Efficiency Platform[149], National Platform Future of Mobility[150] and Platform for Climate Compatible Consumption Germany[151] or Plattform Industrie 4.0[152] (ensuring competitiveness). However, these mainly focus on a specific topic, which means that discussion of the synergistic effects of resource conservation, climate protection and competitiveness remains challenging. The Industrial Resource Strategies think-tank[153], the Collaborating Centre on Sustainable Consumption and Production (CSCP)[154] and the Wirtschaft macht Klimaschutz dialogue forum[155] are examples of how topics can be effectively linked.

What exactly is Germany's position with regard to CE? There is no single answer to this question. On the one hand, Germany has long been viewed as a driving force in Europe for an environmentally friendly economy and has contributed significantly to the European Commission's Circular Economy Package. On the other hand, however, its failure to achieve climate targets calls this role into question and Germany's environmental policy is increasingly perceived as reactive. The Federal government does not yet **have a coherent package of measures for making Germany's economy more circular**. While there is indeed a Sustainable Development Strategy, and the numerous strategies, platforms and initiatives mentioned above, these each tackle only sub-aspects of a CE. A coherent strategy is essential if Germany is to meet its self-imposed targets, appropriately further develop the regulatory framework and assume its international pioneering role. Against the background of this initial situation in Germany, the following chapter throws some light on the development of CE roadmaps and similar initiatives in other European countries and attempts to derive some insights for Germany from them. The focus of the analysis is on the institutional design of these processes, on the narrative selected to explain the necessity of transformation towards a CE, and of setting goals and formulating initial implementation measures.

This preliminary study is thus intended to provide **insights for carrying out the *Circular Economy Initiative Deutschland (CEID),*** which has set itself the goal of developing a **CE roadmap for Germany.** The aim of the following chapter is accordingly to derive relevant insights from the process expertise gained by other countries. A scientific evaluation, for example of the effectiveness of the selected implementation measures, is explicitly not the aim of the present investigation as it will only be possible to carry out such deeper analyses in the context of the *CEID,* which involves many stakeholders.

139 | See European Union 2018.
140 | See BMWi 2010.
141 | See Bundesregierung 2018.
142 | See BMUB/Schäfer & Breuss 2016.
143 | See BMU/BMJV/BMEL 2017.
144 | See BMBF 2018b.
145 | See FNR 2009.
146 | See BMBF 2010.
147 | See Umweltinnovationsprogramm n.d.
148 | See BMU 2018a.
149 | See BMU 2019b.
150 | See NPM n.d.
151 | See Plattform KVK n.d.
152 | See Plattform Industrie 4.0 n.d.
153 | See UM BWL 2017.
154 | See CSCP n.d.
155 | See Wirtschaft macht Klimaschutz n.d.

4 Looking Outwards: National Activities Towards a Circular Economy in Europe

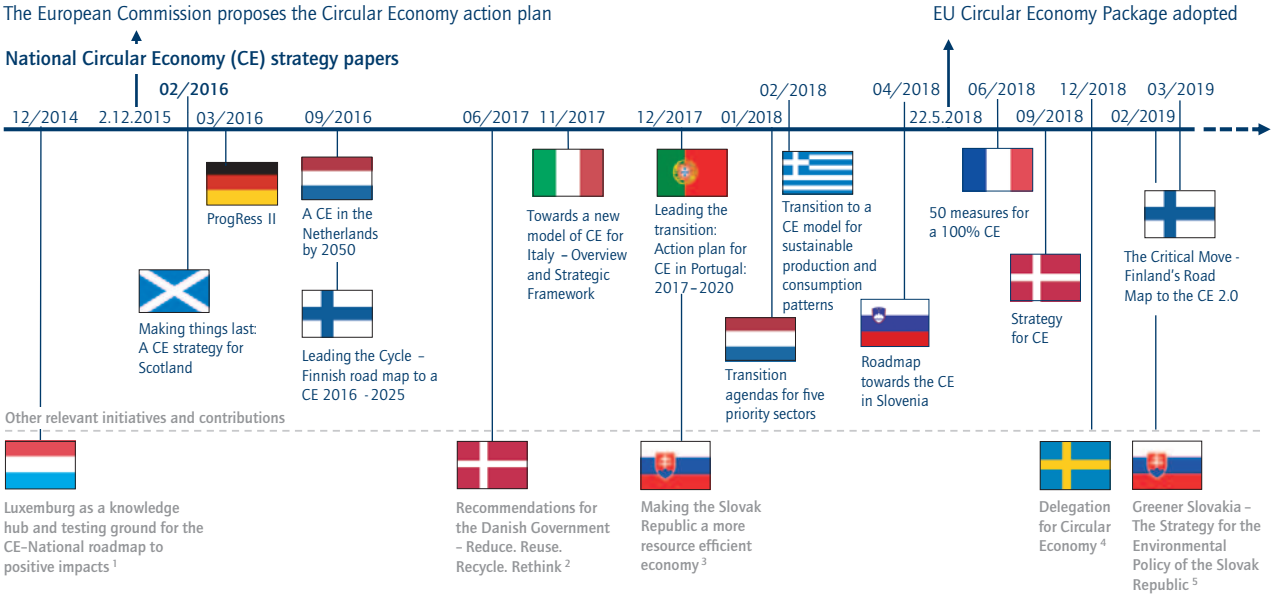
Since a Circular Economy (CE) involves a broader understanding of value creation, applying it means **transforming the manufacturing and economic system from a linear to a circular model of wealth creation**. Achieving such a transformation, especially in a technologically advanced industrial nation such as Germany, with a gross domestic product of some 3.4 trillion euro[156] and fixed assets of 19.5 trillion euro[157], is a major challenge and requires a sound procedure.

This chapter **investigates CE roadmaps and similar initiatives in other European countries**, with the aim of **deriving insights for Germany from them**. The focus of the analysis is on the institutional design of these processes, on the narrative selected to explain the necessity of transformation towards a CE and of setting goals and formulating initial implementation measures. A similar analysis has already been conducted at the EU level for the European Circular Economy Stakeholder Platform. This shows the relevance and advantages of making use of the insights already gained from other countries.[158]

4.1 Procedure and Methodology

The aim of the present preliminary study is to obtain insights and experience from other European countries about how a transformation pathway to a Circular Economy (CE) can be mapped out. This has been achieved by analysing the CE activities of other EU countries, specifically in the form of existing national roadmaps or comparable strategy papers. Using the Aspen Institute's "Theory of Change" approach, the significant stakeholders, assumptions, goals and consequent actions for achieving social change were investigated.[159] The resultant outcomes could be analysed in only a few cases due to the short period of existence of the initiatives at the time of analysis.

Between 2014 and 2018, in connection with the **EU Commission's Circular Economy Package,** many **European countries and regions produced strategy papers** (roadmaps, strategies,



[1] Study carried out by EPEA on behalf of the Ministry of the Economy; national strategy paper planned for 2019
[2] Ed. Danish Advisory Board for Circular Economy
[3] OECD Environment Policy Paper. Country study: Ed. OECD. Content developed with the collaboration of the Ministry of the Environment of Slovakia
[4] Located in the Swedish "Agency for Economic and Regional Growth" in the Ministry of Enterprise and Innovation
[5] Contains a section on the Green Economy with reference to CE principles

Figure 6: Timeline of Circular Economy developments in other European countries (Source: own presentation)

156 | See Destatis 2019a.
157 | See Destatis 2019b.
158 | See EESC 2019.
159 | See Connell et al., 1995.

action plans) with the intention of fostering a CE. These strategy papers from selected countries and regions were then analysed with regard to their "Theories of Change", i.e. investigated in relation to the underlying hypotheses as to how socioeconomic transformation towards a CE can take place. In addition to analysing publicly available information about the various initiatives (desk research), acatech and SYSTEMIQ carried out qualitative interviews (expert survey) with major stakeholders.[160]

The following methodology consisting of five characteristic elements was developed by the team of authors to describe the "**Theory of Change**" and used to investigate the initiatives with regard to their underlying issues. The organization of the following sub-headings also reflects the structure of this analysis.

1. Narrative:
   - What is the fundamental motivation for systemic change?
   - What were the grounds for beginning to move towards a CE?
   - What are the "pressure points" felt by individual stakeholders, how can a willingness to change be created?
2. Drivers:
   - Who is pushing for systemic change?
   - Who initiated the activities and who plays a major role in developing them?
   - How are decisions made during the process?
3. Goal setting:
   - At which level are goals set (using the iooi method)?[161]
   - Where is the change intended to lead and how is it defined (qualitatively or quantitatively)?
4. Interest groups:
   - Which stakeholders are involved in the process?
   - What is the interaction like?
5. Implementation:
   - How and by what specific measures is change to be initiated?
   - Who are the stakeholders and target audience of the resultant information and activities?
   - What goal are these directed at in each case?

The iooi method (see figure 7) was selected for **investigating goal setting** (see point 3 above) in the national strategies.[142] This method describes an evaluation model for entrepreneurial social action. This model was selected since it is generally suitable for the measurement and forward planning of complex systemic change projects. It is used below to categorize the systems of targets selected in the country strategies.

- Inputs (resources) are available financial, material and personnel resources.
- Outputs (results) are the direct results arising from the measures.
- Outcomes (effects/consequences) describe the effects on the target audience group; the short- and medium-term effect.
- The action on the higher-level goal is described at the impact level.

Based on the information obtained from the **desk research and expert survey,** the team of authors set out some initial insights which describe major elements for designing the transformation towards a CE. These insights are shown separately from the main text and in italics in the following sub-headings. On the basis of these insights and additional contributions from the workshops so far carried out for the initiative, the team of authors derived some lessons for Germany. The aim of these is to adapt the insights obtained to the German context and, where possible, to state them in concrete terms. The lessons for Germany are highlighted in text boxes in the following sub-headings. More detailed explanations, such as for example about indicators or about the selection of key themes, are also shown in text boxes.

Figure 7: iooi method (input – output – outcome – impact) (Source: own presentation based on Riess/Held 2010)

160 | List of publications of Luxembourg, Netherlands, Finland, Denmark, Italy, Portugal, Slovenia, Slovakia, France, England and Scotland and interviewees in the Appendix.

161 | See Riess/Held 2010.

4.2 Fundamental Motivation for Systemic Change

The fundamental motivation for systemic change is described in the narrative. The narrative conveys implicit values. The narrative is thus the line of argument which runs through the strategy.

Insight 1: *The EU Circular Economy Action Plan has contributed to creating a European understanding of and narrative about a Circular Economy (CE) which is restated in the national country strategies.*

The EU Circular Economy Action Plan elaborates on the social, environmental and economic potential of the transformation to a CE. Many have used it to legitimize national activities and the narrative of the Circular Economy Action Plan is thus also restated in the country strategies.

Overarching motivations mentioned in the existing narratives include global pressure points such as exceeding planetary boundaries, climate protection or contributing to the UN sustainability goals. Economic issues, such as dependency on raw materials imports, prices or job creation are widely represented in the strategies. There is a common understanding in all EU countries that social, environmental and economic goals can be achieved by the transformation to a CE.

Quote from the EU Action Plan for the Circular Economy:

"The Circular Economy will boost the EU's competitiveness by protecting businesses against scarcity of resources and volatile prices, helping to create new business opportunities and innovative, more efficient ways of producing and consuming. It will create local jobs at all skills levels and opportunities for social integration and cohesion. At the same time, it will save energy and help avoid the irreversible damages caused by using up resources at a rate that exceeds the Earth's capacity to renew them in terms of climate and biodiversity, air, soil and water pollution."[162]

Insight 2: *CE strategies are being used to harmonize various national and international programmes and objectives.*

Many countries emphasized how circular approaches can help to meet self-imposed goals or international commitments. For instance, in the Netherlands the positive interactions with current political strategies were brought to the fore (*inter alia* Biomass Vision for 2030, Raw Materials Memorandum, Green Growth Programmes, etc.). In the coalition agreement for the Dutch government in 2016, a CE was explicitly emphasized as a lever for achieving climate targets. In Scotland too, elements of the CE strategy are restated in the climate protection strategy based thereon. The Slovenian roadmap arose *inter alia* from the "Smart Specialization Strategy", in which a CE was identified as one of three pillars for strengthening the economy with potential for differentiation for Slovenia. Portugal's "Circular Economy Action Plan" demonstrated how policy measures for implementing a CE can also contribute to achieving the UN sustainability goals.

Insight 3: *The economic potential of transformation is emphasized in the narrative since such potential is a suitable common denominator for the long-term involvement of many interest groups.*

Very different priorities are set for the narrative in the various strategies. It is striking that all the initiatives comprehensively emphasize the economic benefits for their country. It was apparent from the interviews that the origin of this emphasis is that the economic dimension is the common denominator for many interest groups (particularly clear for Luxembourg and Denmark). Sustainable management of natural capital is here frequently subordinated to economic objectives as a prerequisite for future economic activity. Social aspects receive less attention and are looked at in less depth in the line of argument, with the exception of France: The French roadmap focuses strongly on job impact, poverty development and education.

It was in turn apparent from the interviews that the aim of prioritization was to create resonance with parties across the entire political spectrum and ensure long-term involvement. This is because it is recognized that the transformation to a CE will take various legislative periods and must accordingly be enshrined beyond these periods in the political agendas of possible future governments.

162 | See European Commission 2015.

Lessons for Germany:

- **EU narrative prominent in German programmes:** Germany played a significant role in devising the EU Circular Economy Action Plan and international processes such as the G7 Alliance for Resource Efficiency and G20 Resource Efficiency Dialogue and so helped to shape the narrative at an EU level. The content of these is therefore prominent in existing German programmes, such as ProgRess II, FONA etc. The development of a uniform CE strategy could build on these successes and give them international visibility.
- **A CE as a trailblazer:** It is important to bring the contribution of a CE to the fore as a trailblazer for national objectives of an economic, environmental and social nature so that a CE strategy can be better fitted into existing regulations and provided with appropriate political significance.
- **A CE is not recycling:** The term CE presents a particular challenge in Germany because the term used, "Kreislaufwirtschaft", is historically strongly associated with the concept of recycling or closed-loop resource management in Germany (see chapter 3). Many stakeholders are therefore choosing to use other terms in order to escape these connotations. It would therefore be helpful to establish a clear definition of a CE.
- **A CE ensures sustainable economic activity:** The narrative should be of relevance to society as a whole. It should therefore be emphasized that a CE helps to ensure future economic activity under environmentally sound conditions.

4.3 Prime Movers and Drivers of Transformation

In the "Theory of Change", drivers are those stakeholders who provide the impetus and spur other interest groups into action. They are crucial to the control and development of the change process and important decision-makers.

Insight 4: *While policy makers define the appropriate framework for the transition to a Circular Economy (CE), the impetus can also originate from other societal stakeholders.*

The legislative framework has to be appropriately adapted to permit the transformation to a CE. The government is thus implicitly a driving stakeholder in the process by establishing the framework within which businesses can act over the long term. National ministries have accordingly authored or been strongly involved in country strategies for other European countries. There have nevertheless been further stakeholders who (jointly) initiated these developments and were thus likewise significant drivers.

In Denmark, for example, the Confederation of Danish Industry adopted an ambitious new environmental strategy in 2015 which addressed issues of raw materials shortages and the environmental impact of industrial processes. The EU Circular Economy Action Plan was adopted that same year and, independently, the Ellen MacArthur Foundation published a study into the potential for circularity in Denmark.[163] The Danish government then tasked an Advisory Board consisting of twelve Danish entrepreneurs with drawing up recommendations for fostering a CE. Industry, while not being the initiator, thus became an important stakeholder. All the Advisory Board's recommendations were ultimately included in the Danish roadmap.

In the Netherlands, Parliament initiated the CE movement by demanding interministerial cooperation on the issue. In Friesland, the impetus for a CE was generated by a regional business movement which jointly developed a regional CE strategy with the regional government.

In Slovenia, it was the non-profit organization Circular Change which initiated the process and ultimately developed the roadmap on behalf of the government. The driving force in Finland was Sitra, an independent public foundation which has operated under the supervision of the Finnish Parliament as a think tank and investor since 1967.

163 | See Ellen MacArthur Foundation 2015.

***Insight 5:** If a CE is to transform society as a whole, cooperation between a number of ministries is required.*

The interdisciplinary nature of a CE is also apparent during development of the country strategies from the involvement of the various stakeholders at a political level. The responsibility was often shared between the ministries of the environment and the economy. Further ministries were sometimes involved as authors or editors if this was appropriate for specific objectives, as for instance in Denmark where a total of eight ministries participated (see Figure 8). Many countries recognized that, as a cross-sectoral issue, a CE has to be integrated into all ministries. As a result, interdisciplinary committees have been established in some countries. In Portugal, for example, there is an interministerial commission for climate protection measures and a CE. This is led by the Minister of the Environment who, when required to establish a consensus, can call on all other ministers to clarify strategies and responsibilities. In Slovenia, the former prime minister set up a "Commission for the Green Economy" which enabled cooperation on CE matters during his legislative period.

	Luxembourg	Scotland	The Netherlands	Finland	Denmark	Italy	Portugal	Slovakia	Slovenia	France
Economy	Ministry of the Economy		Ministry of Economic Affairs and Climate Policy	Ministry of Economic Affairs and Employment	Ministry of Industry, Business and Financial Affairs	Ministry of Economic Development	Ministry of the Economy	Ministry of Economic Affairs		Ministry of the Economy and Finance
Environment		Ministry of the Environment	Ministry of Infrastructure and Water Management	Ministry of the Environment	Ministry of Environment and Food	Ministry of Environment, Land & Sea	Ministry of Environment and Energy Transition	Ministry of the Environment	Ministry of the Environment and Spatial Planning	Ministry of Ecological and Solidarity Transition
Others	Ministry of Energy and Spatial Planning (before: Ministry of Sustainable Development and Infrastructure) Grand Duchy of Luxembourg		Ministry of Foreign Affairs Ministry of Interior and Kingdom Relations	Ministry of Agriculture and Forestry Sitra (Innovation)	Ministries of ▪ Transportation and Building ▪ Utilities, Energy and Climate ▪ Economic affairs ▪ Taxation ▪ Finance ▪ Higher education and Science ▪ Education		Ministry of Science, Technology and Education Ministry of Agriculture, Forestry and Rural Development		Prime minister	

Figure 8: Overview of countries and list of ministerial stakeholders involved in the roadmap process (Source: own presentation)

Lessons for Germany:

- **Policy makers must take the lead:** As in other transformation processes, leadership is the responsibility of policy makers: interviews with national business representatives revealed that German businesses would explicitly like to have clearer conditions for a CE, for example in the form of regulations and standardization. These are vital in order to support the many good approaches, projects and business models which there already are in Germany.
- **Interministerial issue:** A CE is an issue which requires interdisciplinary handling and must spur all relevant stakeholders into action. There are already outstanding examples (such as the Hightech-Strategy 2025) of how such interministerial cooperation can drive forward important future strategies. When it comes to developing a national CE strategy, it would appear to be appropriate to involve various ministries, in a first step for example the ministries with responsibility for the environment, the economy and research. In this way, it is possible to ensure that CE questions have a high profile in major cross-sectoral issues such as the current debate around a new industrial policy. ›

- **Important to assume responsibility for the long term:** Creating an interdisciplinary, independent office for coordinating all relevant ministries and allocating responsibilities would appear to make sense. This is important not only in terms of engagement in the process of devising a CE strategy, but also for the creation of a responsible guarantor with a long-term mandate, i.e. spanning legislative periods. Shared responsibility with a societal stakeholder can also ensure long-term continuity.

4.4 The Target System

4.4.1 Formulation of Goals and Indicators

Insight 6: *A Circular Economy (CE) is a means for achieving existing national targets or national contributions to global goals.*

The investigated country strategies describe a CE as an approach to achieving and harmonizing existing national targets which have already been set in various policy areas, most frequently targets for recycling rates, waste volumes and CO_2 emissions. Moreover, other than in the Netherlands, no additional "national circularity target" (at the impact level in the action model described above) has been defined. It was apparent from the interviews that this procedure avoided protracted discussions about suitable objectives and instead allowed the focus to be placed on the implementation of measures.

Some national strategies define integrated systems of targets. The systems of targets of the Netherlands and the London Waste and Recycling Board (LWARB) are particularly transparent. In these cases, the action level (impact level in the iooi model) from various policy areas was adopted and resources (inputs) provided in the framework of a CE strategy in order to achieve specific results (outputs) with defined effects (outcomes). The systems in the Netherlands and London thus describe the contribution of CE approaches to achieving pre-existing targets, so demonstrating their relevance to different political stakeholders and, as a corollary, fostering engagement by different ministries.

Insight 7: *There is an international consensus that new indicators will have to be developed for measuring the progress of the transformation to a CE.*

Although there is no intention to provide explicit new circularity targets on the impact level (i.e. a goal similar to the two-degree target in climate protection), almost all the countries agree that suitable indicators for measuring progress need to be developed. The currently most widely used indicators for measuring circularity are recycling rates, waste volumes and use of secondary materials. However, these are generally thought to be inadequate for measuring progress towards a CE. Indeed, some interviewees argued that recycling rates could even hinder the transformation to a CE because they are incapable of modelling levers such as sharing and repair. It would thus be helpful for not only individual approaches, but also indicators, to be capable of modelling the systemic effects of circularity levers (see "Circular Economy Indicators" box).

Many countries also stated, however, that for them quantification for measuring progress in the transformation to a CE was initially of secondary importance because they wished to prioritize use of their resources in terms of time, funding and personnel for implementing measures rather than for complex modelling and political debates. Many nations saw the further development of indicators to be a task for the EU, Eurostat having already set up a CE Monitoring Framework[164].

164 | See Eurostat n.d.

Circular Economy Indicators

Indicators are required for making progress towards a CE measurable and for setting suitable targets. Back in 2016, the European Academies Science Advisory Council (EASAC) carried out a comprehensive analysis of CE indicators in order to propose reliable indicators to the EU Commission.[165] In 2018, the EU Commission presented an **EU Monitoring Framework**[166] with ten indicators in the following four categories: (1) production and consumption, (2) waste management, (3) secondary raw materials and (4) competitiveness and innovation. The framework is an important first step towards measuring progress but, due to a strong focus on recycling, has been criticized as inadequate for meaningfully evaluating transformation.[167, 168, 169] The EU Commission itself acknowledged this criticism in its recently published Circular Economy Report.[170] A summary follows of what the existing indicators of the framework are, where there is a need for further development and to what extent other countries have already developed their own solutions for this purpose. Finally, Germany's stance is described.

Indicators in the EU Monitoring Framework and their further development

In the first category, **production and consumption,** it is mainly waste volumes by type of waste (municipal waste and food waste) which are measured. It would be better for the purposes of a CE not only to measure waste volumes at the end of the product's life cycle, but instead to begin at the start of value chain and establish indicators for design and production. This is already being addressed in an Ecodesign Working Plan from the Commission.[171] The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the German Environment Agency (UBA) have done some excellent groundwork in Germany on product design requirements with their Ecodesign Kit.[172] Products must be designed from the outset for high-quality subsequent use and it must be ensured that no toxicological effects, whether on humans or the environment, are to be anticipated during production, application and future use scenarios. There are virtually no indicators for this purpose. The Ellen MacArthur Foundation (EMF) made a proposal at a corporate level with the "Material Circularity Indicator" developed in 2015.[173] At macroeconomic level, France is attempting to measure its progress using the "Ecolabel Holder" indicator, i.e. the percentage of eco-certified businesses.[174]

The **waste management** category lists recycling rates for various waste streams. There is much criticism of using recycling rates as a performance indicator for a CE. These rates are mainly simply collection rates which relate to the input of the collected volumes into the recycling process. The "recycling rate" indicator thus does not describe how much material is actually kept in material cycles. The problem firstly results from the fact that there is fundamentally no uniform definition and standardized measurement of recycling rates. Secondly, these rates also provide no indication of the quality of the resultant secondary material nor of the products for which it can accordingly be reused.[175, 176, 177] One valuable further development is the Circular Economy Index (CEI) from di Maio and Rem (2015). The indicator measures the ratio of the value of the material produced by the recycler (market value) to the value of the material arriving at the recycling plant.[178] The Netherlands already makes use of the CEI under the name "Cyclical Use Rate".[179]

Some criticism even considers volume-based collection rates to be in conflict with central CE principles, since such rates are designed to collect large volumes of products and equipment without material separation, as for example in the case of waste electrical equipment, without being product specific or providing waste streams separated into specific products. This prioritizes the collection of large and heavy items of equipment since existing recycling rates can be achieved more quickly in this way. In addition, equipment is often severely damaged by the infrastructure used for collection, with much being destroyed to such an extent that reuse or repair is impossible. In contrast, CE indicators ought to model

165 | See EASAC 2016.
166 | See Eurostat n.d.
167 | See European Parliament 2018.
168 | See EESC 2018.
169 | See Council of Europe 2018.
170 | See European Commission 2019.
171 | See European Commission 2016.
172 | See BMUB/UBA 2015.
173 | See Ellen MacArthur Foundation et al. 2015.
174 | See Magnier et al. 2017.
175 | See Haupt et al. 2017.
176 | See di Maio/Rem 2015.
177 | See Franklin-Johnson et al. 2016.
178 | See di Maio/Rem 2015.
179 | See Potting et al. 2018.

particularly long-lasting and intensive use of materials together with repair and reuse potential, which is why indicators should be developed for the use phase.[180] These are, however, difficult to define and, in addition, data acquisition can be complex and time-consuming.[181] Franklin-Johnson et al. (2016) made an initial scientific attempt with an "Indicator of Resource Longevity Use".[182] France and the Netherlands defined indicators which were intended to describe intensified use and an extension of the life cycle pragmatically, for example "Consumer Spending by Capita on Maintenance and Repair" and "Car-sharing Frequency Rates".[183, 184]

In the **secondary raw materials** category, trade in recyclable materials is recorded in volume terms. The percentage contribution of recycled materials to raw materials demand is additionally measured.

In the **competitiveness and innovation** category, employment in the recycling sector and repair, reuse, rental and leasing are measured. In addition, the number of patents relating to recycling technology and secondary materials are also recorded.

How are indicators used in other European countries?

Slovenia, Scotland and Portugal have strongly oriented their CE indicators towards waste management and CO_2 emissions. The countries agree, however, that their current framework is only a first step because it is only capable of measuring and controlling progress towards a CE to a very limited extent. The Portuguese Ministry of the Environment is, for example, accordingly developing a partnership with the national statistics office for the further development of CE indicators. Finland is also making the development of a suitable indicator set the strategic priority for its second roadmap.

The Netherlands[185] and France[186] have already developed their own frameworks which are more broadly formulated than the EU framework. They are designed to include not only indicators for assessing the quality of secondary raw material but also for the production and use phases.

The experts surveyed for this analysis consider the existing EU framework to be inadequate and also view the further development of indicators as a joint task for the EU.

Germany's situation

In Germany, the Federal Statistical Office has previously retrospectively collected various indicators of relevance to a CE in the following categories: raw material productivity, raw material consumption, waste volume and recycling.[187] Germany's indicator set therefore goes no further than the EU framework and has thus previously only inadequately modelled control of the transformation to a CE. If it is to be possible to obtain a comprehensive picture of the effect of circularity approaches, it is essential to include indicators in the CE progress measurement which offset the above-described weaknesses. Programmes such as ProgRess I and II are already dedicated to further developing some of these indicators, such as DERec (Direct Effects of Recovery) and DIERec (Direct and Indirect Effects of Recovery).[188] The Federal government's waste prevention programme also suggests the development of new indicators, such as for example the proportion of used equipment which is reused in relation to the collected volumes of used equipment.[189] Further important indicators and their accompanying target definitions are nevertheless still missing.[190, 191]

It should be ensured that the indicators can be applied at corporate level so that they can be used effectively for controlling transformation. Indicators have previously largely been mutually independently developed on the product, corporate and macroeconomic levels. There are accordingly certification schemes, for example the cradle-to-cradle certification at product level,[192] the Circularity Standard (BS 8001) at the corporate level[193] and macroeconomic indicators, all of which

180 | See Vercalsteren et al. 2018.
181 | See Ellen MacArthur Foundation et al. 2015.
182 | See Franklin-Johnson et al. 2016.
183 | See Magnier et al. 2017.
184 | See Potting et al. 2018.
185 | See Potting et al. 2018.
186 | See Magnier et al. 2017.
187 | See. UBA 2017b.
188 | DERec is a virtual parameter which models the extent to which, assuming identical production patterns and technologies, primary raw materials, semi-finished and finished products would have to be imported or obtained domestically if secondary raw materials were not used during production. DIERec additionally models the extent to which, assuming identical production patterns and technologies, primary raw materials would have to be obtained not only domestically but also globally (see ProgRess II).
189 | See BMU 2013.
190 | See SRU 2015.
191 | See Wilts/von Gries 2017.
192 | See C2C 2019.
193 | See BSI 2019.

are differently determined and are thus not readily inter-translatable. When developing and selecting indicators, it would additionally be appropriate to ensure that the indicators can be calculated with the data which is gathered in any event for sustainability reporting in order to maximize synergies and avoid additionally burdening business.[194] Similar considerations should also be taken into account in the current development of the CE-ISO Certification TC323.

Apart from the recycling target for municipal waste, which was set for 2020 and surpassed back in 2016, the most important CE objective for Germany is also the target set by ProgRess of doubling raw material productivity over the period from 1994 to 2020.[195] Raw material productivity is calculated by relating gross domestic product to the abiotic materials used in Germany. Germany looks likely to fall far short of this target. In 2016, the "raw material productivity" indicator was expanded for the German Sustainable Development Strategy to "total raw material productivity". In this latter case, the calculation includes raw materials which are required outside Germany for the production of imported goods. The target of raising the value by 1.5 per cent per year between 2010 and 2030 is currently being surpassed.

The "(total) raw material productivity" indicators are viewed critically from a scientific perspective for only taking an overall view of raw materials. In environmental impact terms, however, it makes a major difference whether it is for example a high-tech metal or gravel which is put to efficient use. In addition, many CO_2-saving measures, such as the expansion of renewable energy sources, initially raise raw material consumption.[196]

Insight 8: *A clear statement in the roadmap of specific measures and their effect is helpful in order to achieve comprehensive implementation of CE measures in practice.*

Two types of strategy are immediately apparent from an analysis of the countries' strategies. Some were stated in very general terms and had the aim of creating a common understanding of a CE (inclusive, non-mandatory approach). Others set out the chain effects of circularity policy levers in detail and derived highly specific activities (explicit approach). In Denmark, for example, a detailed appendix was drawn up for each of the Advisory Board's 27 proposals precisely describing the statement of problem, solution, action, stakeholders and funding requirement (i.e. all iooi target levels). This explicit approach makes responsibilities clear and thus simplifies implementation.

The reason for these different approaches is ultimately the respective starting point. Countries with prior CE activities were mainly also capable of stating more specific targets. For those countries without a prior history in the area, a generally worded strategy would appear to be the solution of choice because advantages can be developed without creating commitments. However, the degree of specificity is in any event crucial to the success of implementation of the proposed measures.

194 | See EASAC 2016.
195 | See UBA 2018c.
196 | See Angerer et al. 2016

Lessons for Germany:

- **An explicit implementation strategy is essential for achieving targets:** German policy makers have already developed a target system through Agenda 2030, national CO_2 targets, the raw material productivity target from ProgRess and the National Sustainable Development Strategy, the targets in the Hightech-Strategy 2025 etc. which a CE strategy can help with achieving. An explicit CE strategy would therefore be of additional benefit to Germany by supporting and driving forward integrated implementation of the existing targets.
- **The indicator set for measuring progress must be expanded:** In order to make the progress towards CE measurable, Germany would have to develop a comprehensive system of indicators going beyond the efficiency concept (see explanations about indicators, page 30 ff.). One important factor here is that macroeconomic models can only deliver relevant insights if the indicators can also be applied at an operational level in order to inform processes in businesses.
- **A hierarchy of targets can avoid conflicts during implementation:** Interviews with experts revealed that developing a hierarchy of targets would be advantageous in relation to possible trade-offs (e.g. climate protection versus independence from critical material imports).

4.4.2 Topic Selection and Prioritization

Insight 9: *Priority selection can be considered on various levels: material, sector or life cycle as well as on the level of an enabling environment.*

When it comes to implementing circularity principles in different value chains, the level selected for consideration is of great significance. The nature of the problem simultaneously predetermines the scope for solutions in CE approaches. The difficulty is to bring a sector's potential to the fore while simultaneously doing justice to the overarching CE approach. Consideration from a material and material flow standpoint is also not ideal, since the possibility of closed-loop circulation is greatly determined by the use to which the material is put. In addition, it is obvious that initiating systemic transformation means it is necessary to establish conditions favourable to circularity, for example by a suitable investment landscape, support for research and innovation and new ways of measuring success. The strategy must also have sufficient space for the necessary measures and for taking account of relevant interest groups. Essentially none of the roadmaps selected one single level for consideration. Denmark, for example, selected the following priority areas: (1) business, (2) data and digitalization, (3) design, (4) consumption patterns, (5) waste and recycling market, (6) construction and biomass. Scotland selected key themes over the product lifetime, Italy proceeded from a stakeholder perspective (companies, consumers, fiscal & economic instruments) while Finland had a sectoral standpoint complemented by a chapter on "joint actions".

Insight 10: *The priority areas in the analysed roadmaps were frequently defined on the basis of economic and political considerations.*

Various criteria were used to prioritize thematic areas, the emphasis often being on strategic relevance to the country as a location for business. Finland and Slovenia, for example, accordingly selected forestry as an important key theme. In some countries, the key themes were also determined on the basis of their political relevance. For example, the French President promised during his campaign that France would have a plastic recycling rate of 100 per cent by the year 2025 and, consequently, plastics are a priority area for the French roadmap. Measures for implementing the President's promise have been developed.

Since, in many countries, the strategy was used to harmonize different national goals, the key themes were sometimes selected to fit with existing initiatives and agendas. For instance, reducing food waste (Finland, Netherlands, Slovenia, Scotland, Portugal and Denmark) or managing large "waste streams" in the construction sector (Netherlands and Denmark). Scotland attempted to prioritize material flows on the basis of their CO_2 emissions and put huge effort into manually adapting an existing energy policy model to model CE control measures and targets.

***Insight 11:** Making a systematic selection of national priorities entails compiling an adequate data set.*

Key themes were often not selected on a scientific basis, which in many cases was due to an inadequate data set. A sectoral standpoint was therefore frequently selected since a good data set and national statistics on material flows and use were usually available. In this way, an overview of potential savings and priorities could be generated.

Some countries, for instance the Netherlands and Portugal, carried out material flow analyses at the start of the roadmap process in order to create a quantitative starting point for prioritization. On this basis, industry was informed of the potential for partnerships spanning value chains for relevant material flows, but this can only ever be a snapshot.

Lessons for Germany:

- **Consideration of functional systems:** Selecting the most suitable level for consideration is a challenge. Consideration on a material, sector or life cycle level limits the scope for solutions. Functional units are another option for defining system boundaries. This level of consideration is already used for compiling life cycle assessments to ISO EN 14044. The functional unit perspective makes it possible to consider not only alternative materials and compositions but also provision of the function by an alternative business model. The focus for optimization is here no longer on a specific product but instead on the benefits a consumer is intended to obtain from an offer.

- **Political topicality increases the prospects for successful mobilization:** Environmental and economic relevance to Germany should be taken into account when selecting key themes and the criteria used for this purpose. Political topicality is, however, of huge significance for ensuring broad engagement by relevant interest groups: selecting topics with relatively high public visibility ("low-hanging fruit") facilitates mobilization and engagement of the various stakeholder groups. They can thus be used as trailblazers for implementation of further interventions.

- **Systemic modelling reveals potential savings:** An adequate data set is the only way of identifying potential savings arising from the implementation of CE levers. Already established data sets for recording material flows[197] should accordingly be built upon in order to add further factors such as potential savings of energy and CO_2 to the material flow standpoint.

- **Take account of transboundary material flows:** Particularly for an exporting country such as Germany, limiting the scope of consideration to within national borders is not helpful when modelling material flows and setting objectives. The indicators of total raw material productivity which are collected in Germany already take account of the material intensity of processes and products across global value chains and this approach can be of distinct benefit to the international debate.

197 | The Wuppertal Institute's „Saving Resources by a Material Category Oriented Recycling Product Industry (ReSeK)" project carried out a comprehensive material flow analysis for the thirty most important materials in volume terms for Germany. The Fraunhofer Institute for Systems and Innovation Research (ISI) is investigating systems aspects of the set of issues around materials and raw materials and modelling material cycles.

4.5 Engagement of Interest Groups

Since the issues around a Circular Economy (CE) have an impact on society as a whole, many social groups have a justified interest in helping to shape the development of a national CE strategy and so set the course for the future of the economy. The prime movers and drivers are thus also dependent on creative contributions from interest groups in order to develop an ambitious and implementable strategy. An effective process for engaging various interest groups is thus of significance to the success of the transformation.

Insight 12: *It is beneficial to involve existing CE activities and initiatives in the strategy process in order to generate momentum and to make effective use of all available resources.*

Avoiding redundancy is also important in relation to implementation of a national CE strategy. It was clear from the interviews that it was important not to allow competitive situations to arise and to build on existing, established programmes (whether backed by the public or private sector or civil society). It must be brought to the fore why it is important for these programmes to join in with a national CE strategy. In this way more resources could be obtained overall for implementation.

London's Circular Economy Route Map is a good example of how to build comprehensively on established programmes. For each of the measures defined in the Route Map, all existing initiatives and projects already carrying out similar measures or with an interest in participation and capable of providing resources were listed. Using this comprehensive overview, dedicated resources can be allocated in a more targeted manner. A similar approach was also used in the Dutch roadmap. Other strategies integrated existing initiatives by presenting them as examples of best practice.

Insight 13: *Broad and early engagement of the private sector creates commitment and identification with the process and so boosts the significance of the issue at a political level.*

As has already been indicated in chapter 4.2, the private sector plays a dual role, both as a driver and as the most important target audience. Firstly, an economic transformation cannot happen without mobilizing the economy, which is why it is essential to involve industry and commerce, trade and services at an early stage in the process. Secondly, the interviews revealed that the private sector plays a central part as a driver for spurring inter-ministerial partnerships into action, since many ministries view industry as their interest and/or target group. The private sector was accordingly involved in almost all of the roadmap processes, often in the form of a dedicated panel of experts.

The great majority of European businesses are small and medium-sized enterprises (SMEs) which, however, do not pursue a uniform political agenda. In most countries, therefore, they are involved through associations. In Denmark, for instance, four industry associations promised the government in a "Circular Summit" in June 2017 to make the CE strategy a prominent part of their programmes. The Danish Advisory Board, working jointly with the four associations, then set out its own ambitious goals for supporting a CE. In the Netherlands, following the publication of Strategy Paper 2016, five transition agendas were developed by specially convened working groups, each of which was led by a business representative.

According to the interview, this was a particularly effective way of creating long-term validity at the political level spanning legislative periods, since the content was prepared by industry and not by the current government. The technically most relevant ministry was given responsibility for implementing the transition agendas.

Insight 14: *Engaging the population is very complex but creates a broad understanding of the purpose of a CE and breaks down obstacles to implementation.*

France, Slovenia and Luxembourg repeatedly invited the population to multi-stakeholder workshops and working groups. In the opinion of the expert interviewees, the process was considered beneficial. In France, for example, these workshops created sixty proposals which were taken into account in the development of the fifty measures in the national strategy.

Open consultation processes have also been carried out in many countries, for example in France and Finland via open web portals. There was a great response to this measure, but it proved complicated to draw specific conclusions for the strategy from the processes. The reason stated by the interviewees was the difficulty in evaluating the often inadequately worked out ideas.

The experience gained from these processes showed that a CE strategy can be more effectively developed by engaging the population through representatives who are committed to an ex-

tended period of participation. The interviewees pointed out that engagement without commitment was not a practical way of developing a national CE strategy, but it did achieve the objective of an educational campaign. Successfully engaging the population means clearly defining in advance a precise goal and the appropriate format to be used.

Insight 15: *CE strategies are prepared in close collaboration with the scientific community, but without the formalized engagement as with businesses.*

Many countries have worked together with universities and research institutes over the course of preparing their CE strategies. In particular, many countries, for instance Portugal, Scotland or Friesland, commissioned material flow analyses and the modelling of macroeconomic potential. Scientific expertise was accordingly generally called on in the context of specific research questions. In Portugal, scientific institutions were involved at the regional level in consultation processes for the development of regional activities.

Insight 16: *Involving local and regional governments is helpful for tackling locally different challenges and for enabling quicker implementation of initiatives.*

In the Netherlands, the regional level of government has been the originator of many initiatives and activities. The national government sees this as providing the strategic advantage of making effective use of resources and has set itself the task of supporting and promoting the involvement of local and regional government initiatives. From the outset, Portugal took account of regional differences (e.g. cork production in the north of the country, agriculture in the south) which require different CE measures. The Comissões de Coordenação e Desenvolvimento – regional, decentralized departments of central government with regional environmental and physical planning powers – were therefore instructed to analyse circularity potential in the light of the geographic and economic circumstances of their regions and to develop appropriately tailored regional strategies.

Moreover, many of the responsibilities of relevance to the implementation of CE measures are held at state or regional level, for which reason close involvement right from the development of the measures is critical to success.

Insight 17: *"Go with the energy"*

It was clear from the interviews that the interest groups to be involved were frequently selected opportunistically in that those involved were simply those who showed the most interest. Instead of using resources for analysing transformation, which is intrinsically highly complex, some countries argue for making a quick start on activities and making subsequent adjustments in the light of the resultant experience.

Some projects in the investigated countries resulted from an attempt to solve an urgent problem with circularity levers. One example is to be found in the Luxembourg hotel trade: family-run hotels have often been unable to afford the capital costs of a new interior. As a result, a new "interior-as-a-service" business model was jointly developed with the government and a study and pilot project are currently under way to discover whether the business model is successful and can be scaled.

It has furthermore been found that influential and charismatic individuals can play an important part in building momentum. Such individuals can play a major creative part, for example by chairing an advisory committee of experts.

Lessons for Germany:

- **Early engagement of interest groups:** In order to bring together the greatest possible resources for implementation, it seems useful for the development of a CE strategy to engage important societal groups and existing relevant initiatives (see chapter 2.3). In particular, close engagement of businesses is essential since they will be directly affected by the implementation of transformation or will be the operational and implementing drivers.

- **Businesses as a strong driving force for transformation:** Given the significance of medium-sized businesses to the German economy, mobilizing these businesses is particularly important to a German CE strategy. At the same time, the spread and diversity of these businesses present a particular challenge. It is possible to build here on existing initiatives which are already widely assisting with boosting energy and material efficiency in SMEs (see for example the VDI Centre for Resource Efficiency (VDI ZRE)).

- **Engagement of Federal states advantageous:** There are already some activities in Germany at Federal state and regional level which are addressing the potential of a CE for their state or region (Baden-Württemberg, North Rhine-Westphalia, Augsburg, etc.). National and regional efforts should here build on one another. A more in-depth analysis of regional potential covering the whole of Germany should also be carried out so that measures can be organized effectively.[198]

- **Society represented by agents:** Societal consultation processes which engage citizens on a grand scale and without any preselection are very complicated and, on the basis of other countries' experience, not efficient. In order to include the perspective of civil society in a CE strategy process, one hybrid model which might be appropriate is the civil "GesprächsStoff Ressourcen" dialogue which the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety is already carrying out for the second time as part of a further development process of the German Resource Efficiency Programme. This dialogue involves recommendations being developed by a preselected representative group of "civil ambassadors" while an accompanying online survey captures and takes account of general public opinion. Such a guided process can generate structured results. Alternatively, existing German societies, consumer associations or non-governmental organisations which likewise represent the interests of the population can be included.

- **Science can provide impetus for Germany's pioneering role:** The transition to a CE will raise important issues for both technology and the social sciences. Both the business-focused research institutes and the well-established government scientific advisory committees are already successfully helping to transfer knowledge into practice. It would in this respect be worthwhile for Germany to consider more systematically involving the scientific community in a strategy process.

4.6 Measures for Implementation

The measures are selected by the driver of the roadmap process. In the European country strategies investigated in this study, policy makers were usually the driver. As part of the interview process, the participating countries were surveyed about the resource policy instruments they used to drive transformation onward. A selection of example measures is shown in tabular form in the appendix. These are broken down on the basis of the PolRess II in-depth analysis.[199]

- **Negative economic incentives:** for example taxes, contributions or fees which inter alia provide an incentive for preventing waste.
- **Positive economic incentives:** for example tax relief, subsidies which inter alia provide an incentive to design higher quality products, keep materials within the loop or carry out repairs.
- **Regulatory instruments:** for example statutory regulations or ordinances which oblige producers and consumers to take a certain course of action. These also include an extended producer responsibility (EPR).
- **Information instruments:** for example environmental labels or campaigns which inform and educate consumers.

198 | See ESPON n.d.

199 | See Postpischil/Jacob 2017.

- **Education and research:** for example educational instruments and funding for research projects which promote an understanding of a Circular Economy (CE) (inter alia the development of national indicators).

The survey of resource policy instruments revealed that, overall, a variety of instruments from all categories is used. One tendency which could be identified was that so far frequent use has been made of measures which are quick to implement, most particularly information instruments. Accordingly, information instruments have already been successfully used in most of the countries, above all business advice services and awareness-raising campaigns for citizens. Public procurement and extended producer responsibility are also pivotal instruments.

Instruments which entail a protracted implementation process involving relatively large administrative effort, such as taxes, fees and subsidies, have in European countries so far only been used, if at all, to a very limited extent for specific products or sectors (see table in appendix 6.1 on page 46). This is hardly surprising given the only recent publication of many national strategies which provide the basis for specific measures. It is accordingly also difficult to judge the effectiveness of the various measures since there is almost no prior experience which permits an international comparison.

The resource policy instruments presented below are intended to mobilize other societal stakeholders for the transformation process. They are accordingly broken down by the intended target audience: private sector, civil society and scientific community.

4.6.1 Private Sector Mobilization

Insight 18: *If the many operational obstacles to the implementation of CE activities are to be overcome, business involvement is important for identifying them.*

Political frameworks often reflect a linear understanding of value chains and need to be adapted to enable the implementation of circular business models. "Political innovation" is helpful in this respect. All the countries investigated have recognized this need and taken various measures. The Dutch Green Deals approach is particularly noteworthy and has in the meantime been adopted by many countries and at the EU level.

Example of implementation: Dutch Green Deals

The "Green Deal" programme in the Netherlands is a joint initiative of the Ministry of Economic Affairs and Climate Policy, the Ministry of Infrastructure and Water Management and the Ministry of the Interior and Kingdom Relations. By means of this programme, the government enables organizations and businesses on their own initiative to identify existing barriers to green growth or the implementation of CE activities and to submit a request for review. By providing advice on regulation, administration or funding and, in some cases, on amending regulations, the government has managed to stimulate the economic activity of circular business ideas from scratch without providing further financial incentives.[200]

In Portugal and the Netherlands, measures are being taken to check the tax system for "CE compatibility". Luxembourg is pursuing three main lines of attack to mobilize business: supporting businesses financially (e.g. the "Fit 4 Circularity" programme), creating a market for circular products and services and producing an environment favourable to entrepreneurial activity and a "level playing field" (adaptation of legislation in preparation).

Example of implementation: "Fit 4 Circularity" programme in Luxembourg[201]

In Luxembourg, the Ministry of the Economy offers businesses assistance with restructuring to circular business models by providing a fifty per cent subsidy for advice from an external CE consultancy provider. Following a modest response to this offer, free workshops were additionally offered and these boosted demand for the programme.

200 | See Business.gov.nl n.d.

201 | See Myenergy Luxembourg 2017.

Insight 19: Moderated platforms help businesses to work on circular solutions in new combinations spanning value chains.

Being dependent on a network of suppliers, competitors and/or customers, no business can implement a CE alone. Completely new industry ecosystems are also often necessary to allow successful circular business models to become a reality. Therefore, a forum has to be provided to enable such partnerships. Finland has a CE Accelerator which connects start-ups with larger businesses. Enabling instruments, such as standardized data transfer, play a major role here.

Example of implementation: CEL.CYCLE[202] in Slovenia

The EU-funded CEL.CYCLE programme, which is coordinated by the Slovenian Pulp and Paper Institute, focuses on the use of biomass as a renewable raw material for industry and research. The organization consists of 21 partners spanning the entire biomass value chain, twelve being businesses working in the paper, chemicals, textiles, timber and automotive industries, construction, engineering and engineering, and nine being research organizations. It is a textbook example of the introduction of a CE, the partnership involving numerous interest groups from the private sector.

Insight 20: Establishing new rationales for optimization helps to break down current linear market structures.

New rationales for optimization must be established and new momentum provided in order to create a market for circular products and services. There are various starting points for breaking through the old rationales.

Since the state is a significant stakeholder on the demand side, it can provide considerable incentives through its purchasing decisions. For instance, European public procurement amounts to some 14 per cent of European gross domestic product (GDP).[203] Following the lead of the Netherlands, which made the first changes to its award criteria as long ago as 2008, many other countries have since identified public procurement as a lever for a CE and drawn up national action plans. This process is also supported by the European Commission.[204] Little is yet known about the effect and effectiveness of these adjustments.

In their roadmaps, Portugal and the Netherlands moreover define measures for mobilizing investment. The Netherlands in particular mention breaking down obstacles to investment, such as for example existing risk/return profiles of circular products and services, different depreciation periods and cost/benefit structures than for linear products. In addition to measures for supporting businesses with the transformation of their business models, the issue of access to capital is also addressed, for example by the Juncker Fund or supporting banks in the design of new financial products.

Lessons for Germany

- **Breaking down barriers to innovation:** Like other countries, Germany also has regulations which, as a result of conflicting goals, are obstacles to circularity levers. One example is the irreconcilability of hygiene regulations with the use of secondary material for foodstuffs packaging. Such conflicts, being large in number and complex, cannot readily be solved by a higher-level authority. Germany could follow the example of the Dutch "Green Deals" to break down these barriers and the European Commission's "Innovation Deals" to identify and break down barriers to innovation.[205]
- **Partnerships spanning value chains are important:** In Germany too, connectedness across value chains in industry is essential to accelerating transformation. Because optimization is generally carried out from a corporate perspective, there is virtually no incentive to implement circularity measures, the benefits of which are felt at other stages in the value chain. Consortia and partnerships spanning value chains and voluntary commitments by entire sectors are helpful in expanding the perspective to encompass an entire value network.

202 | Pulp and Paper Institute n.d.
203 | See Neubauer et al. 2017.
204 | See European Commission 2018c.
205 | See European Commission 2018d.

- **New evaluation methods are necessary:** Current indicators for evaluating investment decisions underestimate the commercial worth of a CE business model. They are also incapable of fully reflecting a CE business model's rationale for optimization. As a result, there is a funding gap for CE business models. Since other roadmaps also provide little guidance in this respect, it appears to be helpful to take a closer look at the financial obstacles and suitable measures for overcoming them.
- **Public procurement as a significant lever:** Public procurement indisputably has a role to play as a lever for boosting demand for innovative sustainable products. Accordingly, it seems to be helpful also to apply the Hightech-Forum's[206] recommendation to the procurement of circularly designed products, for example by linking up with Germany's national programme for sustainable consumption.
- **Digitalization paves the way to a CE:** The transition to a CE will only be successful if full use is made of the possibilities offered by digitalization and connectedness as well as automated data processing. They enable essential CE functionalities which in the past were impossible at reasonable cost. This also includes identifying specific levels for innovation and tracking down new fields of investment and lines of business.

4.6.2 Social Mobilization

Insight 21: *The success of circular products and services entails behavioural changes among consumers, as a CE is not just a technical fix.*

The role played by consumers in the transformation process is disputed, the roadmaps taking different positions in this respect. Many roadmaps do not address the responsibility of consumers at all (Denmark and Luxembourg) while others make their responsibility clear (Italy and France). What is certain is that the use phase involving consumers is a critical phase for a CE and many circularity levers act here (see ReSOLVE).

Measures for mobilizing consumers are being discussed on two levels: pricing or monetary incentives and education and information, for instance by training or other channels. There are individual projects which are emerging from civil society or being developed and implemented by non-governmental organizations.

The French roadmap in particular takes account of the part played by consumers, one of the four levers being "Mobilize all Actors". The dissemination and sustainable implementation of a CE is being fostered by public presentations about the results of the roadmap and by involving local and regional authorities and associations. Slovenia is talking about a "Circular Culture", emphasizing the simultaneous responsibility of individuals as consumers (purchasing decisions) and citizens (expression of political opinion). In Scotland, Zero Waste Scotland is researching incentive schemes and behavioural change.

Example of implementation: Zero Waste France[207]

Zero Waste France has set up a „Nothing New" campaign to challenge society to question its consumption habits and, if possible, to purchase nothing new. In 2018, 14,000 participants committed to avoiding the purchase of new products and finding alternatives to consumption. The campaign has been extended in 2019 and is aiming to reach 100,000 participants by the end of the year.

Insight 22: *If consumers are to be enabled as stakeholders, the principles and mechanisms of action of a CE must become general knowledge.*

Some countries have specifically developed the role of education in enabling consumers. The Portuguese Action Plan contains a package of measures called "Educating for Circularity". In addition to the integration of CE into the curriculum, there are also numerous measures for adult education. In Luxembourg CE teaching material is being jointly developed with the Ministry of Education.

206 | See Hightech-Forum 2017.

207 | See Foulon 2018.

Example of implementation: Finnish educational reform

Finland is a good example of the shift of focus onto implementation: while the role of the educational sector was not specified in greater detail in the strategy, it has since become a major topic. In the meantime, the Finnish education system has been adjusted such that 75,000 pupils and students from nursery school up to university now receive teaching units about a CE.

In Spring 2018, public calls for proposals were issued for pilot projects and partnerships for educational initiatives. By integrating CE issues into existing syllabuses, the intention is to educate the CE experts of the future and disseminate circular thinking. The first courses will be tested during the 2019 summer semester at various universities and will become an official part of the syllabus from the winter semester. These pilot courses are funded and supported by Sitra.

Lessons for Germany:

- **Consumer perspectives important:** Consumer behaviour during the use phase of products and services and the part consumers play in reverse logistics mean that they are important stakeholders in a CE. Their perspectives must be taken into consideration when considering and evaluating different circularity levers. The extent to which and by what measures consumers can be made accountable is yet to be determined. Creating transparency for consumers is important. The European Commission's efforts mentioned in the CE Action Plan to ensure disclosure of the environmental footprint of products and companies are central here.[208]

- **Enable citizens:** Educational programmes and information enable individuals to make informed decisions. Existing best practice examples such as the "Too good for the bin" campaign by the German Federal Ministry of Food and Agriculture (BMEL)[209] can provide inspiration. The educational sector has an important role to play in laying the foundations for future generations who will play their part in a CE. Citizens should also be encouraged and supported to take action themselves (repair cafés, food sharing, urban farming, etc.). Local and regional governments in particular can create appropriate conditions.

- **Breaking down consumption patterns:** Above and beyond education, it is important to work out what type of incentives are suitable for fostering resource-efficient behaviour. It is possible to build on existing initiatives such as the "National Programme for Sustainable Consumption"[210] or the "Climate-compatible Consumption Platform"[211].

- **Acceptance by social engagement:** It would appear helpful to build on the initiatives of stakeholders which, like policy makers, are driving social mobilization, such as NGOs. In addition to sharing experience, this can also create broader acceptance of the goals and measures set out in a national strategy.

208 | See European Commission 2019.
209 | See BMEL 2019.
210 | See BMU/BMJV/BMEL 2017.
211 | See Plattform KVK n.d.

4.6.3 Science and Research

Insight 23: *Policy makers have identified the potential of a CE for innovation and are supporting the scientific community in investigating this potential.*

The national strategies clearly reveal the considerable need for research in many areas. Many country strategies are accordingly pressing ahead with the development of specific areas of research and mobilizing research budgets. In Denmark, for example, CE is prominently mentioned in the government's RESEARCH2025 catalogue, which forms the basis for strategic investment in future research activities. In Slovenia, CE issues have been made a key theme in the context of a "Strategic Research and Innovation Partnership (SRIP)". In Portugal, the Ministry of Science, Technology and Higher Education has set up a programme which fosters "Collaborative Labs". In addition, April 2019 saw the publication of Portugal's national research and innovation agenda for a CE.[212]

Insight 24: *The scientific community has identified challenges associated with a CE and is beginning to develop dedicated educational programmes and courses.*

In the light of the burgeoning public debate around a CE, scientific stakeholders have begun to develop dedicated training programmes and courses and so address the interdisciplinary challenges associated with a CE. Worldwide, numerous university departments are working on business management and macroeconomic theories which are helping to clarify current trends and further develop management methods. The necessity of teaching circularity principles during professional training for disciplines such as design and materials research has also been recognized. In Scotland, pilot projects for integrating CE thinking into various disciplines have been started in universities.

One positive side-effect of the increased attention of universities is the large number of university spin-offs promoting circular ideas. Those demonstrate how universities are continuing to act as incubators.[213]

Lessons for Germany:

- **Cooperation with science holds great potential for innovation:** In Germany, science and research are often closely linked to business, not least due to its leading, business-focused research institutions such as the Fraunhofer Institutes and the many courses of study in business management and technology. This unique feature of the German economy makes science an integral part of the country's innovation agenda. This can boost the German economy's potential for innovation and help to ensure that the technological challenges of a CE are identified and solved at an early stage.
- **CE platforms for focusing interest and implementation:** Precisely because of a CE's interdisciplinary nature spanning value chains, developing "innovation networks"[214] would appear to be particularly appropriate. This can be appropriately supported by establishing political/strategic or operational platforms (e.g. in the form of regional clusters) and developing corresponding research programmes.
- **Actively fill in gaps in research using funding schemes:** Science and research are important "executive agencies" of an "innovative state"[215] because they can use government research funding to fill in gaps in research and development identified by policy makers. The new "resource-efficient circular economy" research plan established by the German Federal Ministry of Education and Research (BMBF), for example, directly contributes to setting a course towards a CE.
- **Make use of international efforts:** International competition and cooperation are characteristic of science, particularly in capital-intensive innovative fields of industry. It is accordingly important to bring unique features to the fore and to endeavour to build partnerships, for example in the context of European programmes such as "Circular Economy Research and Innovation" under Horizon 2020.[216]

212 | See FCT 2019.
213 | Examples of German university spin-offs are Noyanum, Agrilution, Twaice, Li plus, E.go and StreetScooter.
214 | See Hightech-Forum 2017.
215 | See Mazzucato 2015.
216 | See European Commission 2017.

4.7 Synopsis

The aim of the analysis in chapter 4 was to obtain insight and experience from other European countries about how the pathway for transformation to a Circular Economy (CE) can be mapped out. This analysis was based on country roadmaps or comparable strategy papers, other publicly available material and qualitative interviews with major stakeholders. Using the Aspen Institute's "Theory of Change" approach, significant stakeholders, assumptions, goals and consequent actions were investigated.

Key insights are once again summarized below:

- A CE is not an end in itself but instead a means for achieving higher-level goals and harmonizing different national goals.
- In the countries analysed, differing social forces were the prime mover behind CE strategies. Policy makers must, however, take on the lead role in the transformation process by establishing suitable conditions.
- Current indicators are inadequate for measuring progress towards a CE. Effort is therefore being put into further development of the indicators taking account of the EU Monitoring Framework.
- Key themes were usually not systematically derived from a science-based overview of potential and options but were instead directed by current political goals. Functional units would appear to be the suitable level for consideration of the implementation of CE measures in value chain networks.
- Inclusion of pre-existing activities and a broad stakeholder base is important for creating acceptance, generating momentum and making good use of resources.
- Many resource policy instruments which are intended to mobilise the private sector, civil society and the scientific community are already being implemented. It is currently, however, not yet possible to estimate their overall effect. Comprehensive reforms have not yet been made, incremental measures tending to be used instead.

The insights obtained were applied to the German context at the end of each sub-heading in the form of "Lessons for Germany". The following chapter draws on these lessons to develop succinct propositions as to how a German pathway towards a CE can be mapped out.

It should again be noted at this point that the analysis was performed in preparation for the *Circular Economy Initiative Deutschland (CEID)*. It was carried out over a three-month period by the team of authors. A more in-depth scientific assessment of the addressed issues of relevance to a CE will be carried out within the initiative which will conclude in 2021 with the compilation of a CE roadmap for Germany.

5 Synopsis and Next Steps: Options for Shaping Germany's Transition to Circularity

The review of the situation in Europe and activities in other countries reveals a broad range of options for initiating processes of change to society as a whole and achieving a transition to an optimized Circular Economy (CE). The following propositions set out by the team of authors build on the lessons derived in chapter 4 and describe elements of a pathway on which economic development in Germany could be decoupled from resource consumption. These ten elements reflect the structure of the preceding chapter and identify stakeholders in politics, science, business and civil society in the same way.

Why – fundamental motivation for systemic change

1. Develop a concrete shared vision for a CE as a means for achieving important societal goals
   This vision positions the CE as the principle of a fundamentally different economic system which takes equal account of natural, social and economic capital. It is manifested by its positioning with regard to current sectoral trends (e.g. changing mobility), political priorities (e.g. sustainable industrial policy and its connection with effective environmental protection) and the international debate (e.g. climate, development, and trade policy). It is important here to link this vision with existing national and international strategies and to develop a narrative that makes a CE relevant to all societal stakeholders. The relationship to work and well-being is here just as important as the positioning of significant leading figures whose credibility represents the necessity of the transformation.

Who - prime movers and drivers of transformation

2. Establish an independent operational unit for driving forward a CE in Germany across disciplines and policies
   The implementation of other transformative processes (e.g. the energy transition) has shown that identifying a single organizational structure holding overall responsibility which coordinates and acts across disciplines and policies may be key to success. Long-term monitoring of a CE strategy would accordingly require a central stakeholder leading the process over an extended period (i.e. spanning legislative periods) and acting as an independent contact point for all interest groups. In line with the cross-sectoral, interdisciplinary nature of CE issues, this unit could act as a neutral broker, particularly capable of handling not only industry, civil society and science but also any relevant ministries and their subordinate agencies. Such an operational unit also consistently and effectively tracks targets and monitors progress and actively tackles deadlock situations. In addition, it manages integration into both sub-national and European and international initiatives.

Where to – the target system

3. Develop a consistent system of targets and indicators for control and tracking
   Starting from the premise that a CE is not an end in itself, it can be helpful also to control and measure it on the basis of the higher-level targets. This ensures the relevance, selectivity and quality of indicators for measuring progress. The indicators can also be qualitative or based on milestones so that the resultant greater level of detail can be used to describe the vision and form opinions effectively. Wherever possible and meaningful, use should be made of established data, processes and structures which are already applied at the national or international level. A resource model which attempts to quantify the economic and environmental effects of CE measures on a macroeconomic level, including its transboundary effects, could be of considerable benefit to the debate around the potential of a CE.

4. Systematically prepare specific proposed solutions to barriers and incentives for CE
   A systematic analysis of existing barriers and incentives reveals core problems and systemic effects and helps to inform the political debate around measures for directly or indirectly fostering a CE. Possible proposals may be, for example, proposed adjustments to the legislative framework, such as for instance a revision of the German Waste Management Act to bring it into line with CE principles.

5. Develop a national CE roadmap based on the vision and target system
   Formulating a national CE strategy can assist in making the CE vision a reality taking account of the identified barriers and existing incentives and achieving industrial, environmental, and social policy goals. Achieving this requires integration into strategies at a national level for energy, mobility,

agricultural transition and digitalization. The roadmap sets out strategic priorities, defines specific intermediate targets with different time horizons and on different levels (technologies, products, infrastructure, consumer behaviour) and quantifies their effect on existing higher-level goals (e.g. climate protection, dependency on raw materials imports etc.).

With whom – engagement of interest groups

6. Establish a cross-sectoral, precompetitive space in which information is openly exchanged, partnerships are established and (industry) standards are defined
   Engaging significant interest groups increases social acceptance and ensures long-term implementation. Continuous engagement both at the outset and during the implementation of a transformation programme takes account of the dynamics of technical and social trends. It is useful to create a defined framework within which relevant stakeholders working cross-sectorally can develop integrated potential solutions and support and drive forward their ongoing refinement and implementation. Examples include establishing partnerships and initiating specific projects. Precompetitive collaboration also makes it easier to define (industry) standards.

How – measures for implementation

7. Initiate specific measures for fostering business models and technologies
   Defining specific measures can provide targeted support for the implementation of a CE. It is advisable when identifying and selecting suitable areas of activity to start with focus sectors which are particularly politically, economically, environmentally and socially relevant. Targeted use may be made of current discontinuities, such as the transformation to electrical mobility which is currently under way. The measures developed ideally follow an identification of the key levers which support economic activity in line with CE principles. Furthermore, the measures should be derived from the defined strategic objectives in the target vision. This relates in particular to technological and infrastructural foundations, new business models and regulatory conditions. Where it makes sense, initial pilot projects can be branched off.

8. Establish "circular clusters" to focus development on fields of particular relevance for the future
   Taking the tried and trusted structures of German industrial clusters as a model, the most important industrial applications of a CE could be significantly boosted by creating and supporting regional industrial partnerships (clusters). The priority areas are identified from the higher-level goals or from the roadmap with the participation of politics, science and business. This generates a high level of cooperation and a shared commitment among the interest groups while simultaneously ensuring that gaps in technologies, business models and the development of value networks can be plugged.

9. Initiate an educational initiative to embed the central ideas of a CE and the systemic approach in relevant curricula
   The success of a transformation to a CE is substantially dependent on social acceptance and not least on active consumer engagement. The current social momentum for example in the debates around packaging waste and biodiversity can be harnessed here to position a CE as a potential solution. This is most effective in cooperation with existing social initiatives. Embedding CE concepts in the long term, however, also requires a review and updating of education at school, professional and university levels. Only once the principles of a CE and the net-positive economy have become part of the curriculum can it also be expected that the designers, engineers and design managers of the future will include them in their thinking.

10. Position Germany in the EU and internationally as a CE pioneer
    By designing a new future and actively shaping the European framework for a CE, Germany has the opportunity to position itself as a pioneer and so safeguard hard-won national success internationally. The export-oriented German economy will only see the full potential of a CE in an international context. At the same time, a CE offers Germany the opportunity to introduce a new perspective and new momentum into other international debates such as those around the Sustainable Development Goals, the two-degree or 1.5-degree target and the protection of biodiversity.

The *Circular Economy Initiative Deutschland (CEID),* initiated by acatech and SYSTEMIQ and funded by the German Federal Ministry of Education and Research (BMBF), will tackle these ten propositions in its work while its planned working groups will carry out in-depth investigations of individual elements. With its political mandate, the initiative will bring together business, science and societal stakeholders to develop a shared vision for Germany, to investigate specific applications and support their implementation and to identify enabling factors for a CE.

Using the knowledge gained during the compilation of this preliminary study, the *CEID* started its practical work and, by 2021, map out a pathway for Germany to draw the best possible benefit from the CE model.

6 Appendix

6.1 Examples of the Use of Resource Policy Instruments

The following table shows examples of resource policy instruments from other European countries and thus some of the results from a broad survey of all the interviewees. Examples which have progressed to different levels of implementation were deliberately selected.

Negative economic incentives	
Taxes	
	**Great Britain:** Plastic bag tax (5 pence per bag): demonstrable influence on consumer behaviour, encouragement to use reusable carrier bags, 80 per cent drop in sales just in the first year after implementation.
Fees	
	**Slovakia:** Legislation for the introduction of a bottle deposit for plastics bottles set in train.
	**Netherlands:** Significant increase in waste fee from € 13.21 per 1000 kg in 2018 to € 32.12 per 1000 kg in 2019.

Positive economic incentives	
Tax relief	
	**Portugal:** Tax reductions on car and motorcycle repairs, on research and development costs for SMEs (general; additional reductions for ecodesign R&D).
	**Luxembourg:** Reduced tax rate of eight per cent on repairs to bicycles, shoes, leather goods, for clothing alterations and home textiles. A further reduction to three per cent is currently being checked for compliance with European legislation.
	**France:** Reduction of value-added tax on CE-related activities, at the planning stage.
Subsidies	
	**Portugal:** Grants for CE projects by businesses, universities and local authorities (funding rate 85 per cent on average, no repayment).
	**Netherlands-Friesland:** Funding for SMEs to develop circular business models; assistance with funding applications at the national and EU level.

Information instruments

Public information campaigns

France: "National Debate" to facilitate political participation by citizens: public dialogue between policy makers and citizens, web portal with function for submitting criticism and suggestions. One part of the National Debate addresses the environmental transformation of the country. This clearly revealed that environmental issues and a CE are important to citizens.

Scotland: Annual "Pass It On Week": mobilization of citizens to arrange swap, donation or repair activities. Material is provided online with guidelines and ideas for successful implementation.[217]

Great Britain: "Love Food Hate Waste" campaign to educate citizens about preventing food waste and provide tips for avoiding it.[218]

Ecolabels

Luxemburg: The aim of the "SuperDrecksKëscht" "Clever akafen" campaign is to raise the visibility of environmentally friendly and low-waste products in commerce and help consumers choose sustainably. Selected products in participating supermarkets and specialist retailers are marked with a "Clever akafen" (shop smart) label.[219]

LENOZ – sustainable construction certificate, sustainability assessment system for buildings.[220]

Business advice service

Scotland: "Circular Economy Support Service" and "Resource Efficient Scotland Programme": expert advice and assistance for SMEs for introducing energy efficiency and circularity measures.

Luxembourg: Fit4Circularity programme: workshops and conferences to get CE issues on the innovation agenda in businesses.[221]

Portugal: "Vale Economia Circular" supports CE advice services for businesses.

Other

Finland: List of best practice examples from businesses and cities in the implementation of CE measures.

Netherlands-Friesland: Large-scale survey of regional SMEs in order to develop evidence-based policies for implementing circular business models.

217 | See Recycle for Scotland 2019.
218 | See WRAP 2018.
219 | See SDK 2019.
220 | See 1nergie S.A. 2018.
221 | See Luxinnovation n.d.

Regulatory incentives

Extended producer responsibility

Luxembourg: "Ecobatterien" is a non-profit association which organises separate collection of primary and secondary batteries for portable, industrial and vehicle applications and proper, environmental disposal and recycling.[222]

France: There are 14 mandatory EPR regulations which cover far more than the EU-specified product streams. Examples include EPR systems for furniture, tyres, printing paper and infectious healthcare waste.

Standardization

Great Britain: Standardization for the use of polymers at the planning stage.

Netherlands-Friesland: Standardization for the construction sector at the planning stage.

Public procurement

Finland: Establishment of a competence centre for sustainable and innovative public procurement in 2018, for example to support cities in also taking account of CE aspects for future procurement.

Slovakia: Third "National Action Plan for Green Public Procurement" (2016-2020) with twelve priority product groups already in force.

Scotland: Inclusion of lifetime cost and life cycle factors in public procurement, process under way.

Portugal: Strategy for green public procurement with 20 product groups, for six of which corresponding lists of criteria and indicators have been developed. Another six product groups are set to be underpinned by indicators in 2019.

Other

Netherlands: The "Dutch Green Deals" enable businesses to request a review of legislation which impedes CE business models.

222 | See Ecobatterien n.d.

Education and research

Establishment of university departments and courses

Scotland: Various Scottish universities are currently developing CE Master's degree programmes.

Portugal: Master's degree programme in "Eco Design for Circular Economy" at the University of Aveiro; "Industrial Ecology" is part of the syllabus for environmental and mechanical engineering courses.

Netherlands: There are already four Master's degree programmes at three different universities dedicated to CE.

Integration into general education

Finland: Finnish educational reform: integration of CE issues into existing syllabuses from nursery to university level.

Netherlands-Friesland: "Spark the Movement" – programme to support educational institutions with structurally integrating CE teaching content.[222]

Portugal: National strategy for environmental education – one pillar of which is a CE. Funding from the Environmental Funding Program is available for implementing the strategy.

Earmarking of research budget

Slovakia: The national funding programme for supporting research and development (2019-2023) is set to provide 112 million euro for research and development into materials and products based on domestic raw materials and efficiently recovered secondary materials. One sub-item of this research priority is "Effective processing of strategically important raw materials as a basis for the Circular Economy". The funding programme is still going through the approval process.

Other

Netherlands-Friesland: Professional development for all public sector staff to inform them about CE issues and enable them to take CE-compliant decisions.

Slovakia: In 2017, the Slovakian government set up a Green Education Fund in collaboration with the commercial and non-governmental sector. This fund is an innovative instrument for fostering environmental awareness and environmental education. A second edition is currently in preparation.

Slovenia: CEL.CYCLE: With EU co-funding, 21 companies have come together to research, develop and manufacture in line with a CE in order to scale the potential of biomass for a CE.

Voluntary commitments

Scotland: SWITCH – Scottish Waste Industry Training, Competence, Health & Safety Forum – aims to assume a pioneering role in raising standards in health and safety, training and development and technical skills and to foster Scotland's resource management industry.

Finland: "Society's Commitment to Sustainable Development" as an instrument for creating a common system of values and arrive at shared areas of responsibility in the form of a society-wide "competition". Businesses, training institutions, administrative bodies, parties, local authorities and other stakeholders can enter into specific operational commitments in order to contribute to making the common goals a reality.

6.2 List of Publications and Interviewees

Denmark

Ministry of Environment and Food: *The Advisory Board for Circular Economy. Recommendations for the Danish Government*, Copenhagen 2017.

Ministry of Environment and Food/Ministry of Industry, Business and Financial Affairs: *Strategy for Circular Economy. More value and better environment through design, consumption, and recycling*, Copenhagen 2018.

Interviewee:
Tobias Beck, *Team leader for Circular Economy, Resources and Utilities, Ministry of Environment and Food of Denmark*

England

London Waste and Recycling Board: *London's Circular Economy Route Map*, London 2017.

The Waste and Resources Action Programme (WRAP): *Resource Revolution: Creating the Future. WRAP's plan. 2015-2020*, 2015. URL: www.wrap.org.uk/sites/files/wrap/WRAP-Plan-Resource-Revolution-Creating-the-Future.pdf [as at: 13.05.2019].

Interviewees:
Stuart Ferguson, *Head of Investment, London Waste and Recycling Board*
Peter Skelton, *Strategic Partnerships Manager, WRAP Global*

Finland

The Finnish Innovation Fund Sitra: *Leading the cycle. Finnish road map to a circular economy 2016-2025*, Helsinki 2016.

The Finnish Innovation Fund Sitra: *The critical move. Finland's road map to a circular economy 2.0*, 2019. URL: https://www.sitra.fi/en/projects/critical-move-finnish-road-map-circular-economy-2-0/#challenge [as at: 13.05.2019].

Interviewees:
Laura Järvinen, *Specialist in Circular Economy, Finnish Innovation Fund Sitra*
Leena-Kaisa Piekkari, *Expert, Ministry of the Environment*

France

Ministry for an Ecological and Solidary Transition/Ministry for the Economy and Finance: *50 measures for a 100% circular economy*, Paris 2018.

Interviewees:
Marline Weber, *Chargée de mission affaires juridiques, Institut National de l'Économie Circulaire*

Italy

Ministry of Economic Development and Ministry of Environment, Land & Sea/Ministry of Economic Development: *Towards a Model of Circular Economy for Italy. Overview and Strategic Framework*, Rome 2017.

Luxembourg

EPEA Internationale Umweltforschung GmbH: *Luxembourg as a knowledge capital and testing ground for the circular economy. National roadmap to positive impacts. Tradition, Transition, Transformation*, Luxembourg 2014.

Interviewees:
Tock Christian, *PhD, Attaché, Director Sustainable Technologies, Ministry of the Economy*
Jeannot Schroeder, *Partner, Positive ImpaKT*

The Netherlands

Ministry of Infrastructure and Water Management/Ministry of Economic Affairs and Climate Policy/Ministry of Foreign Affairs/Ministry of the Interior and Kingdom Relations: *A circular Economy in the Netherlands by 2050. Government-wide Programme for a Circular Economy*, The Hague 2016.

Keurentjes, J./Augustijn, A./Kohl, J./de Boer, S./Vierstra, J./Roest, S./Verkoren, M./van Loon, M./Bakker, F./van der Giessen, T./van Crevel, R./van den Berg, D./van Arkel, G./Kooloos, R./de Ruijter, E./Stijnen, T./Passenier, A./de Jong, H./Hamelink, M.: *Transition agenda Plastics*, 2018. URL: https://hollandcircularhotspot.nl/wp-content/uploads/ 2018/06/TRANSITION-AGENDA-PLASTICS_EN.pdf [as at: 13.05. 2019].

Rakhorst, A.-M./Boekkooi, M./Dalm, V./Spanbroek, N./ter Grote, T./Roeleveld, T./Heideveld, A./Westra S./van de Pol, M./Wentink, C./Passenier, A./Rohde, J./Hoogendoorn, D./Prinsen, O./

Hinfelaar, J./Vierstra, J.: *Transition agenda Consumer Goods*, 2018. URL: https://hollandcircularhotspot.nl/wp-content/uploads/ 2018/06/TRANSITION-AGENDA-CONSUMER-GOODS_EN.pdf [as at: 13.05.2019].

Interviewees:

Tjitske IJpma, *Senior Policy Advisor, Department for International Affairs, Dutch Ministry of Infrastructure & Water Management*
Sander Bos, *Programme coordinator, Innovatiepact Fryslân*

Portugal

Ministry of the Environment/Ministry of the Economy/Ministry of Agriculture, Forestry and Rural Development/Ministry of Science, Technology and Education: *Leading the transition. Action plan for circular economy in Portugal 2017-2020*, Lisbon 2017.

Interviewees:

Alexandra Ferreira de Carvalho, *Secretary-General, Ministry of Environment and Energy Transition of Portugal*
Inês Costa, *Aide to the Minister, Ministry of Environment and Energy Transition of Portugal*

Scotland

The Scottish Government: *Making things last: A circular economy strategy for Scotland*, Edinburgh 2016.

Interviewees:

Ian Gulland, *Director, Zero Waste Scotland*
Michael Lenaghan, *Environmental Policy Advisor, Zero Waste Scotland*
Callum Blackburn, *Head of Policy, Research and Evaluation, Zero Waste Scotland*

Slovakia

Organisation for Economic Co-operation and Development (OECD): *Making the Slovak Republic a more resource efficient economy* (OECD Environment Policy Paper No. 7), 2017. URL: https://www.oecd.org/environment/waste/Policy-Paper-Making-the-Slovak-Republic-a-more-resource-efficient-economy.pdf [as at: 13.05.2019].

Interviewees:

Milan Chrenko, *Director General, Directorate for Environmental Policy, EU and International Relations, Ministry of Environment of the Slovak Republic*
Barbora Bondorová, *Head of Environmental Policy Department, Directorate for Environmental Policy, EU and International Relations, Ministry of Environment of the Slovak Republic*

Slovenia

Godina Košir, L./Korpar, N./Potočnik, J./Kocjančič, R.: *Roadmap towards the circular economy in Slovenia*, Ljubljana: Ministry of the environment and spatial planning 2018.

Interviewees:

Janez Potočnik, *Co-Chair UNEP International Resource Panel (IRP), former EU Commissioner, Partner at SYSTEMIQ*
Ladeja Godina Košir, *Founder and Executive Director, Circular Change*
Niko Korpar, *Project Manager and Circular Economy Expert, Circular Change*

List of Figures

Bibliography

1nergie S.A. 2018
1nergie S.A.: *Lenoz Zertifizierung*, 2018. URL: https://www.1nergie.lu/de/produkt/lenoz [as at: 12.04.2019].

A.G. Pheifer 2017
A.G. Pheifer: *Barriers & Enablers. To Circular Business Models* (ValueC Whitepaper), 2017. URL: https://www.circulairondernemen.nl/uploads/4f4995c266e00bee8fdb8fb34fbc5c15.pdf [as at: 12.04.2019].

acatech et al. 2017
acatech/Leopoldina/Akademienunion (Eds.): *Rohstoffe für die Energiewende: Wege zu einer sicheren und nachhaltigen Versorgung* (Science-based Policy Advice publication series), Berlin 2017.

Agora Energiewende/Agora Verkehrswende 2018
Agora Energiewende/Agora Verkehrswende (Ed.): *Die Kosten von unterlassenem Klimaschutz für den Bundeshaushalt, Die Klimaschutzverpflichtungen Deutschlands bei Verkehr, Gebäuden und Landwirtschaft nach der EU-Effort-Sharing-Entscheidung und der EU-Climate-Action-Verordnung*, Berlin 2018.

Allwood 2014
Allwood, J.M.: "Squaring the Circular Economy: The Role of Recycling within a Hierarchy of Material Management Strategies". In: Worrell, E./Reuter, M. (Eds.): *Handbook of Recycling*, Waltham, MA: Elsevier 2014, p. 445-477.

Allwood et al. 2017
Allwood, J.M./Gutowski, T.G./Serrenho, A.C./Skelton, A.C.H./Worrell, E.: "Industry 1.61803: The Transition to an Industry with Reduced Material Demand Fit for a Low Carbon Future". In: *Philosophical Transactions of the Royal Society A*, 375: 20160361, 2017, p. 1-31.

Amit/Zott 2010
Amit, R./Zott, C.: "Business Model Innovation: Creating Value in Times of Change". In: *IESE Business School Working Paper*, 870, 2010.

Angerer et al. 2016
Angerer, G./Buchholz, P./Gutzmer, J./Hagelüken, C./Herzig, P./Littke, R./Thauer, R.K./Wellmer, F.-W.: *Rohstoffe für die Energieversorgung der Zukunft: Geologie – Märkte – Umwelteinflüsse* (Energy Systems of the Future publication series), Munich 2016.

Antikainen et al. 2018
Antikainen, M./Uusitalo, T./Kivikytö-Reponen, P.: "Digitalisation as an Enabler of Circular Economy". In: *Procedia CIRP*, 73, 2018, p. 45-49.

BAFU/ERA-NET ECO-INNOVERA 2014
Bundesamt für Umwelt (BAFU)/ERA-NET ECO-INNOVERA (Ed.): *Internationale Studie über Öko-Innovationspärke. Erkenntnisse zur räumlichen Dimension von Öko-Innovation* (Summary of publication "International Survey on Eco-innovation Parks"), Bern 2014.

Bakker et al. 2014
Bakker, C./Wang, F./Huisman, J./den Hollander, M.: "Products That Go Round: Exploring Product Life Extension Through Design". In: *Journal of Cleaner Production*, 69, 2014, p. 10-16.

BMBF 2010
Bundesministerium für Bildung und Forschung (BMBF): *Nationale Forschungsstrategie BioÖkonomie 2030. Unser Weg zu einer biobasierten Wirtschaft* (Research), Berlin 2010.

BMBF 2018a
Bundesministerium für Bildung und Forschung (BMBF): *Ressourceneffiziente Kreislaufwirtschaft. Forschungskonzept für eine kreislaufoptimierte Wirtschaftsweise*, Bonn 2018.

BMBF 2018b
Bundesministerium für Bildung und Forschung (BMBF)*: Forschung und Innovation für die Menschen - Die Hightech-Strategie 2025,* Berlin, 2018.

BMEL 2019
Bundesministerium für Ernährung und Landwirtschaft (BMEL): *Zu gut für die Tonne*, 2019. URL: https://www.zugutfuerdietonne.de/ [as at: 12.04.2019].

BMU/BMJV/BMEL 2017
Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (BMU)/Bundesministerium der Justiz und für Verbraucherschutz (BMJV)/Bundesministerium für Ernährung und Landwirtschaft (BMEL) (Eds.): *Nationales Programm für Nachhaltigen Konsum. Gesellschaftlicher Wandel durch einen nachhaltigen Lebensstil*, Berlin: 2017.

BMJV 2012
Bundesministerium der Justiz und für Verbraucherschutz (BMJV): "Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Bewirtschaftung von Abfällen (Kreislaufwirtschaftsgesetz – KrWG): § 6 Abfallhierarchie". In: *German Resource Management Act of 24 February 2012 (Federal Law Gazette I, p. 212), as most recently amended by article 2, para. 9 of the Act of 20 July 2017 (Federal Law Gazette I, p. 2808)*.

BMU 2013
Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU): *Abfallvermeidungsprogramm des Bundes unter Beteiligung der Länder*, Bonn 2013.

BMU 2016
Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU): *Klimaschutzplan 2050. Klimaschutzpolitische Grundsätze und Ziele der Bundesregierung,* 2nd edition, Berlin 2016.

BMU 2018a
Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU): *GreenTech Made in Germany 2018. Umwelttechnik-Atlas für Deutschland*, Berlin 2018.

BMU 2018b
Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU): *Klimaschutz in Zahlen. Fakten, Trends und Impulse deutscher Klimapolitik*, Berlin 2018.

BMU 2019a
Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU): *Klimaschutzbericht 2018 zum Aktionsprogramm Klimaschutz 2020 der Bundesregierung*, Berlin 2019.

BMU 2019b
Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU): *NaRess – Nationale Plattform für Ressourceneffizienz*, Berlin 2019.

BMUB/UBA 2015
Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (BMUB)/Umweltbundesamt (UBA) (Eds.): *Ecodesignkit*, 2015. URL: https://www.ecodesignkit.de/home-willkommen/ [as at: 12.04.2019].

BMUB 2016
Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorschutz (BMUB): *Deutsches Ressourceneffizienzprogramm II. Programm zur nachhaltigen Nutzung und zum Schutz der natürlichen Ressourcen*, Berlin 2016.

BMUB/Schäfer & Breuss 2016
Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (BMUB)/Schäfer & Breuss: *Den ökologischen Wandel gestalten. Integriertes Umweltprogramm 2030*, Berlin 2016.

BMWi 2010
Bundesministerium für Wirtschaft und Technologie (BMWi): *Rohstoffstrategie der Bundesregierung. Sicherung einer nachhaltigen Rohstoffversorgung Deutschlands mit nicht-energetischen mineralischen Rohstoffen*, Berlin 2010.

Braungart/McDonough 2002
Braungart, M./McDonough, W.: *Cradle to Cradle. Remaking the Way We Make Things,* New York: North Point Press 2002.

Bringezu/Schütz 2014
Bringezu, S./Schütz, H.: *Indikatoren und Ziele zur Steigerung der Ressourcenproduktivität. Arbeitspapier 1.4. im Projekt Ressourcenpolitik: Analyse der ressourcenpolitischen Debatte und Entwicklung von Politikoptionen (PolRess)*, 2014. URL: https://refubium.fu-berlin.de/bitstream/handle/fub188/19686/PolRessxAP1_IndikatorenxundxZielexzurxSteigerungxderxRessourcenproduktivitxt_WI.pdf?sequence=1&isAllowed=y [as at: 10.05.2019].

Bruel et al. 2018
Bruel, A./Kronenberg, J./Troussier, N./Guillaume, B.: "Linking Industrial Ecology and Ecological Economics: A Theoretical and Empirical Foundation for the Circular Economy". In: *Journal of Industrial Ecology*, 23: 1, 2018, p. 12-21.

BSI 2019
The British Standards Institution (BSI): *The Rise of the Circular Economy. BS 8001 – A New Standard is Available*. 2019. URL: https://www.bsigroup.com/en-GB/standards/benefits-of-using-standards/becoming-more-sustainable-with-standards/BS8001-Circular-Economy/ [as at: 12.04.2019].

BUND 2019
Bund für Umwelt und Naturschutz Deutschland (BUND): *Ein Schritt in Richtung – Ausstieg aus der Wegwerfgesellschaft. Nachhaltigkeit, Naturschutz, Ressourcen & Technik*, 2019. URL: https://www.bund.net/service/presse/pressemitteilungen/detail/news/ein-schritt-in-richtung-ausstieg-aus-der-wegwerfgesellschaft/ [as at: 12.04. 2019].

Bundesregierung 2002
Bundesregierung: *Perspektiven für Deutschland – Unsere Strategie für eine nachhaltige Entwicklung,* Berlin: Presse- und Informationsamt der Bundesregierung (Ed.) 2002.

Bundesregierung 2018
Bundesregierung: *Deutsche Nachhaltigkeitsstrategie. Aktualisierung 2018*, Berlin: Presse- und Informationsamt der Bundesregierung (Ed.) 2018.

Business.gov.nl n.d.
Business.gov.nl: *Green Deal*. URL: https://business.gov.nl/subsidy/

green-deal/ [as at: 12.04.2019].

C2C 2019
The Cradle to Cradle Products Innovation Institute (C2C): *Home page.* 2019. URL: https://www.c2ccertified.org [as at: 12.04.2019].

Cambridge Econometrics 2014
Cambridge Econometrics: *Study on Modelling of The Economic and Environmental Impacts of Raw Material Consumption* (European Commission Technical Report 2014-2478). Luxembourg: Publications Office of the European Union 2014.

CIRAIG 2015
International Reference Centre for the Life Cycle of Products Processes and Services (CIRAIG): *Circular Economy: A Critical Literature Review of Concepts,* 2015. URL: http://www.ciraig.org/pdf/CIRAIG_Circular_Economy_Literature_Review_Oct2015.pdf [as at: 12.04.2019].

Connell et al. 1995
Connell, J. P./Kubisch, A. C./Schorr, L. B./Weiss, C. H. (Eds.): *New Approaches to Evaluating Community Initiatives. Concepts, Methods, and Contexts*, Washington DC: The Aspen Institute, 1995.

Crutzen 2002
Crutzen, P. J.: "Geology of Mankind". In: *Nature*, 415: 6867, 2002, p. 23.

CSCP n.d.
Collaborating Centre on Sustainable Consumption and Production (CSCP): URL: https://www.scp-centre.org/ [as at: 9.06.2019].

Destatis 2019a.
Destatis (Statistisches Bundesamt): Bruttoinlandsprodukt 2018 für Deutschland. URL: https://www.destatis.de/DE/Presse/Pressekonferenzen/2019/BIP2018/pressebroschuere-bip.pdf?__blob=publicationFile&v=3 [as at: 13.05.2019].

Destatis 2019b.
Destatis (Statistisches Bundesamt): Volkswirtschaftliche Gesamtrechnungen. URL: https://www.destatis.de/DE/Themen/Wirtschaft/Volkswirtschaftliche-Gesamtrechnungen-Inlandsprodukt/anlagevermoegen-vermoegensrechnung.html [as at: 13.05.2019].

de Jesus/Mendonça 2018
de Jesus, A./Mendonça, S.: "Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy". In: *Ecological Economics*, 145, 2018, p. 75-89.

di Maio/Rem 2015
di Maio, F./Rem, P.: "A Robust Indicator for Promoting Circular Economy through Recycling". In: *Journal of Environmental Protection*, 6: 10, 2015, p. 1095-1104. URL: https://www.scirp.org/journal/PaperInformation.aspx?PaperID=60160 [as at: 12.04.2019].

Dobos/Richter 2006
Dobos, I./Richter, K.: "A Production/Recycling Model With Quality Consideration". In: *International Journal of Production Economics*, 104: 2, 2006, p. 571-579.

Du et al. 2012
Du, Y./Cao, H./Liu, F./Li, C./Chen, X.: "An Integrated Method for Evaluating the Remanufacturability of Used Machine Tool". In: *Journal of Cleaner Production*, 20: 1, 2012, p. 82-91.

EASAC 2016
European Academies Science Advisory Council (EASAC): *Indicators for a Circular Economy* (EASAC Policy Report 30), Halle: Deutsche Akademie der Naturforscher Leopoldina (Ed.), 2016.

ECN 2015
European Compost Network (ECN): Certification of ECN-QAS. URL: https://www.compostnetwork.info/ecn-qas/quality-mark/ [as at: 20.04.2019].

Ecobatterien n.d.
Ecobatterien: *Home page*. URL: http://www.ecobatterien.lu/de/ [as at: 12.04.2019].

EESC 2018
European Economic and Social Committee (EESC): *Monitoring Framework for the Circular Economy* (Communication), 2018. URL: https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/monitoring-framework-circular-economy-communication [as at: 12.04.2019].

EESC 2019
European Economic and Social Committee (EESC): *Circular economy strategies and roadmaps in Europe. Identifying synergies and the potential for cooperation and alliance building*. Final Report, 2019. URL: https://www.eesc.europa.eu/sites/default/files/files/qe-01-19-425-en-n.pdf [as at: 02.05.2019].

Ellen MacArthur Foundation 2013
Ellen MacArthur Foundation: *Towards the Circular Economy. Economic and Business Rationale for an Accelerated Transition*, 2013. URL: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf [as at: 12.04.2019].

Ellen MacArthur Foundation 2015
Ellen MacArthur Foundation: *Potential for Denmark as a Circular Economy. A Case Study from: Delivering the Circular Economy – A Toolkit for Policy Makers*, 2015. URL: https://www.ellenmacarthurfoundation.org/assets/downloads/20151113_DenmarkCaseStudy_FINALv02.pdf [as at: 12.04.2019].

Ellen MacArthur Foundation 2019
Ellen MacArthur Foundation: *Cities and the Circular Economy for Food*, 2019. URL: https://www.ellenmacarthurfoundation.org/assets/downloads/Cities-and-Circular-Economy-for-Food_280119.pdf [as at: 12.04.2019].

Ellen MacArthur Foundation et al. 2015
Ellen MacArthur Foundation/Granta Design/LIFE EU: *Circularity Indicators. An Approach to Measure Circularity* (Methodology), 2015. URL: https://www.ellenmacarthurfoundation.org/assets/downloads/insight/Circularity-Indicators_Methodology_May2015.pdf [as at: 12.04.2019].

Ellen MacArthur Foundation et al. 2017
Ellen MacArthur Foundation/SUN Institute/SYSTEMIQ: *Achieving Growth Within. A €320-Billion Investment Opportunity to Accelerate Europe's Circular Economy Transition*, 2017. URL: https:// www.ellenmacarthurfoundation.org/assets/downloads/publications/Achieving-Growth-Within-20-01-17.pdf [as at: 12.04.2019].

EPRS/Bourguignon 2016
European Parliamentary Research Service (EPRS)/Bourguignon, D.: *Circular Economy Package. Four Legislative Proposals On Waste. Briefing EU Legislation in Progress*, January 2016. URL: http://www.europarl.europa.eu/EPRS/EPRS-Briefing-573936-Circular-economy-package-FINAL.pdf [as at: 12.04.2019].

ESPON n.d.
European Spatial Planning Observation Network (ESPON): *CIRCTER – Circular Economy and Territorial Consequences*. URL: https://www.espon.eu/circular-economy [as at: 12.04.2019].

Council of Europe 2018
Council of Europe: *Outcome of Proceedings. Delivering on the EU Action Plan for the Circular Economy – Council Conclusions.* (Annex, 10447/18, DG E 1A, published on 25.06.2018). URL: https://www.consilium.europa.eu/media/35781/st10447-en18.pdf [as at: 12.04.2019].

European Commission 2005
European Commission: *EU Waste Policy. The Story Behind the Strategy*, 2005. URL: http://ec.europa.eu/environment/waste/pdf/story_book.pdf [as at: 12.04.2019].

European Commission 2015
European Commission: "Den Kreislauf schließen – Ein Aktionsplan der EU für die Kreislaufwirtschaft" (Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 02.12.2015). URL: https://eur-lex.europa.eu/legal-content/DE/TXT/HTML/?uri=CELEX:52015DC0614&from=EN [as at: 12.04.2019].

European Commission 2016
European Commission: *Ökodesign-Arbeitsprogramm 2016–2019* (Communication from the Commission, COM(2016) 773 final, 30.11.2016). URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016DC0773 [as at: 12.04.2019].

European Commission 2017
European Commission: *Circular Economy Research and Innovation. Connecting Economic & Environmental Gains* (Research and Innovation), Brussels 2017.

European Commission 2018a
European Commission: *Report on Critical Raw Materials and the Circular Economy* (Commission Staff Working Document, Part 1/3, 16.01.2018). URL: https://ec.europa.eu/docsroom/documents/27327/attachments/1/translations/en/renditions/native [as at: 12.04.2019].

European Commission 2018b
European Commission: *A Clean Planet for All a European Strategic Long-Term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy* (Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank, 28.11.2 URL: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN [as at: 12.04.2019].

European Commission 2018c
European Commission: *Öffentliche Auftragsvergabe zur Förderung der Kreislaufwirtschaft. Bewährte Verfahren und Leitlinien*, Luxembourg: Publications Office of the European Union 2018.

European Commission 2018d
European Commission: "European Commission Tackles Barriers to Innovation: the Second Innovation Deal Focuses on Batteries for Electric Vehicles" (press release, 12.03.2018). URL: https://ec.europa.eu/info/news/european-commission-tackles-barriers-innovation-second-innovation-deal-focuses-batteries-electric-vehicles-2018-mar-12_en [as at: 12.04.2019].

European Commission 2019
European Commission: *Bericht der Kommission an das Europäische Parlament, den Rat, den Europäischen Wirtschafts- und Sozialausschuss und den Ausschuss Der Regionen über die Umsetzung des Aktionsplans für die Kreislaufwirtschaft* (Swd (2019) 90 Final, 04.03.2019). URL: https://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:52019DC0190&from=EN [as at: 12.04.2019].

European Commission et al. 2014
European Commission/Cambridge Econometrics/BIO Intelligence Service: *Study on Modelling of the Economic and Environmental Impacts of Raw Material Consumption* (Technical report 2014-2478, 09.04.2014). URL: https://publications.europa.eu/en/publication-detail/-/publication/15b47bd3-ce94-46a4-99a9-2206f4fdc658/language-en [as at: 12.04.2019].

European Parliament 2018
European Parliament: *Parliamentary Questions. Question for Oral Answer O-000087/2018*, 2018. URL: http://www.europarl.europa.eu/doceo/document/O-8-2018-000087_EN.html?redirect [as at: 12.04.2019].

European Union 2018
European Union: "Rechtsvorschriften L150". In: *Official Journal of the European Union*, 61, 2018, p. 1-168. URL: https://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=OJ:L:2018:150:FULL&from=EN [as at: 12.04.2019].

Eurostat 2018
Eurostat: *Eco-innovation index*, 2018. URL: https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=t2020_rt200&plugin=1 [as at: 12.04.2019].

Eurostat n.d.
Eurostat: *Circular Economy Monitoring Framework*. URL: https://ec.europa.eu/eurostat/web/circular-economy/indicators/monitoring-framework [as at: 12.04.2019].

Ex'tax Project et al. 2016
The Ex'tax Project Foundation/Cambridge Econometrics/Trucost/Deloitte/EY/KPMG Meijburg/PwC: *New Era. New Plan. Europe. A Fiscal Strategy for an Inclusive, Circular Economy,* Utrecht 2016.

FCT 2019
Fundação para a Ciência e a Tecnologia: *Agenda Temática de Investigação e Inovação. Economia Circular*, 2019. URL: https://www.fct.pt/agendastematicas/docs/Agenda_Economia_Circular_Final.pdf [as at: 02.05.2019].

Fennemann et al. 2017
Fennemann, V./Hohaus, C./Kopka, J.-P.: "Circular Economy Logistics: Für eine Kreislaufwirtschaft 4.0". In: ten Hompel, M./Henke, M./Clausen, U.: *Future Challenges in Logistics and Supply Chain Management* (Whitepaper Fraunhofer-Institut für Materialfluss und Logistik IML), Dortmund 2017.

FES 2016
Friedrich-Ebert-Stiftung (FES) (Ed.): *Germany on the Road to a Circular Economy?* (Wiso Diskurs, 10, 2016), Bonn 2016.

FinanCE 2016
Working Group FinanCE: *Money Makes the World Go Round (and Will it Help to Make the Economy Circular As Well?)* (PGGM, March 2016). URL: https://usfl-new.wp.hum.uu.nl/wp-content/uploads/sites/232/2016/04/FinanCE-Digital.pdf [as at: 12.04.2019].

FNR 2009
Fachagentur Nachwachsende Rohstoffe e.V. (FNR): *Aktionsplan der Bundesregierung zur stofflichen Nutzung nachwachsender Rohstoffe*, Berlin: Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (Ed.) 2009.

Foulon 2018
Foulon, M.: *Un Défi "Rien de Neuf" à Grande Echelle pour 2019*, 2018. URL: https://www.zerowastefrance.org/un-defi-rien-de-neuf-a-grande-echelle-pour-2019/ [as at: 12.04.2019].

Franklin-Johnson et al. 2016
Franklin-Johnson, E./Figge, F./Canning, L.: "Resource Duration as a Managerial Indicator for Circular Economy Performance". In: *Journal of Cleaner Production*, 133: 1, 2016, p. 589-598.

Fraunhofer UMSICHT 2017
Fraunhofer-Institut für Umwelt-, Sicherheit- und Energietechnik UMSICHT (Ed.): *Studie zur Circular Economy im Hinblick auf die chemische Industrie* (study commissioned by the German chemical industry association (VCI)), Oberhausen 2017.

Frietsch et al. 2018
Frietsch, R./Schubert, T./Feidenheimer, A./Rammer, C.: *Innovations Indikator 2018*, Berlin: Bundesverband der deutschen Industrie e.V. (BDI) 2018.

Ghisellini et al. 2016
Ghisellinia, P./Cialanib, C./Ulgiati, S.: "A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems". In: *Journal of Cleaner Production*, 114, 2016, p. 11-32.

Global Footprint Network 2018
Global Footprint Network: *Home*, 2018. URL: http://data.footprintnetwork.org/ [as at: 03.04.2019].

Hagelüken 2018
Hagelüken, C.: "Will it Go Round in Circles? Why a Circular Economy is Essential for Emerging Technologies – And How to Get There" (Going Green – CARE INNOVATION 2018, Wien, 26-29 Nov.), 2018.

Haupt et al. 2017
Haupt, M./Vadenbo, C./Hellweg, S.: "Do We Have the Right Performance Indicators for the Circular Economy? Insight into the Swiss Waste Management System". In: *Journal of Industrial Ecology,* 21: 3, 2017, p. 615-627.

Hieminga 2015
Hieminga, G.: *Rethinking Finance in a Circular Economy. Financial Implications of Circular Business Models* (ING Economics Department), 2015. URL: https://www.ing.nl/media/ING_EZB_Financing-the-Circular-Economy_tcm162-84762.pdf [as at: 12.04.2019].

Hightech-Forum 2017
Hightech-Forum: *Gemeinsam besser: Nachhaltige Wertschöpfung, Wohlstand und Lebensqualität im digitalen Zeitalter – Innovationspolitische Leitlinien des Hightech-Forums*, Berlin: Hightech-Forum 2017.

Hilty 2008
Hilty, L.: *Information Technology and Sustainability: Essays on the Relationship between Information Technology and Sustainable Development*, Norderstedt 2008.

Hood 2016
Hood, B.: "Make Recycled Goods Covetable". In: *Nature*, 531, 2016, p. 438-440.

Huber 2000
Huber, J.: *Industrielle Ökologie: Konsistenz, Effizienz und Suffizienz in zyklusanalytischer Betrachtung*, Baden-Baden, 2000.

IIASA 2019
International Institute for Applied Systems Analysis (IIASA): *Science-based Targets Network Workshop*, 2019. URL: http://www.iiasa.ac.at/web/home/research/twi/190114-SBT.html [as at: 22.02.2019].

IPBES 2019
Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES*): Global Assessment Report on Biodiversity and Ecosystem Services: Summary for Policy Makers*, 2019. URL: https://www.ipbes.net/sites/default/files/downloads/summary_for_policymakers_ipbes_global_assessment.pdf [as at: 07. 05. 2019].

IPCC 2014
Intergovernmental Panel on Climate Change (IPCC): *Climate Change 2014 – Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects: Working Group II Contribution to the IPCC Fifth Assessment Report*, Cambridge, MA: Cambridge University Press 2014.

IPCC 2018
Intergovernmental Panel on Climate Change (IPCC): *Global Warming of 1.5 °C. An IPCC Special Report on the Impacts of Global Warming of 1.5 °C Above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*, Geneva: World Meteorological Organization 2018.

IRP 2011
International Resource Panel (IRP): *Decoupling Natural Resource Use and Environmental Impacts from Economic Growth*, Nairobi, Kenya: United Nations Environment Programme 2017.

IRP 2017
International Resource Panel (IRP): *Assessing Global Resource Use. A Systems Approach to Resource Efficiency and Pollution Reduction*, Nairobi, Kenya: United Nations Environment Programme 2017.

IRP 2018
International Resource Panel (IRP): *Redefining Value. The Manufacturing Revolution. Remanufacturing, Refurbishment, Repair and Direct Reuse in the Circular Economy*, Nairobi, Kenya: United Nations Environment Programme 2018.

IRP 2019
International Resource Panel (IRP): *Global Resources Outlook 2019: Natural Resources for the Future We Want*, Nairobi, Kenya: United Nations Environment Programme 2019.

Kauffmann/Dodick 2017
Kauffmann, D./Dodick, J.: The Route to Circular Economy. A Review of the European Union's Circular Economy Policy, 2017. URL: http://www.r2piproject.eu/wp-content/uploads/2017/04/A-Rview-of-the-European-Unions-Circular-Economy-Policy.pdf [as at: 12.04.2019].

Kirchherr et al. 2017
Kirchherr, J./Reike, D./Hekkert, M.: "Conceptualizing the Circular Economy: An analysis of 114 Definitions". In: *Resources, Conservation and Recycling*, 127, 2017, p. 221-232.

Kirchherr et al. 2018
Kirchherr, J./Piscicelli, L./Bour, R./ Kostense-Smit, E./Muller, J./Huibrechtse-Truijens, A./Hekkert, M.: "Barriers to the Circular Economy: Evidence from the European Union (EU)". In: *Ecological Economics*, 150, 2018, p. 264-272.

Korhonen et al. 2018
Korhonen, J./Honkasalo, A./Seppälä, J.: "Circular Economy: The Concept and its Limitations". In: *Ecological Economics*, 143, 2018, p. 37-46.

KPMG International 2017
KPMG International Cooperative (KPMG International): *Venture Pulse Q3 2017. Global Analysis of Venture Funding*, 11.10.2017. URL: https://assets.kpmg/content/dam/kpmg/de/pdf/Themen/2017/kpmg-venture-pulse-q3.pdf [as at: 12.04.2019].

LE Europe et al. 2018
LE Europe, VVA Europe, Ipsos, ConPolicy, Trinomics: *Behavioural Study on Consumers' Engagement in the Circular Economy,* Brussels 2018.

Luxinnovation n.d.
Luxinnovation: *Performance Programmes. Fit 4 Circularity*. URL: https://www.luxinnovation.lu/innovate-in-luxembourg/performance-programmes/fit-4-circularity/ [as at: 12.04.2019].

Magnier et al. 2017
Magnier, C./ Auzanneau M./ Calatayud P./ Gauche M./ Ghewy X./ Granger M./ Margontier S./ Pautard E.: *10 Key Indicators for Monitoring the Circular Economy,* 2017 Edition, La Défense cedex: The Monitoring and Statistics Directorate (SOeS) (Ed.) 2017.

March 1991
March, J.: "Exploration and Exploitation in Organizational Learning". In: *Organization Science*, 2: 1, 1991, p. 71-87.

Material Economics 2018
Material Economics Sverige AB: *The Circular Economy – A Powerful Force for Climate Mitigation. Transformative Innovation for Prosperous and Low-carbon Industry*, Stockholm 2018.

Max-Planck-Institut für Chemie 2019
Max-Planck-Institut für Chemie: *Fragen und Antworten zum ARD-Monitor-Beitrag vom 17.1.2019, ‚Feinstaub durch Landwirtschaft: Seit Jahren verharmlost'* (press release, 17.01.2019). URL: https://www.mpic.de/aktuelles/pressemeldungen/news/fragen-und-antworten-zum-monitor-beitrag-vom-1712019-feinstaub-durch-landwirtschaft-seit-jahren-verharmlost.html [as at: 12.04.2019].

Mazzucato 2015
Mazzucato, M.: *The Innovative State. Governments Should Make Markets, Not Just Fix Them. Foreign Affairs*, 2015. URL: https://www.foreignaffairs.com/articles/americas/2014-12-15/innovative-state [as at: 12.04.2019].

McCarthy et al. 2018
McCarthy A./Dellink, R./ Bibas, R.: *The Macroeconomics of the Circular Economy Transition: A Critical Review of Modelling Approaches* (OECD Environment Working Papers 130), Paris: OECD Publishing 2018.

Meadows et al. 1972
Meadows, D. H./Meadows, D. L./Randers, J./Behrens, W.: *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*, New York: Universe Books 1972.

Michelini et al. 2018
Michelini, G./Moraes, R./Cunha, R./Costa, J./Ometto, A.: "From Linear to Circular Economy: PSS Conducting the Transition". In: *Procedia CIRP*, 64, 2017, p. 2-6.

Moraga et al. 2019
Moraga, G./Huysveld, S./Mathieux, F./Blengini, G.A./Alaerts, L./Van Acker, K./de Meester, S./Dewulf, J.: "Circular Economy Indicators: What Do They Measure?" In: *Resources, Conservation & Recycling* 146, 452-461, 2019.

Myenergy Luxembourg 2017
Myenergy Luxembourg: "5. Klimapakt-Tag: ein einstimmiges Engagement mit vielfältigen Zukunftsperspektiven" (press release, 29.09.2017). URL: https://www.myenergy.lu/de/mediathek/news/5-klimapakt-tag-ein-einstimmiges-engagement-mit-vielfaeltigen-zukunftsperspektiven [as at: 12.04.2019].

Nasr et al. 2018
Nasr,N./Russell, J./Bringezu, S./Hellweg, S./Hilton, B./Kreiss, C./von Gries, N.: *Redefining Value. The Manufacturing Revolution. Remanufacturing, Refurbishment, Repair and Direct Reuse in the Circular Economy* (A Report of the International Resource Panel), Nairobi, Kenya: United Nations Environment Programme 2018.

Neubauer et al. 2017
Neubauer, C./Jones, M./Montevecchi, F./Schreiber, H./Tisch, A./Walter, B.: *Green Public Procurement and the EU Action Plan for the Circular Economy. Study for the ENVI Committee*, Brussels: European Parliament 2017.

NPE 2018
Nationale Plattform Elektromobilität (NPE): *Fortschrittsbericht 2018 – Markthochlaufphase*. URL: http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/NPE_Fortschrittsbericht_2018_barrierefrei.pdf [as at: 03.05.2019].

NPM n.d.
Nationale Plattform Zukunft der Mobilität (NPM): *Die Zukunft der Mobilität*. URL: https://www.plattform-zukunft-mobilitaet.de/ [as at: 12.04.2019].

OECD 2018
Organisation for Economic Co-operation and Development (OECD): *RE-CIRCLE: Resource Efficiency and Circular Economy*, 2018. URL: http://www.oecd.org/environment/waste/recircle.htm [as at: 26.04.2019].

OECD 2019
Organisation for Economic Co-operation and Development (OECD): *Global Material Resources Outlook to 2060. Economic Drivers and Environmental Consequences*, Paris: OECD Publishing 2019.

Paech 2012
Paech, N.: *Befreiung vom Überfluss: Auf dem Weg in die Postwachstumsökonomie*, Munich: oekom verlag 2012.

Pagoropoulos et al. 2017
Pagoropoulos, A./Pigosso, D./McAloone, T.: "The Emergent Role of Digital Technologies in the Circular Economy: A Review". In: *Procedia CIRP*, 64, 2017, p. 19-24.

Peters et al. 2018
Peters, J./Baumann, M./Weil, M.: "Recycling aktueller und zukünftiger Batteriespeicher: Technische, ökonomische und ökologische Implikationen: Ergebnisse des Expertenforums am 6. Juni 2018 in Karlsruhe". In: *KIT Scientific Working Papers, 99* (Institut für Technikfolgenabschätzung und Systemanalyse, Helmholtz-Institut Ulm), Karlsruhe: Karlsruher Institut für Technologie 2018.

Plattform Industrie 4.0 n.d.
Plattform Industrie 4.0: *Home page*, 2019. URL: https://www.plattform-i40.de/PI40/Navigation/DE/Home/home.html [as at: 12.04.2019].

Plattform KVK n.d.
Plattform Klimaverträglicher Konsum Deutschland (Plattform KVK): *Home page*. URL: http://www.plattform-kvk.de [as at: 12.04.2019].

Postpischil/Jacob 2017
Postpischil, R./Jacob, K.: *Ressourcenpolitische Innovationen in den EU Mitgliedsstaaten. Inspirationen für Deutschland?* (In-depth analysis in the Ressourcenpolitik 2 project, commissioned by the German Federal Ministry for the Environment and the German Environment Agency (FKZ: 3715 11 110 0), November 2017). URL: https://refubium.fu-berlin.de/bitstream/handle/fub188/22490/Postpischil%20Jacob%202017%20PolRess%20II%20VA%20RE%20Innovationen%20MS.pdf?sequence=1&isAllowed=y [as at: 12.04.2019].

Potočnik 2018
Potočnik, J.: *Personal correspondence, 5 September 2018 and 18 January 2019*.

Potting et al. 2018
Potting, J./Hanemaaijer, A. (Eds.)/Delahaye, R./Ganzevles, J./Hoekstra, R./Lijzen, J.: *Circular Economy: What we Want to Know and Can Measure. Framework and Baseline Assessment for Monitoring the Progress of the Circular Economy in the Netherlands* (Policy report), The Hague: PBL Netherlands Environmental Assessment Agency, 2018.

Pulp and Paper Institute n.d.
Pulp and Paper Institute: CEL.CYCLE. Discarded potentials of biomass. URL: http://celkrog.si/?lang=en# [as at: 14.05.2019].

Recycle for Scotland 2019
Recycle for Scotland: *Re-Use. Pass it on Week*, 2019. URL: https://www.recycleforscotland.com/re-use/passing-it [as at: 12.04.2019].

Riess/Held 2010
Riess, B./Held, J.: *Die iooi-Methode* (Bertelsmann Stiftung – Projektthemen), 2010. URL: https://www.bertelsmann-stiftung.de/de/unsere-projekte/abgeschlossene-projekte/cri-corporate-responsibility-index/projektthemen/die-iooi-methode/ [as at: 12.04.2019].

Ritzén/Sandström 2017
Ritzén, S./Sandström, G.: "Barriers to the Circular Economy – Integration of Perspectives and Domains". In: *Procedia CIRP*, 64, 2017, p. 7-12.

Rockström et al. 2009
Rockström, J./Steffen, W./Noone, K./Persson, Å./ Chapin, III, F.S./Lambin, E./Lenton, T.M./Scheffer, M./Folke, C./Schellnhuber, H./Nykvist, B./De Wit, C.A./Hughes, T./van der Leeuw, S./Rodhe, H./Sörlin, S./Snyder, P.K./Costanza, R./Svedin, U./Falkenmark, M./Karlberg, L./Corell, R.W./Fabry, V.J./Hansen, J./Walker, B.H./Liverman, D./Richardson, K./Crutzen, C./Foley, J.: "A Safe Operating Space for Humanity". In: *Nature*, 461: 24, 2009, p. 472-475.

Roland Berger/BVK/IE.F 2018
Roland Berger GmbH (Roland Berger)/Bundesverband Deutscher Kapitalbeteiligungsgesellschaften (BVK)/Internet Economy Foundation(IE.F) (Eds.): *Treibstoff Venture Capital. Wie wir Innovationen und Wachstum befeuern*, Munich 2018.

Sawanishi et al. 2015
Sawanishi, H./Torihara, K./Mishima, N.: "A Study on Disassemblability and Feasibility of Component Reuse of Mobile Phones". In: *Procedia CIRP*, 26, 2015, p. 740–745.

SBTi 2019
Science Based Targets (SBTi): *What is a Science Based Target?*, 2019. URL: https://sciencebasedtargets.org/what-is-a-science-based-target [as at: 29.02.2019].

Schmidt-Bleek 1994
Schmidt-Bleek, F.: "Wieviel Umwelt braucht der Mensch? MIPS – das Maß für ökologisches Wirtschaften", 1994. In: Wilts et al. (Eds.): *Benefits of Resource Efficiency in Germany* (short study), Wuppertal Institut, 2016.

Schmidt 2008
Schmidt, M.: "Die Bedeutung der Effizienz für Nachhaltigkeit – Chancen und Grenzen". In: Hartard, S./Schaffer, A./Giegrich, J. (Eds.): *Ressourceneffizienz im Kontext der Nachhaltigkeitsdebatte*, Baden-Baden Nomos-Verlag 2008, p. 31–46.

Schmidt et al. 2019
Schmidt, M./Spieth, H./Haubach, C./Kühne, C. (Eds.): *100 Pioneers in Efficient Resource Management. Best Practice Cases from Producing Companies*, Berlin: Springer Verlag 2019.

Schroeder et al. 2018
Schroeder, P./Anggraeni, K./Weber, U.: "The Relevance of Circular Economy Practices to the Sustainable Development Goals". In: *Journal of Industrial Ecology*, 23: 1, 2018, p. 77-95.

SDK 2019
SuperDrecksKëscht (SDK): *Home page, Quick links*, 2019. URL: https://www.sdk.lu/index.php/lu/ [as at: 12.04.2019].

SPARK n.d.
SPARK: *Home page*. URL: https://sparkthemovement.nl/ [as at: 12.04.2019].

SRU 2015
Sachverständigenrat für Umweltfragen (SRU): *Kurzkommentar zu ProgRess II* (Kommentar zur Umweltpolitik, No. 16), Berlin 2015.

Stahel 2016
Stahel, R.: "The Circular Economy". In: *Nature*, 531: 7595, 2016, p. 435-438.

Steffen et al. 2015
Steffen et al.: "Planetary Boundaries: Guiding Human Development on a Changing Planet". In: *Science*, 347: 6223, 2015, p. 736-746.

Subcommission on Quaternary Stratigraphy 2019
Subcommission on Quaternary Stratigraphy: *Working Group on the ‚Anthropocene'*, 2019. URL: http://quaternary.stratigraphy.org/working-groups/anthropocene/ [as at: 12.04.2019].

Technopolis Group et al. 2016
Technopolis Group/Fraunhofer ISI/thinkstep/Wuppertal Institute (Eds.): *Regulatory barriers for the Circular Economy. Lessons from Ten Case Studies* (Final report 13.07.2016), Amsterdam 2016.

Totzauer 2016
Totzauer, J.: *Elektroschrott: Kostbares Gift*, 2016. URL: https://uni.de/redaktion/elektroschrott-kostbares-gift [as at: 12.04.2019].

UBA 2016a
Umweltbundesamt (UBA) (Ed.): *Die Nutzung natürlicher Ressourcen. Bericht für Deutschland 2016*, Dessau-Roßlau 2016.

UBA 2016b
Umweltbundesamt (UBA): *Ökodesign-Richtlinie*, 19.08.2016. URL: https://www.umweltbundesamt.de/themen/wirtschaft-konsum/produkte/oekodesign/oekodesign-richtlinie#textpart-1 [as at: 12.04.2019].

UBA 2016c
Umweltbundesamt (UBA): *Abfallrecht*, 29.02.2016. URL: https://www.umweltbundesamt.de/themen/abfall-ressourcen/abfallwirtschaft/abfallrecht [as at: 12.04.2019].

UBA 2017a
Umweltbundesamt (UBA): *Zu viel Dünger: Trinkwasser könnte teurer werden. Preissteigerung bis zu 45 Prozent erwartet* (press release, 09.06.2017). URL: https://www.umweltbundesamt.de/presse/pressemitteilungen/zu-viel-duenger-trinkwasser-koennte-teurer-werden [as at: 12.04.2019].

UBA 2017b
Umweltbundesamt (UBA) (Ed.): *Daten zur Umwelt 2017* (Indikatorenbericht), Dessau-Roßlau 2017.

UBA 2018a
Umweltbundesamt (UBA): *Indikator: Recycling von Siedlungsabfällen*, 09.11.2018. URL: https://www.umweltbundesamt.de/indikator-recycling-von-siedlungsabfaellen#textpart-1 [as at: 12.04.2019].

UBA 2018b
Umweltbundesamt (UBA) (Ed.): *Die Nutzung natürlicher Ressourcen. Bericht für Deutschland 2018*, Dessau-Roßlau 2018.

UBA 2018c
Umweltbundesamt (UBA): *Rohstoffproduktivität*, 2018. URL: https://www.umweltbundesamt.de/daten/ressourcen-abfall/rohstoffe-als-ressource/rohstoffproduktivitaet#textpart-7 [as at: 12.04.2019].

UM BWL 2017
Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg (UM BWL): *Technologien der Zukunft* (Thinktank Industrielle Ressourcen-Strategien), 2018. URL: https://um.baden-wuerttemberg.de/fileadmin/redaktion/m-um/intern/Dateien/Dokumente/2_Presse_und_Service/Publikationen/Wirtschaft/Think_Tank_Industrielle_Ressourcenstrategien.pdf [as at: 12.04.2019].

Umweltinnovationsprogramm n.d.
Umweltinnovationsprogramm: *Umweltinnovationsprogramm*. URL: https://www.umweltinnovationsprogramm.de/ [as at: 12.04.2019].

UNEP and IRP 2018
UN Environment and International Resource Panel: *Push to Pick up the Pace on the Circular Economy*, 24.01.2018. URL: http://www.resourcepanel.org/news-events/push-pick-pace-circular-economy [as at: 26.04.2019].

UN 2018
United Nations Climate Change News: *Circular Economy Is Crucial to Paris Goals – Study*, 6 June 2018. URL: https://unfccc.int/news/circular-economy-is-crucial-to-paris-goals-study [as at: 11.05.2019]

Vanner et al. 2014
Vanner, R. et al.: *Scoping Study to Identify Potential Circular Economy Actions, Priority Sectors, Material Flows and Value Chains* (Final Report), Luxembourg: Publications Office of the European Union 2014.

Vella 2015
Timmermans, F., Katainen, J., Bienkowska, and Vella, K.: *Closing the Circle and Opening Conversation on Circular Economy*. URL: https://ec.europa.eu/commission/commissioners/2014-2019/vella/blog/closing-circle-and-opening-conversation-circular-economy-frans-timmermans-jyrki-katainen-elzbieta_en [as at: 26.04. 2019].

Vercalsteren et al. 2018
Vercalsteren, A./Christis, M./Van Hoof, V.: *Short-term Assignment. Indicators for a Circular Economy, Summa Circular Economy Policy Research Centre,* 2018. URL: https://circulareconomy.europa.eu/platform/sites/default/files/summa_-_indicators_for_a_circular_economy.pdf [as at: 12.04.2019].

Wang/Wang 2018
Wang X. V./Wang L.: "Digital Twin-based WEEE Recycling, Recovery and Remanufacturing in the Background of Industry 4.0". In: *International Journal of Production Research*, 2018, p. 1-11.

Waters et al. 2016
Waters, C. N. et al., 2016: "The Anthropocene is Functionally and Stratigraphically Distinct from the Holocene". In: *Science*, 351: 6269, 2016, p. 137-147.

WBGU 2019
Wissenschaftlicher Beirat der Bundesregierung – Globale Umweltveränderungen (WBGU): *Unsere gemeinsame digitale Zukunft – Empfehlungen*, Berlin 2019.

WEF 2019
World Economic Forum (WEF): *Platform for Accelerating the Circular Economy*, 2019. URL: https://www.weforum.org/projects/circular-economy [as at: 12.04.2019].

Wellmer/Becker-Platen 2001
Wellmer F.W./Becker-Platen J.D.: "World natural resources policy (with focus on mineral resources)", In: Tolba, M.K. (Ed.): *Our fragile World – Challenges and Opportunities for Sustainable Development.* Eolss Publishers Co. Ltd Oxford, UK, 2001.

Wilts/von Gries 2017
Wilts, C./von Gries, N.: "Der schwere Weg zur Kreislaufwirtschaft". In: *Gesellschaft, Wirtschaft, Politik* (GWP), 66:1, 2017, p. 23-28.

Wirtschaft macht Klimaschutz n.d.
Wirtschaft macht Klimaschutz: *Home page*. URL: https://www.wirtschaft-macht-klimaschutz.de/ [as at: 12.04.2019].

WRAP 2018
The Waste and Resources Action Programme (WRAP): *Love Food Hate Waste*, 2018. URL: https://www.lovefoodhatewaste.com/ [as at: 12.04.2019].

Wuppertal Institut n.d.
Wuppertal Institut: *Ressourcen sind endlich*. URL: https://wupperinst.org/themen/ressourcen/ [as at: 03.04.2019].

WWF 2017
World Wide Fund for Nature (WWF): "Fokus Bauen und Wohnen. In Kreisen denken". In: *WWF Magazin*, *Landwirtschaft*, 3, 2017, p. 8.

WWF 2018
World Wide Fund for Nature (WWF): *Living Planet Report 2018*. Gland 2018.

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