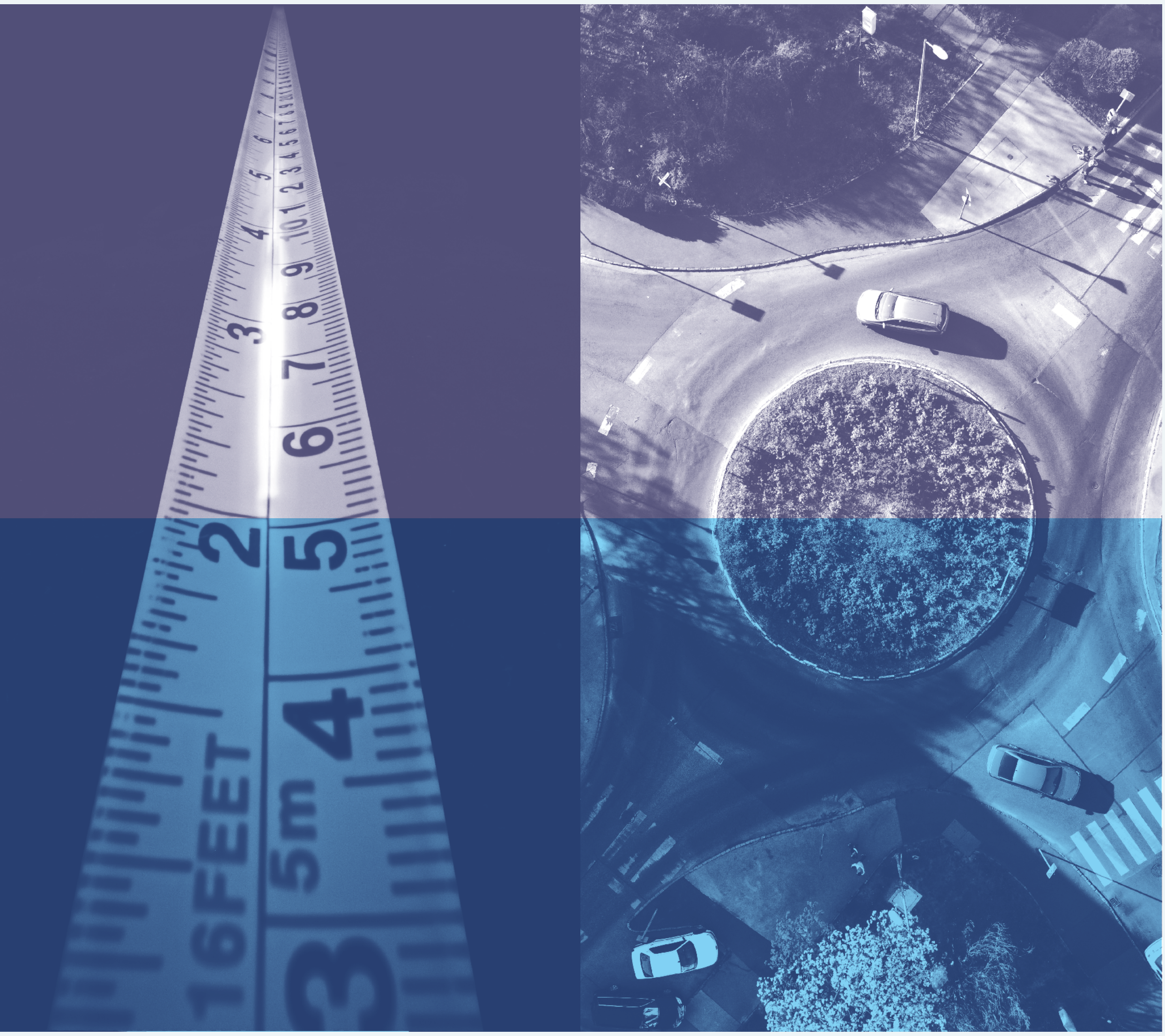
MAKING THE CIRCULAR ECONOMY COUNT

AN ANALYSIS OF AVAILABLE CIRCULAR ECONOMY METRICS TO DEVELOP A PRACTICAL, IMPLEMENTABLE SET FOR NATIONAL PROGRESS MONITORING



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MAKING THE CIRCULAR ECONOMY COUNT

A report to make the Circular Economy metrics world more applicable to policymakers, business leaders, and society.

SUMMARY

In the last five years, business leaders and policymakers have been paying more and more attention to the circular economy concept, which represents a possible solution to achieve absolute resource reduction by decoupling economic growth from unsustainable resource consumption while building resilience against future pandemics and the impact of climate change.[1] In contrast to the 'take-make-waste' linear model, a circular economy is regenerative by design. It aims to gradually decouple growth from the consumption of finite resources while eliminating waste. A circular economy enables society and businesses to use natural resources more efficiently and keep resource consumption within the planetary boundaries while contributing to GHG emissions reduction and limiting the depletion of natural capital and biodiversity loss. With a narrowing window of opportunity for systemic change, policymakers need to measure the progress towards a circular economy at a national level to effectively steer the transition from a linear to a circular economy (CE).[2]

There is an increasing variety of circular economy metrics by academia and practice available today. They are developed to very different depths. However, there is a lack of an aligned set of CE metrics supporting policy and society to choose relevant circular economy metrics evaluating the successful implementation of national circular economy policies.[3] This report, funded by the SUN Foundation and published by acatech – National Academy of Science and Engineering and SYSTEMIQ, evaluates the current state of research and practice regarding circular economy metrics based on an extensive literature analysis and expert perceptions. The analysis follows a three-step approach to illustrate the selection and prioritisation of existing CE metrics supporting policymakers in deriving a practical and feasible set of CE metrics. It enables policymakers to (1) obtain an overview of the current status quo of existing CE metrics, (2) evaluate the national transition progress towards CE with a set of metrics according to key dimensions of CE and (3) understand why national monitoring should be complemented by standardised reporting mechanisms to evaluate resource flows at the company level.

The results of the analysis of over 230 CE metrics support policymakers in developing a national monitoring framework to evaluate the transition towards a CE. There are many metrics suggested for countries to assess the outcomes of a CE, such as national resource and waste reduction. However, proposed metrics to evaluate the transition process are still underrepresented in the current discussion, and many of these metrics require company-level data. In line with the systemic approach of the concept, national monitoring must assess the contribution of CE activities towards all three sustainability dimensions. As metrics to assess environmental impacts of the activities are strongly underrepresented in literature, it remains an open issue to evaluate how far CE activities lead to resource reduction and the expected decrease in negative environmental and socio-economic impacts, such as on health, quality of labour, and well-being.

1 Corona et al. (2019)
2 European Commission (EC) (2018b)
3 Moraga et al. (2019)

A national CE monitoring framework should be built around key subject areas determined by national targets. Depending on the CE definition and targets applied, a national CE monitoring framework should include metrics to evaluate CE related subject areas which are (i) resource inputs, (ii) resource use (throughput) and stock, (iii) resource outputs and (iv) additional resource-use dependent on environmental as well as social impacts of a CE. Progress in these areas should be measured with metrics evaluating the desired outcomes of CE and also be capable of evaluating national activities enabling the transition process.[4]

A prioritised set of CE metrics paves the way for national CE monitoring frameworks. Ten requirements are derived from science and policy publications to prioritise a practical, feasible set of 50 CE metrics from the 230 metrics identified. The proposed set includes metrics to evaluate the impacts of CE (outcomes) and metrics to steer the transition process (enablers). The main contribution of a CE is to achieve absolute resource reduction and reduction of waste, resulting in a reduction of environmental impact. In the proposed framework, metrics from material flow accounts[5] and consumption-based metrics (e.g., footprints) are the most represented. A country's material footprint, also known as its raw material consumption, takes into account the total mass of raw materials extracted along the entire supply chain to produce the final products/ services consumed. The material footprint also considers environmental and social impacts caused outside the country's borders. As various CE definitions lead to different prioritisations on what should be measured, it can be concluded that a proposed set of metrics and its evaluation will always be subjective.

To adapt the set of CE metrics to national conditions, five policy implications are raised. The EU's binding climate and energy targets for 2020 and 2030 have shown how effectively they trigger action and policy developments. If the goal of absolute resource reduction, as pushed by the EU, is really to be achieved, ambitious targets for a CE are required.[6] These comprise the aspect of setting absolute targets on raw material consumption and waste prevention. It is important that national targets go beyond increasing resource efficiency, which in Germany, for example, have so far only led to incremental changes. To evaluate progress towards these targets, policymakers should agree on a manageable set of CE metrics. To mandate data reporting required for CE monitoring, for example, legal frameworks could form the required national legal basis through existing standards.

Moreover, policymakers should support further research to assess the environmental and socio-economic impacts of national CE activities. For holistic progress monitoring, governments need to collect company-level data to explore the successful implementation of CE activities in specific industries in a standardised way. Although companies increasingly adopt circular principles for circular activities, it is challenging to assess whether these activities replace their usual consumption and lead to noticeable resource savings.[7]

Governments should establish new reporting schemes for material-intensive industries and products beyond the voluntary presentation of sustainability information by companies. In the short run, national sustainability monitoring could be extended by existing CE metrics. In the long run, a CE reporting infrastructure to aggregate information about

[4] Potting and Hanemaaijer (2018)

[5] Material flow accounting (MFA) is the study of material flows on a national or regional scale.

[6] European Parliament (2020)

[7] Friends of the Earth Europe, European Environmental Bureau, Vienna University of Economics and Business (2020)

the transition of companies towards CE should be fostered. Company-level data is needed to explore the successful implementation of CE activities in specific industries in a standardised way. A multi-year journey lies ahead as countries collaborate and converge. However, this process might be sped up by: (1) utilising the key learnings from the implementation of the International Standard on Financial Reporting Scheme and (2) fostering the development of a robust circular economy standard (a framework and principles for implementation of CE activities on business, city, and governmental levels) with good governance such as ISO/TC 323 which might help to guide nations and organisations through change.

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INTRODUCTION

With global resource use accounting for 90% of biodiversity loss and 50% of global GHG emissions, policymakers have begun to develop new strategies that go beyond the scope of decarbonisation.[8] The transition towards a circular economy (CE) aims for efficient and circular use of natural resources to keep societal demands within environmentally sustainable levels.[9] CE strategies have the potential to reduce global GHG emissions by 45% by 2050 and limit the depletion of natural capital and biodiversity.[10] Moving towards a circular economy helps to build resilience by reducing the reliance on scarce resources and other material import dependencies and provides a $4.5 trillion economic opportunity[11] with the potential to result in the net growth of six million jobs globally by 2030.[12]

In recent years, to seize this potential, the CE concept has been adopted and further developed by many actors. Businesses have begun to translate their internal waste management programs into CE strategies or seek to build business opportunities along with the promoted CE strategies. Policymakers are driving the concept forward, and numerous European countries, the European Union, and China have already developed roadmaps and action plans based on the desire to achieve more sustainability through CE.[13] Since 2015, 13 countries across the globe plus the EU have implemented national circular economy policies, and pioneering countries like the Netherlands and Finland have set nationwide circularity targets.[14]

However, open questions remain on how these actors can effectively measure the desired social, environmental, and economic impacts of their respective CE initiatives and monitor progress regarding their targets. Although academic literature on CE metrics is expanding, in-depth investigation and prioritisation of metrics to measure the circularity of countries are still rare. In the recent CE Action Plan, the European Commission has recognised the need to advance CE metrics further at national levels.[15]

Consolidating the understanding of a CE with an assessment of existing metrics is required to bridge the gap between proposing general CE strategies on the one side and their successful implementation in practice on the other.

One of the main challenges in today's discourse related to a CE is to be clear on its principal targets and respective metrics because the term CE has thus far often been used as an umbrella term, under which various and partly conflicting meanings are subsumed.[16] This has led to wide dissemination of the concept offering many opportunities

[8] International Resource Panel (2019)
[9] Desing et al. (2020)
[10] International Resource Panel (2019)
[11] Ishii and van Houten (2020)
[12] Internationales Arbeitsamt (2018)
[13] European Commission (EC) (2020a)
[14] Chatham House (2020)
[15] European Commission (EC) (2020b)
[16] Blomsma and Brennan (2017).

for various economic operators (i.e., product designers and material scientists) and industries (i.e., steel, textiles and electronics). However, it has also led to an increasing variety of proposed metrics to evaluate desired effects.

The objective of this research and resulting publication is to inform society, policymakers, and business leaders about scientific insights in the field of environmental and socio-economic impact quantification of national CE strategies with a focus on Germany. Building upon the analysis, the results of the report inform the discussion of a CE roadmap as suggested by the Circular Economy Initiative Germany (CEID).[17]

The following report provides an assessment of existing CE metrics on the macro-level (national level) and suggests a prioritisation of selected CE metrics enabling the evaluation of the progress of nations towards CE. Five policy implications obtained from a science-based discourse on how CE metrics could be operationalised are provided. Recognising the need to involve both public (i.e., governments) and private actors (i.e., businesses) in the monitoring of a CE, the report will elaborate on a standardised reporting scheme based on learnings from international financial reporting standardisation (IFRS) for CE as one of the five policy implications in further detail. A standardised reporting scheme for CE is necessary to obtain information on the progress towards CE at the company level. The findings derived from the analysis should provide national policymakers with insights into the current research and practice of potentially applicable CE metrics and provide a mapping of CE indicators according to the potential key subject areas for a monitoring framework.

[17] As local context and legislation might differ, not all findings from Germany can be directly used to inform other country roadmaps, however most core findings will be applicable.

STATUS QUO OF NATIONAL CE MONITORING

The evaluation of the effectiveness of CE actions at a national level is crucial to assess and steer the transition from the linear economy model to a CE. Several monitoring frameworks for a CE at the national, EU, and international level are already applied in theory and practice[18,19] (i.e., UN PACE Partnership in Accelerating Circular Economy[20], the Bellagio Process[21] and the European Circular Economy Monitoring framework[22]).

The number of scientific papers dealing with how to measure specific variables, actions, and effects, etc., in line with CE is increasing.[23] Whereas sustainability metrics are well developed in academic literature[24], there is only a limited amount of research focusing on metrics that monitor CE objectives and strategies, which is why several authors suggest further investigation in this area.[25] This report provides an overview of the current status quo of existing CE metrics after shortly introducing the general benefits of CE metrics and current governmental developments relevant to CE metrics selection.

[18] Di Maio and Rem (2015)
[19] Potting and Hanemaaijer (2018)
[20] See https://pacecircular.org/
[21] See https://epanet.eea.europa.eu/reports-letters/monitoring-progress-in-europes-circular-economy
[22] European Commission (EC) (2018a)
[23] Elia et al. (2017); Moraga et al. (2019); Škrinjarić (2020)
[24] Howard et al. (2019)
[25] Genovese et al. (2017); Ghisellini et al. (2016); Howard et al. (2019)

APPLICATION OF CE MONITORING TO EVALUATE POLITICAL CE TARGETS

The concept of CE is gaining ground in current policy discussions and legislation.[26] The European Union as a whole, several European countries independently, and other countries such as China have already developed CE roadmaps and action plans.[27] These policies define qualitative and quantitative targets to steer the transition towards CE. Governmental targets help political decision-makers, businesses, and societal partners transition from an existing state to a desired outcome. They are frequently applied because they provide a pragmatic view on the outcome when they can be measured.

The EU and its member states strive to strengthen CE targets, but these are only slowly being fulfilled. To achieve the sustainable development goals by 2030, the European CE action plan includes several targets enabling a transition to a circular economy on a global level while contributing to climate neutrality. Besides the aim of reducing consumption footprints and doubling the circular material use rate (CMU)[28] by 2030, the ambition is to minimise the burden of the transformational change towards more sustainability on people and businesses while ensuring sustainable products in a way where waste is avoided. Furthermore, trade with high quality secondary raw materials shall be ensured in the coming decade.[29] To meet these objectives, the European Commission aims, for example, to regulate energy and material efficiency, chemical substances, carbon, and environmental footprints and increased high-quality recycling content.[30] Unfortunately, developments on a European level are not going fast enough in the right direction. So far, almost all European countries have implemented targets either for resource efficiency, a circular economy, or the supply of raw materials, where waste is one of the main areas mentioned in this context.[31] Nevertheless, a report from the European Commission confirms that more than half of the member states are unlikely to achieve 2020 targets regarding recycling and waste policies.[32] Whereas several European countries have implemented CE strategies and a monitoring system, Germany still lacks an explicit CE strategy. Given European developments (i.e., the implementation of the European Green Deal), it is expected that CE will sooner or later also become a strategy for resource conservation in Germany which goes beyond resource efficiency and recycling and which will require monitoring to evaluate progress towards a CE.

Germany lacks legally binding CE targets that regulate trends in the growth of resource consumption and related environmental impacts. In Germany, the Resource Efficiency

[26] European Commission (EC) (2015a, 2020b); Ghisellini et al. (2016)
[27] European Commission (EC) (2018a); Geng et al. (2012); Magnier et al. (2017)
[28] The CMU calculates the share of material recovered that is given back into the economy and is currently at 12% for the EU.
[29] European Commission (EC) (2020b)
[30] European Commission (EC) (2020a)
[31] European Environment Agency (EEA) (2019)
[32] European Commission (EC) (2018b)

Program (ProGress III), the German Strategy for Sustainable Development (DNS) and the “Kreislaufwirtschaftsgesetz” (KrWG) include targets and metrics relevant for CE, hence are part of the assessment of CE metrics. Examples include decoupling of resource consumption and economic growth, high-quality recycling, and recovery of separately collected waste. The current indicator report by the federal statistical office shows an increase in total raw material productivity.[33] However, it is debated whether this metric adequately reflects the optimisation of economy-wide resource use, as desired in a CE.[34] Scientists argue that productivity indicators do not reflect resource consumption in absolute terms because economic growth might outpace productivity gains, resulting in an absolute increase in resource consumption.[35] Additionally, the current DNS Indicator Report reveals that only marginal improvements to reach national targets in the context of SDG Goal 12 have been achieved. As an example, CO_2 emissions from private households, including the emission content of consumer goods and emissions from the combustion of biomass in 2015, decreased by only 1.0% compared to 2005.

There is a need to measure and compare CE-related targets. The assessment of political targets through performance measurement helps steer governmental processes, as intended results are determined in advance, and monitoring frameworks help evaluate progress against specific criteria.[36] Progress monitoring requires metrics based on comparable data to inform political decision-makers and society.[37] Performance measurement is widely used in the public sector, for example, to reform initiatives. Performance measurement consists of five activities (1) defining what should be measured, (2) selection of metrics, (3) collection of data, (4) analysing data, and (5) reporting.[38] In this report, the measurement objective is the assessment of national progress towards a CE. National CE roadmaps and action plans differ greatly in scope and priorities on circular economy strategies. Therefore, CE metrics need to be tailored for a specific monitoring purpose.

A CE monitoring should move from measuring circularity for its own sake to a more holistic approach, where CE metrics are considered by their contribution to socio-economic and environmental systems. The concept of a CE is now part of many political debates. However, the lack of a consistent definition of CE is leading to many different targets and priorities in policymaking and monitoring. Because of the landscape of existing CE metrics, it becomes evident that there is no consistent classification available at any level of analysis for measuring the CE.[39] As a result, today, several subjective methodological categorisation frameworks evaluating different dimensions of CE exist. A national CE monitoring framework should include metrics to evaluate CE-related subject areas defined by political targets[40] and process-related metrics that evaluate different phases of the transition.[41]

[33] Statistisches Bundesamt (Destatis) (2018)
[34] Geng et al. (2012)
[35] Rodriguez et al. (2020)
[36] Bevan and Hood (2006)
[37] OECD (2011)
[38] van Dooren (2015)
[39] European Academies Science Advisory Council (EASAC) (2016); Haupt et al. (2017); Niero and Kalbar (2019); Potting et al. (2017); Saidani et al. (2019)
[40] E.g., waste targets in a CE strategy require metrics for recycling and waste sent to landfill.
[41] Potting and Hanemaaijer (2018)

OVERARCHING SUBJECT AREAS OF CE IN A MONITORING FRAMEWORK: MATERIAL AND RESOURCE FLOWS, ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS

The framework provided by the Dutch Ministry of Environment (PBL Netherlands) lays the foundation for selecting metrics to evaluate objectives and principles at a national level. Key dimensions/subject areas of a CE are (i) resource inputs, (ii) resource use (throughput), (iii) resource output and (iv) effects of a CE.[42] With these dimensions, the framework aims to assess resource consumption (illustrated on the left side of Figure 1) as well as the environmental and socio-economic impacts (illustrated on the right side of Figure 1). One example of an environmental impact indicator is the CO_2 emissions intensity.[43]

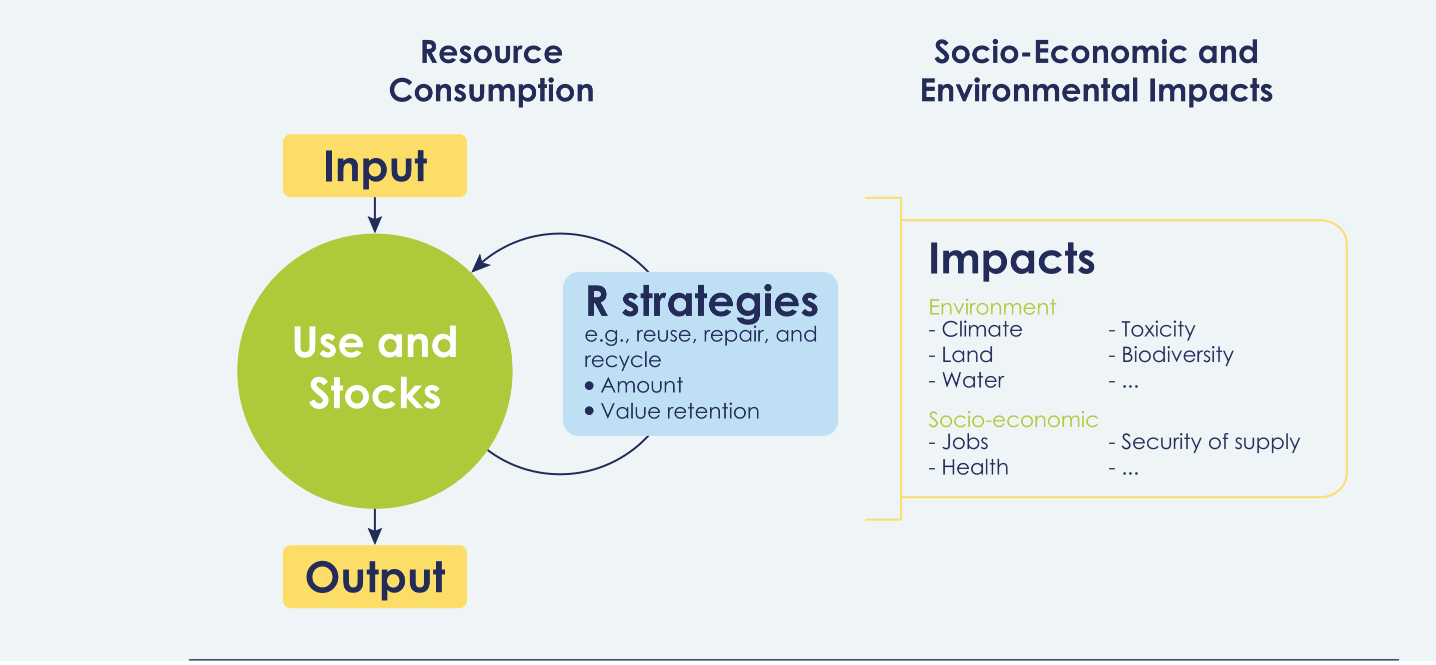

Figure 1: General framework for CE targets and metrics
Source: Own illustration, adapted from PBL Netherlands.[44]

[42] Dutch Ministry of Environment (PBL Netherlands) (2020)
[43] Potting and Hanemaaijer (2018)
[44] Dutch Ministry of Environment (PBL Netherlands) (2020))

National monitoring consists of a set of metrics evaluating the dimensions/subject areas that are prioritised in political strategies. The concept of the Circular Economy encompasses several strategies and goals that go beyond the reduction of waste and resource consumption. The three CE principles of (1) design out waste and pollution, (2) keep products and materials in use and (3) regenerate natural systems are operationalised through resource value retention activities, so-called R-Strategies. Examples include reuse, reduce, remanufacture, and recycling (for further information, please see Annex A). Assessing progress towards a CE and the effectiveness of action at the EU and national level requires a reliable set of metrics.

SIMPLIFIED PROCESS PHASES IN A MONITORING FRAMEWORK: ENABLER AND OUTCOME METRICS

The CE transition is a process, which consists of several phases. Consequently, a monitoring framework may be designed to evaluate the transition progress of all CE aspects in these phases. A national monitoring framework should follow the logical approach to include CE macro-level metrics measuring outcomes and metrics for the transition process towards a CE. Therefore, metrics should be divided into measures for activities enabling the transition and actual outcomes of a CE.[45] In the monitoring tool *Circulytics* by Ellen MacArthur Foundation (2020), a distinction is made between the desired *outcomes* and *enablers* that bring about the transition process. Although the tool was originally designed to evaluate CE at a company level, the two categories of *outcomes* and *enablers* represent a simplification of the process phases, which could potentially be applied to any set of metrics independent of the level of analysis.[46]

The outcome category thereby consists of metrics to evaluate energy use and material flows, for example, the share of secondary materials used in production. Metrics in the enabler category aim to assess how far a system (in that context, a company) activity supports the implementation of CE. Metrics in this category evaluate, for example, the number of jobs dedicated to CE. The description of the categories is illustrated in Table 1, which will be applied in the next step to sort a set of national CE metrics.

Transition to a CE ↓

Category	Description	Exemplary metric
Enablers	Means and activities enabling the transition …towards a CE	Share of CE-related investments
Outcomes	Impacts leading to a decrease in resource consumption, thereby reducing environmental and socio-economic effects of CE	The total amount of waste sent to landfill

Table 1: Illustration of the process categories in CE monitoring
Source: Own illustration, adapted from Ellen MacArthur Foundation (2020).

[45] Ellen MacArthur Foundation (EMF) (2020)

[46] Information from a previous meeting with EMF Data Lead Jarkko Havas (19.05.2020)

PRIORITISATION OF CE METRICS: A THREE-STEP APPROACH TO DEVELOP A MANAGEABLE SET OF CE METRICS

The selection and prioritisation of existing CE metrics resulting in a practical, feasible set that informs decision-makers and society follows a three-step approach (detailed information on the methodology can be found in Annex B). First, over 230 CE metrics proposed in the literature and applied in practice (i.e., part of the French CE monitoring framework and the German Resource Efficiency Program) were collected and analysed. As a next step, a general set of 50 CE metrics, including a mix of measurable and not yet measurable indicators, is proposed. This procedure allows a clear overview to be obtained of the most relevant metrics enabling policymakers to select metrics according to national circumstances to develop a national monitoring framework that evaluates the transition from a linear to a circular economy. The report concludes with initial thoughts on how metrics that are not yet measurable can be operationalised by monitoring CE at the company level (see Figure 2).

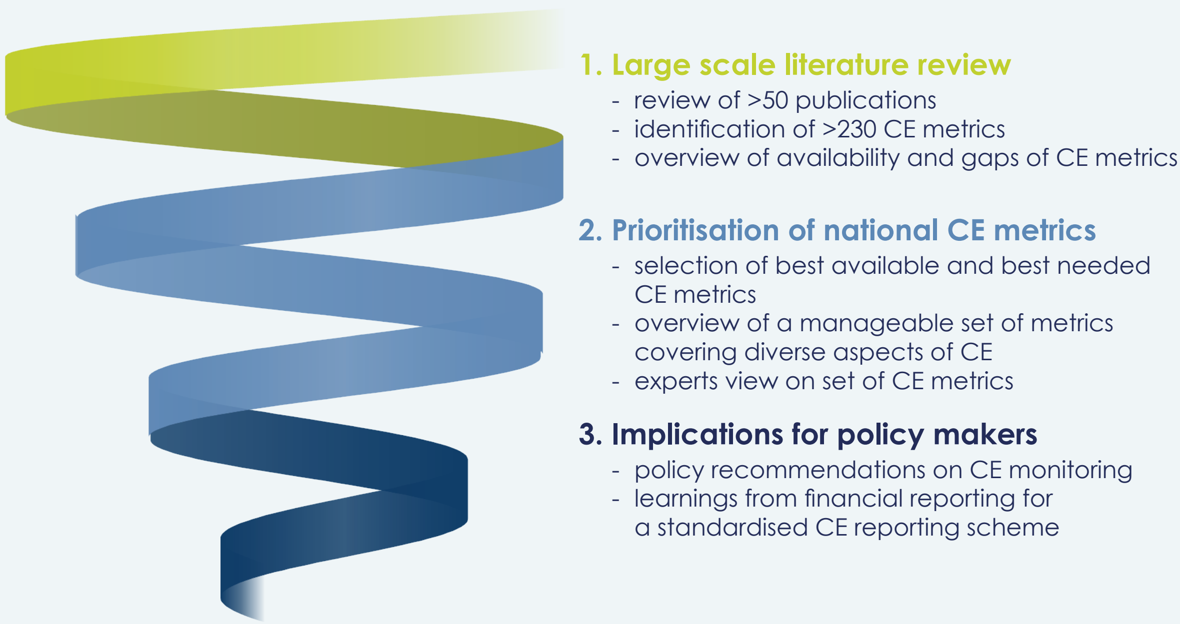

Figure 2: Funnel applied in this study to inform national CE roadmap about existing CE metrics
Source: Own overview.

STEP 1: LITERATURE ANALYSIS PROVIDES A FULL OVERVIEW OF OVER 230 CE METRICS

Over 50 European publications (academic literature and grey literature on macro-level CE metrics) were reviewed, and over 230 CE metrics were identified that evaluate CE at a national level. Although many metrics on a macro-level currently exist, not all are suited for the evaluation of outcomes of CE. To prioritise and select a set of CE metrics suitable to assess national progress towards CE, an analysis of existing CE metrics at the macro-level is necessary (for further explanation of the literature review and the different levels of analysis, please see Appendix A).

Many metrics, especially to measure resource and waste reduction as outcomes of a CE, currently exist. They are based on calculation methods where data is available.[47] Metrics for R-Strategies are required to evaluate whether certain CE related activities lead to the desired outcomes of a CE. The analysis, however, reveals that only a few metrics, mainly for Recycling (R8) and Recovery (R9) (see Figure 3), are currently suggested for an assessment at a national level. Furthermore, most of the proposed metrics associated with R-Strategies currently lack a calculation method and data.

Only a few metrics are proposed in the literature to evaluate socio-economic and environmental impacts. According to the current CE definitions raised by governments, academia, and practice, a CE should lead to resource and waste reduction and contribute to regenerative ecosystems, economic growth, and wellbeing.[48] It is questionable whether the metrics proposed by science can measure the contribution of CE activities to decrease effects (e.g., biodiversity loss, water scarcity) at a national level.[49] Economy-wide measures of environmental flows and resource use exist at a national level (e.g., indicators on land use and water use). However, impact indicators focusing on the interlinkages between circularity and effects on the environment are underrepresented in national monitoring frameworks.

The analysis further reveals that only a few metrics currently exist to evaluate transition dynamics towards a CE, and most of them lack data and a calculation method. This is problematic, as metrics for the transition process (herein called *enablers*) would help steer governmental progress as outcomes of CE activities only become visible at a later stage. By then, many options for change may have already been missed if no other control measures are available. The results of the analysis are presented in Figure 3.

There are currently metrics in place to measure national resource inputs and outputs. However, metrics to evaluate CE activities (R-Strategies) and related socio-economic impacts and environmental effects require further development. Policymakers should start monitoring activities and impacts of CE to steer a transition towards CE that, by promoting the right strategies, leads to the desired effects on the environment and society.

[47] Alaerts et al. (2019); Potting and Hanemaaijer (2018)
[48] Ellen MacArthur Foundation (EMF) (2015); European Commission (EC) (2020b); Kirchherr et al. (2017)
[49] Blum et al. (2020); Helander et al. (2019)

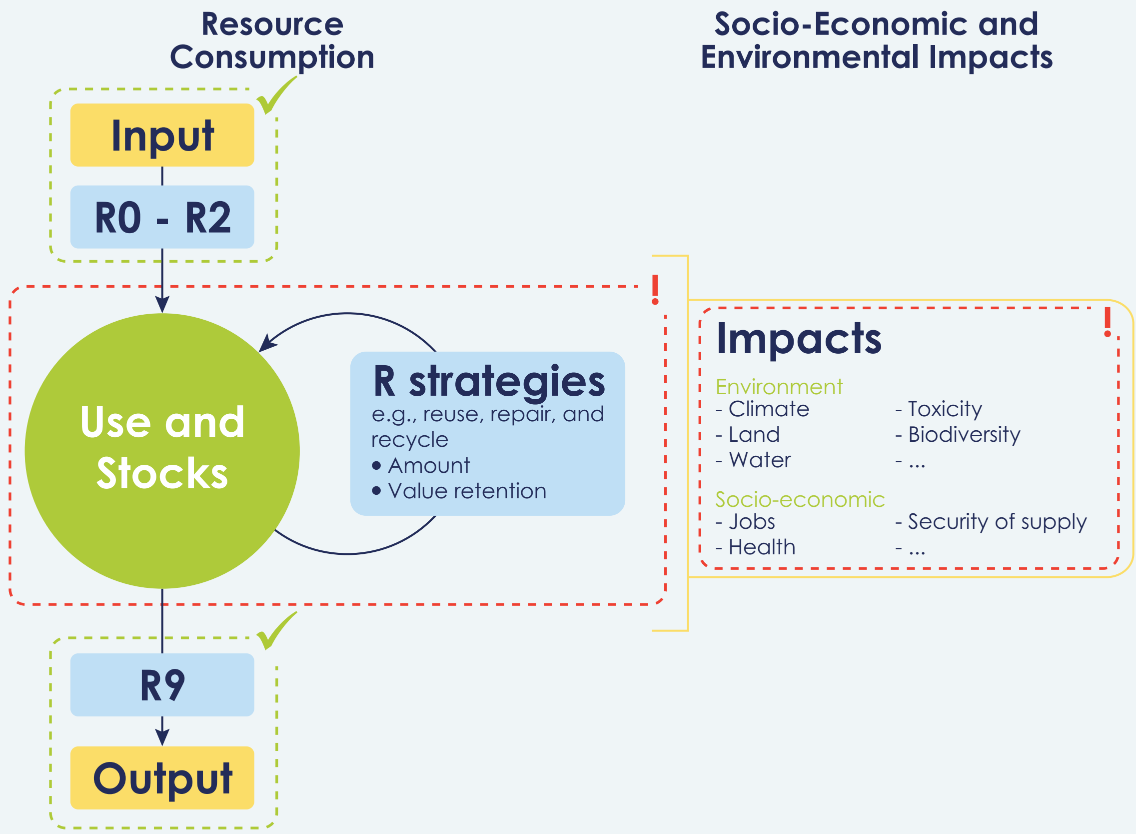

Figure 3: Availability of CE metrics to evaluate key dimensions of CE
Source: Own illustration, adapted from Dutch Ministry of Environment (2020).

STEP 2: A PRIORITISED SET OF 50 CE METRICS PAVES THE WAY FOR NATIONAL CE MONITORING

Gaining insights on a manageable number of metrics supports policymakers in developing a national CE monitoring framework. A manageable set of 50 metrics is derived and grouped according to the key dimensions of CE. To reduce the CE metrics to a manageable number, CE metrics that appeared in several sources or showed little semantic differences but aim to measure the same processes or effects of a CE were eliminated.[50] An example is the domestic material consumption metric (DMC) which, amongst others, is proposed by Eurostat and EEA. In another step, national metrics were allocated to predefined requirements. The requirements are based on European policy documents and high ranked publications from science and are described in detail in Table 2. The prioritisation of CE metrics was further discussed with 13 experts familiar with current CE metrics developments at a national level and represent diverse views from different perspectives and disciplines. These experts work for (governmental) organisations and scientific institutions originating in the Netherlands, Italy, Wales, Austria, Sweden, Belgium, France, Spain, and Germany and are either active or overseeing the development of CE metrics. A detailed description of the criteria for selecting the interview partners can be found in Appendix C.

[50] An example of metrics which aim to evaluate the same outcome are "Persons employed" included in the EU CE Monitoring Framework (2018a) and "Employment in eco-innovation and CE" proposed by Smol et al. (2017).

TEN REQUIREMENTS TO SELECT A PRACTICAL, FEASIBLE SET OF CE METRICS

A set of CE metrics evaluating national progress needs to be tailored to the specific transition progress of nations. To stay in line with current informed-science and political developments, ten requirements for a CE and its consequent need for measurement were obtained from literature and tested with experts. The requirements are used to prioritise a practical, feasible set of CE metrics from all available metrics.

Predefined requirements derived from literature
1. National CE-metrics should assess the progress towards decoupling economic growth from resource use and its impacts at a national level.[51,52,53,54]
2. National CE-metrics should consider global supply chains whenever applicable (= the effects along the global value chain).[55,56]
3. National CE-metrics should evaluate enabling activities and the actual effects of CE implementation.[57]
4. National CE-metrics should assess environmental pressures and impacts, including impacts outside Europe's borders.[58;59,60,61,62]
5. National CE-metrics should assess the impact on social wellbeing.[63]
6. National CE-metrics should measure the scale and effects of CE strategies (10R). Therefore, metrics must consider inner-loops (for an explanation of 10Rs, please see Appendix A).[64]
7. National CE-metrics should assess the reduction of intake of primary raw materials and use of recycled/ renewable resources.[65]
8. National CE-metrics should assess the reduction of waste generation.[66,67]
9. National CE-metrics should assess the decoupling of economic growth from (sectoral) waste generation and waste treatment.[68,69]
10. National CE-metrics should have a minimum lead time of implementation. Therefore, CE-metrics already produced and where data can be derived from official statistics should be preferred.[70]

Table 2: Ten requirements for a feasible set of metrics
Source: Own overview, elaborated from several contributions (as depicted in table)

[51] European Environment Agency (EEA) (2019)
[52] European Academies Science Advisory Council (EASAC) (2016)
[53] Lonca et al. (2019)
[54] Wit et al. (2019)
[55] European Commission (EC) (2014)
[56] Elia et al. (2017)
[57] Ellen MacArthur Foundation (EMF) (2020); Potting and Hanemaaijer (2018)
[58] Kristensen and Mosgaard (2020)
[59] Haupt and Hellweg (2019)
[60] Helander et al. (2019)
[61] Blum et al. (2020)
[62] European Commission (EC) (2020a)
[63] Corona et al. (2019); European Commission (EC) (2015a); Geert Woltjer (2018); Kristensen and Mosgaard (2020)
[64] Moraga et al. (2019); Potting et al. (2017); Potting and Hanemaaijer (2018)
[65] Elia et al. (2017); Ellen MacArthur Foundation (EMF) (2015); Ghisellini et al. (2016); Haas et al. (2015)
[66] Elia et al. (2017); European Commission (EC) (2020a); European Environment Agency (EEA) (2019); Magnier et al. (2017); Zaman and Lehmann (2013)
[67] Mayer et al. (2019)
[68] European Commission (EC) (2020a)
[69] European Environment Agency (EEA) (2019)
[70] Mayer et al. (2019); Müller et al. (2020); Škrinjarić (2020); Vercalsteren et al. (2017)

THE PROPOSED SET IS GROUPED ACCORDING TO KEY DIMENSIONS OF CE AND INCLUDES 50 CE METRICS

The assignment of metrics proposed in the literature to predefined requirements resulted in a final selection of 50 metrics presented in an adopted framework proposed by the Dutch Ministry of Environment (2020).[71] The key themes material and resource flows, environmental impacts and socio-economic impacts further break down into categories that exhaustively describe each subject while keeping the categories to a minimum. Besides the effect of reducing the number of metrics, some categories and subcategories[72] , respectively, are eliminated. This is because the contained metrics could not meet the requirements, or there is a general lack of metrics (see Table 2). The proposed set includes metrics to evaluate the impacts of CE (outcomes) as well as metrics to steer the transition process (enablers). Four overarching themes serve as a starting point to cluster the proposed metrics. To holistically measure a CE metric with a database behind them and also newly proposed metrics are included in the assessment and are marked as either best-available or best-needed metrics, respectively. The key results of discussions with experts on the proposed set of CE metrics are summarised in the upcoming section. The approach aims to overcome the current substantial lack of data in the CE metrics debate and is intended to motivate the collection of necessary data for CE policy making in the long term. In the short run, the best-available metrics can be applied to evaluate CE, while the set of best-needed metrics first requires the further collection of CE data.

This set includes various metrics that should make it possible to measure the different aspects of CE. It is important to recognise that linkages between the selected metrics might exist. For example, those related to resource consumption tend to have some degree of relation between them (e.g., linkages between resource extraction and CO_2 emissions are already shown by the International Resource Panel[73]). This is important because if some indicators are linked or correlated, it might be possible to reduce the number of metrics in the set. This process should be undertaken after a proper assessment, once the monitoring process has generated enough data to determine whether any metric can be linked to other metrics. A detailed overview of metrics that have been analysed can be found in the supplementary material.

[71] Please see Appendix B for detailed description of the Research Methodology.

[72] I.e., toxicity (environmental impacts) and self-sufficiency (socio-economic impacts). Although methodologies exist (UseTox) they were not mentioned in the analysed literature.

[73] International Resource Panel (2019)

		Categories	Subcategories	50	✗/✓	E/O	Metric
Overarching themes	Material flows	Input	Energy	3	✓	E	Energy productivity (EC, 2015),
					✓	O	Cumulative energy consumption (BMU, 2016),
					✓	O	Share of renewable energy in gross final energy consumption (EC, 2015)
			Resources	2	✓	O	Total Material Requirement (Mayer, 2019),
					✓	O	Total Raw Material Productivity (BMU, 2016)
			Secondary materials	3	✓	O	DERec (UBA, 2012),
					✓	O	DIERec (UBA, 2012),
					✓	O	National Circularity Metric (De Wit et al., 2019)
		Use and Stocks	Anthropogenic stocks	1	✓	O	In-use stocks (Mayer et al., 2019)
			Material use	5	✓	O	Consumption related material productivity (EC, 2014),
					✓	O	Raw Material consumption per capita (Haas et al., 2015),
					✗	O	Share of circular products in total number of products (Potting & Hanemaaijer, 2018),
					✓	O	Circular Material Use Rate (EC, 2018)
		R-Strategies	R1 Rethink	1	✗	E	Number of new revenue models (Potting & Hanemaaijer, 2018)
			R2 Reduce	1	✓	O	Value based resource efficiency indicator (Di Maio & Rem, 2017)
			R4 Repair	1	✓	E	Household spending on product repair and maintenance (Magnier et al., 2017)
			R6 Remanufacture	1	✗	E	Share of remanufacturing business in the manufacturing economy (EEA, 2016)
			R8 Recycle	7	✓	O	Substitutionsquote (KRU, 2019),
					✓	O	Recycling rate of all waste excluding major mineral waste (EC, 2018),
					✓	O	Value based recycling index (Van Schaik and Reuter, 2016),
					✓	O	Recycling process efficiency rate (Graedel et al., 2011),
					✓	O	End of life recycling input rate (Graedel et al., 2011),
					✗	E	Share of materials where safe recycling options exist(EEA, 2016),
					✓	O	Material quality indicator (Steinmann et al., 2019)
		Output	Waste generation	4	✓	O	Generation of municipal waste per capita (EC, 2018),
					✓	O	Quantities of waste sent to landfill (Magnier et al., 2017),
					✗	O	Food waste (EC, 2018),
					✓	O	Municipal waste collected selectively in relation to the total amount of municipal waste collected (Avidushchenko et al., 2019)

		Categories	Subcategories	50	✗/✓	E/O	Metric
Overarching themes	Environmental impacts	Combined environmental impacts		3	✓	E	Amount of institutions with EMAS (Destatis, 2018),
					✗	E	Share of sustainably certified materials (EEA, 2016),
					✗	E	Lifecycle assessments of enterprise activity (Smol et al., 2017)
		Climate		2	✓	O	GHG emission intensity (Smol et al., 2017),
					✗	O	CO_2 consumption footprint (Potting and Hanemaaijer, 2018)
		Land		1	✗	O	Land use, direct (Potting et al., 2018)
		Water		2	✓	O	Water productivity (Smol et al., 2017),
					✓	O	Water exploitation index (EC, 2015)
	Socio-economic impacts	Jobs		1	✓	O	Persons employed in repair, reuse and recycling sector (EC, 2018)
		Competitiveness & Innovation		6	✗	E	Economic growth CE part (Potting & Hanemaaijer, 2018),
					✗	E	Number of companies with "zero waste" program (Smol et al., 2017),
					✓	E	Market value of products with national eco labels (Destatis, 2018),
					✓	E	Patents related to recycling and secondary raw materials (EC, 2019),
					✗	E	Investment in CE research (Potting & Hanemaaijer, 2018),
					✓	E	Regional total value of green early stage investments (Smol et al., 2017)
		Education		2	✗	E	Number of circular courses (Potting & Hanemaaijer, 2018),
					✗	E	Expenditure on environmental education (Potting & Hanemaaijer, 2018)
		Political instruments		4	✗	E	Number of legal and regulatory barriers to the circular economy removed,
					✗	E	Number of CE policy advisors (Potting & Hanemaaijer, 2018),
					✓	E	Share of Blue Angel paper in the total paper consumption of the direct federal administration (Destatis, 2018),
					✗	E	Green Public Procurement (EC, 2018)

Table 3: Prioritisation of CE metrics based on requirements and perception of experts
Source: Own overview

MATERIAL AND RESOURCE FLOWS

The 29 metrics in this overarching theme assess resource flows entering (inputs) and leaving the economy (output), thereby also aiming to evaluate CE activities related to these resource flows. Many of the metrics are based on Material Flow Accounts (MFA) and are widely applied in practice. Furthermore, metrics assigned to the material and resource flow theme aim to measure CE in terms of productivity (e.g., energy productivity metric, resource productivity metric) and economic value (e.g., value-based resource efficiency metric). Most metrics included assess the resource input, material use, and waste generation. It is important to note that although there is a wide range of metrics available to measure material flows, only a few metrics aim to evaluate a specific category in absolute terms or based per capita. However, these metrics are preferred as they provide reliable results. Absolute measurements avoid influences on the outcome by other changes such as general economic development. As part of the material flow theme, 11 metrics can be assigned to specific R-Strategies, and more than half (seven) evaluate recycling. No metrics can be assigned to R0, R3-R5, and R7 (refuse, re-use, repair, refurbish, repurpose) since the metrics potentially available do not meet the predefined requirements. Although R-Strategies should result in actions to transform products and components towards a CE, hardly any methods are proposed to map progress through these strategies at the national level because *enabler* metrics are missing. The only four of the 29 metrics considered to be *enablers are* the *number of new revenue models*[74], *household spending on product repair and maintenance*[75], the *share of remanufacturing business in the manufacturing economy*[76], *and share of materials where safe recycling options exist* [77]. These are all assigned to the R-strategy category. Most of the metrics evaluating material flows in the economy are best-available, and seven are best-needed, again, mainly to evaluate R-strategies.

ENVIRONMENTAL IMPACTS

No metrics are identified to cope with the requirements and measure the environmental impacts of CE on biodiversity and toxicity. Consequently, these categories do not appear in the proposed set of CE metrics. Eight metrics within the proposed set aim to measure environmental impacts on land, water, and climate. Three of the metrics evaluate combined impacts, however, at the company level (micro-level). These are *the number of institutions with EMAS*[78,79], *the share of sustainably certified materials*[80], and *lifecycle assessments of enterprise activity.*[81]

Five metrics evaluate environmental outcomes on water, climate, and land. Only a single metric can be selected to measure the environmental impact on land; however, no calculation method for this metric is proposed. The combined environmental impact metrics, which are explained above, are all assigned to the enabler category. The metrics for measuring environmental impacts are equally distributed, half of them are best-available, and half are best-needed. One reason for the equal distribution is the consideration of metrics of the German Strategy on Sustainable Development. Although several policies set the reduction of environmental impacts as an overarching goal of CE to achieve sustainability (two requirements explicitly include this aspect), the least number of metrics could be identified in this category.

[74] Potting and Hanemaaijer (2018)
[75] Magnier et al. (2017)
[76] European Environment Agency (EEA) (2016)
[77] European Environment Agency (EEA) (2016)
[78] EMAS is a voluntary eco-management and audit scheme for organisations, developed by the European Commission
[79] Statistisches Bundesamt (Destatis) (2018)
[80] Statistisches Bundesamt (Destatis) (2018)
[81] Smol et al. (2017)

SOCIO-ECONOMIC IMPACTS

Twelve metrics are suggested to evaluate socio-economic impacts and are assigned to the categories: jobs, education, competitiveness, innovation, and political instruments. Surprisingly, many metrics primarily referring to economic impacts could not be considered because they do not meet the predefined requirements. Only one metric can exclusively be considered as a social metric, namely the *number of circular courses*.[82] All other metrics include economic values or aspects; hence a complete evaluation of the social dimension about the transformation towards CE is not possible. Metrics equally link to the competitiveness and innovation category (three metrics each). In contrast, only one metric evaluates the jobs generated in a CE (e.g., *People employed in the repair, reuse, and recycling sector)*. Eight out of nine metrics evaluate transition dynamics (enablers), and the *economic growth CE part* metric proposed by Potting and Hanemaaijer (2018) actually evaluates one of the desired CE outcomes. Unfortunately, this metric is still in the "best-needed" category. Apart from five metrics currently part of policy-driven monitoring sets like the EU Monitoring Framework and the German Sustainability Strategy, no calculation method exists for seven metrics, thus classified as best-needed (i.e., Green Public Procurement and Economic Growth CE part[83]). This implies that most metrics evaluating socio-economic impacts are significantly less developed than material and resource flow metrics.

5 EXPERT CONSIDERATIONS ON THE PRIORITISATION OF METRICS IN A NATIONAL CE MONITORING SYSTEM

Interviews with experts in the fields of CE, sustainability, material flow analysis, and policymaking were conducted. These people are familiar with the specific CE metrics or measurement types evaluating key dimensions of CE and can validate the framework, prioritise CE metrics, and bring up additional aspects. Overall, the experts perceive the overarching themes of the framework as a good starting point for setting up a national monitoring framework. However, it is necessary to mention that a proposed set of metrics and its evaluation will always be subjective, as various CE definitions lead to different prioritisations of experts on what should be measured. However, another legitimate approach is to prioritise metrics that evaluate circularity at the product level. The European CE Action Plan, for example, focuses on the circularity of products, which is why metrics at the product level to assess circular innovation, product design, product reparability and durability, product financing, production investment and jobs in the CE sector can play a more dominant role.

1. **The overarching theme "resource and material flows" should be prioritised.** As stated in literature[84] and by experts, the main contribution of CE is to achieve absolute resource reduction and reduction of waste as well as related environmental impacts (e.g., GHG emissions). Therefore, measuring material and resource flows through the methodology of material flow accounts and input-output tables should become a priority. These methods provide information about the mass balance of inflows and outflows in an economy and represent the economy's stock addition, for example, in buildings or materials incorporated in durable products such as cars. At some point, they become waste. Hence, assessing these stocks

[82] Potting and Hanemaaijer (2018)
[83] European Commission (EC) (2018a)
[84] Ellen MacArthur Foundation (EMF) (2015)

can potentially provide estimates of what can be put into circulation in the future. Additionally, the experts emphasise absolute CE metrics evaluating the global effects of material and resource flows. Next to the methodology of material flow accounts, experts prioritise evaluating associated environmental impacts with consumption-based metrics (i.e., footprints). Footprint metrics (i.e., for food, land, water, and materials) assess the consumption of resources along the entire value chain and provide more transparency of the production and impact of economic goods. Although Eurostat and other institutions provide a methodology for countries to measure national material footprints, only nine countries currently use these. Reasons for this may be the lack of statistical capacity and the lack of mandatory regulations. Although footprint metrics are suggested in some references to assess circularity[85], they are not part of current CE monitoring frameworks such as the EU Monitoring framework. However, with the EU currently working on a revision of the framework, this may soon change. In addition to the assessment of resource flows, experts agree on the need to analyse whether certain R-strategies are environmentally beneficial and thus support the evaluation of environmental impacts of CE activities. Despite LCAs as a potential solution, CE metrics are still missing to assess these impacts.[86] To do so, experts suggest collecting and aggregating micro-level data, as the implementation of R-strategies such as remanufacturing usually occurs at a company level.

2. **Further metrics are required to measure the socio-economic and environmental impacts of CE.** Although the interviewees generally agree on the importance of measuring the ecological and social impacts of a CE, experts estimate that socio-economic and environmental impacts related to a CE are complex to measure and might not result in a manageable framework. To assess environmental impact, metrics based on standard environmental methodologies like LCAs could be considered in national CE monitoring. Although originally designed to assess certain products impacts', the methodology can also be applied at a national level. For example the Welsh government analysed Wales' waste to estimate how recycling rates lead to relative savings of CO_2. However, experts assume that conducting LCAs at a national level to evaluate the environmental impacts of material use can be significantly cost-intensive and challenging to conduct.

   The evaluation of environmental impacts and the evaluation of socio-economic impacts is important, as EU policy refers to positive socio-economic effects through CE.[87] Unfortunately, metrics to assess these effects are somewhat neglected and require further development.

3. **Metrics should evaluate the impact of CE beyond national borders on society.** A CE related monitoring framework should help to assess how far CE is going to impact society. Therefore, it is equally important to measure CE's effects in terms of global prosperity and the improving quality of life in emerging and developing countries. Instead of shifting, e.g., resource-intensive manufacturing businesses, establishing remanufacturing businesses in developing countries could lead to less resource extraction and pollution in respective countries.

[85] Helander et al. (2019) and targeted in the new CEAP

[86] Desing et al. (2020)

[87] European Commission (EC) (2015b)

4. **Data availability for CE metrics needs to increase.** In general, not enough data is available to evaluate the global effects of resource extraction and the effects of R-Strategies (e.g., reduce, reuse, refurbish). The database and methods of material flow analysis already provide adequate information on resource inflows and outflows. On the other side, data is not sufficiently available for specific materials important for national production systems such as critical raw materials and plastics. Consequently, important materials are not well accounted for in macroeconomic monitoring.

   Furthermore, there is a lack of data to calculate material, food, and land footprints. The data comes from so-called multi-regional input-output databases that are not located at a statistical office but are from academic research. Experts question whether regular updates will be available for future evaluation.

   Moreover, not enough data is available to evaluate the implementation of R-strategies at the macro-level. The R-Strategies consist of principles that are usually implemented at the company level (micro-level). For the national monitoring of these, sectoral and local data would have to be aggregated. The same applies to the environmental impacts of circular products, as they would need to be assessed through lifecycle assessments, for which limited data is available. To obtain information on circularity at the micro-level, there would be a need to mandate businesses to report in a standardised way on their recycling and waste recovery, remanufacturing activities, refurbishment activities, etc. However, this is not yet implemented. To assess the R-strategy reuse (R3), for example, information on professional sharing businesses such as second-hand platforms and non-official channels, such as Facebook groups, would be required, but this would be challenging. In summary, the lack of data and methodology to evaluate the implementation of the R-Strategies and related environmental effects at a national level potentially prevents a holistic evaluation of the CE concept. Only a few metrics allow for practical evaluation of national transition activities (enablers).[88] According to several experts, these metrics are useful to oversee progress until CE activities' outcomes become visible, yet only a few of them are currently available.

5. **Productivity metrics should play a less important role in CE monitoring.** Experts criticise the utility of existing metrics applied to measure CE and criticise productivity metrics[89] in a proposed set of CE-metrics. Most interview partners raised concerns about including resource productivity metrics in national CE monitoring frameworks. Productivity metrics are widely used for monitoring the decoupling of resource consumption, the main goal pursued by CE. They are part of many (supra)national monitoring frameworks (i.e., in Europe, Germany, France and the Netherlands). In general, productivity metrics (GDP/ Resource Consumption) are used to measure system efficiency and lead the current political debate on resource reduction. Productivity measures are assumed to evaluate the outcomes of a CE and enable a comparison of nations. However, resource productivity metrics punish nations where a lot of resource extraction occurs, depending on whether international trade flows are considered in the calculation method applied for resource consumption. In addition, critics refer to the use of GDP in productivity or efficiency indicators as GDP might be a poor indicator of wellbeing.

[88] Potting and Hanemaaijer (2018)

[89] Rodriguez et al. (2020)

Based on increasing evidence, it is debatable if absolute decoupling is even possible, as any economic growth is related to resource extraction.[90] Resource productivity is a lead metric used by several European countries and the EU. However, it is not creating the narrative around resource reduction as an urgent matter to combat climate issues.

In Germany, for example, resource productivity is increasing every year. However, absolute resource consumption is still on the rise. That is because GDP grows faster than resource consumption. The metric can give politicians the impression society is improving towards absolute decoupling, although this is not the case. Since the indicator is mainly useful for comparing states, productivity metrics should play a less important role in national CE monitoring.

[90] Rodriguez et al. (2020)

STEP 3: RESULTS AND IMPLICATIONS FOR POLICYMAKERS

The report provides an overview of existing metrics available for CE, therefore supporting political decision-makers in identifying and selecting the essential metrics for evaluating progress towards a CE at a national level. The set of CE metrics provides the basis for selecting metrics for comprehensive national monitoring. The analysis shows that governments could already apply metrics to assess the primary outcomes of a CE, which are the reduction of resources and waste. However, significant data gaps still need to be closed in the metric discussion, such as on environmental and socio-economic impacts of a CE by examining best-available and best-needed metrics. A monitoring framework should include CE metrics that guide transition dynamics and enable a regular political debate on resource use decisions and actions. These metrics (enablers) steer the transition towards the desired outcome of a CE. For holistic progress monitoring, governments need to collect micro-level data to explore the successful implementation of R-Strategies in specific industries in a standardised way. Therefore, governments should establish new reporting schemes for material-intensive industries and products beyond the voluntary presentation of sustainability information by companies.

01 short term	include metrics relevant to evaluate CE of current policy programs in existing legally anchored monitoring frameworks. In the case of Germany, proposed metrics on secondary materials of the German Resource Efficiency Program should be included in the German Strategy on Sustainable Development
02 short term	complement productivity measures with more informative metrics on resource consumption such as material footprint metrics
03 long term	establish a standardized reporting scheme on R-Strategies for resource-intensive industries and sustainability reporting for all industries to obtain data about the transition process and its effects
04 long term	decide on absolute reduction targets for footprint metrics
05 long term	agree on targets for CE and make their evaluation through a set of metrics legally binding. The designation of targets thus has a strong impact on the choice of metrics.

Figure 4: Five implications for policymakers to implement a national CE monitoring in the long run
Source: Own overview

Moreover, the final selection and prioritisation of metrics depend not only on the CE definition applied but also on agreed targets a nation wants to achieve with a CE. For instance, a CE in Germany should go beyond recycling, efficiency, and productivity targets, which currently have not led to much improvement regarding a reduction in resource use. While resource productivity metrics enable a comparison of nations, targets, e.g., for material footprints, are required. With the new CE action plan, the European Commission wants to achieve a decoupling of resource use from economic growth.[91] In view of these targets, it is now time for member countries to contribute to this goal by setting concrete targets on resource reduction and evaluating them through comprehensive CE monitoring.

In short, this work contributes to the question of what national governments could consider to further develop successful monitoring of the desired effects of a CE:

01 (short term) Include metrics relevant to evaluate CE of current policy programs in existing legally binding monitoring frameworks.
In the case of Germany, proposed metrics on secondary materials of the German Resource Efficiency Program (ProgRess III) should be included in the German Strategy on Sustainable Development. Although these metrics make it possible to assess the direct and indirect effects of substituting primary raw materials with secondary materials, the results have not yet led to increased political action. By including important indicators in existing legally anchored monitoring frameworks, the results can receive more attention and hopefully lead to a higher level of ambition.

02 (short term) Complement productivity measures with more informative metrics on resource consumption such as material footprint indicators.
The resource productivity metric alone, as currently the lead metric to assess resource efficiency, is not enough and does not give an accurate picture of the EU's and Germany's progress on resources.[92,93] Although helpful to compare progress between nations, the metric does not consider the effects of resource consumption across borders. Consumption metrics, such as for raw material, land and water, could ensure the implementation of CE would focus on reducing resource consumption.

03 (long term) Establish a standardised reporting scheme on R-Strategies for resource-intensive industries and sustainability (environmental and socio-economic) reporting for all industries to obtain data about the transition process and its effects.
The success of a nation in achieving resource and waste reduction is reliant on the adoption of CE by companies, as companies' productivity is intrinsically linked to a nation's resource use. To operationalise a national CE monitoring framework, governments need to obtain information about CE activities (R-Strategies) which are usually implemented at the company level (micro-level). However, metrics proposed to evaluate the transition process are still underrepresented in the current discussion, and many of these metrics require micro-level data. A standardised reporting of industries for which a CE is appropriate would be desirable to overcome these challenges.

[91] European Commission (EC) (2020b)
[92] Weber and Stuchtey (2019)
[93] Friends of the Earth Europe, European Environmental Bureau, Vienna University of Economics and Business (2020)

DEEP DIVE ON POLICY IMPLICATION 03: THE IMPLEMENTATION OF CE METRICS AND STANDARDS CAN LEARN FROM THE GLOBALISATION OF FINANCIAL STANDARDS

The concept of the circular economy (CE) has existed for some time now. However, only in the last decade has there been a development of circular economy standards to provide authoritative guidance on circular economy principles, strategies, implementation, and reporting. To date, CE standards are hugely fragmented, and it is difficult to assess whether business level activities deliver any tangible resource savings. Therefore, the EU should include CE reporting into the European semester to enforce the alignment of metrics. There must be a strong push (e.g., from industrial associations, consultancies, and accountants) to translate CE metrics into a good practice based on easy-to-apply instructions. Currently, this transmission is largely missing, and standards are not practical and are hard to adopt. (e.g., require high effort from companies and are costly).

So far, CE standards[94] have been developed differently, with metrics being developed mutually independent at the corporate and national levels; they are therefore not readily inter-translatable. The implementation of the standards, including metrics and reporting, is not mandatory, leading to a lack of circular economy data required to assess the progress of companies towards CE. The foundation of a national circular economy standard is in place; however, it needs adaptation and scrutiny to meet national or international requirements. A multi-year journey lies ahead as countries collaborate and converge. However, this process could be sped up by utilising the key learnings from the implementation of IFRS and encouraging the EU to take the lead on driving the process forward. The development of a robust circular economy standard with good governance will guide nations and organisations through change, making them and the European economy more transparent as a result.

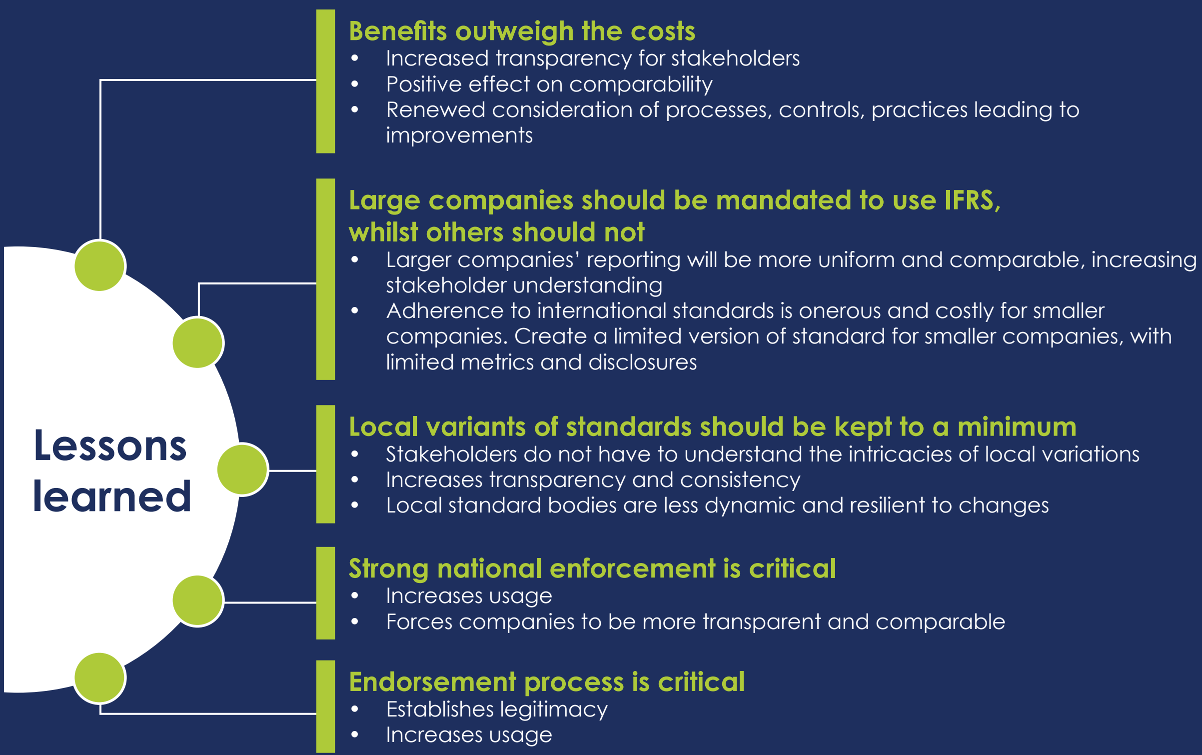

Figure 5: Five key learnings from the implementation of International Financial Reporting Standards (IFRS)
Source: Own overview

[94] An overview of existing CE standards and waste standards can be found in Annex D

The international convergence of accounting standards has taken place over decades, with a shared objective of developing high-quality, common standards[95] and an overseeing international board alleviating complexities and conflict. Whilst not a simple process, the collaborative effort to converge has resulted in several benefits, as described in Figure 5.

Building on the key findings of this analysis, expert interviews, and the key learnings from ISFR, nations could mandate specific sectors or companies of a specific size (e.g., listed companies) to adhere to circular economy standards, in line with IFRS application and create a limited version of the standard for smaller companies. The tools and guidance for basing this on already exist.

A. **Nations should refrain from creating new standards.** Years of rigorous research, debate and discussion have gone into developing existing standards. Nations should build on this adapting it for national requirements and refrain from creating a new standard. There are currently three prominent and specific circular economy standards. In addition, two new waste standards were also examined as they introduce concepts of circularity (for further information, please see Appendix D).

   BS 8001:2017 currently appears to be the most advanced circular economy standard and most aligned with existing circularity tools (e.g., EMF's Circulytics tool). EMF has played a pivotal role in the development of BS 8001:2017[96]. It is a standard providing guidance on a microeconomic level and must therefore be adapted for use on a macroeconomic level as a national standard. To be suitable for a nation, definitions should also be scrutinised, and gaps identified should be addressed (e.g., application for buildings). Adapting an existing standard could potentially save countries years of development.

   The standard should make clear connections to Sustainable Development Goals (SDGs), policies, and climate targets at a national level. As Circle Economy recommended within its Circularity Gap Report, "Develop decision metrics and a measurement framework. This will encourage goal-setting, evaluations and peer review, which will, in turn, serve to benchmark performance and track progress against longer-term global ambitions such as the Paris targets and the SDGs."[97]

   Germany, or perhaps the EU, could define a macro level CE standard building on existing standards but leaving room for national adaptions and context.

B. **The European Commission, standard-setting bodies and organisations creating CE measurement tools should work collaboratively to align circular economy terms, principles, vision, and actions.** Standard-setting bodies (e.g., ISO, BSI, AFNOR) and circular economy measurement tools (e.g. Circulytics) should work collaboratively to align circular economy terms, principles, vision, and actions, eliminating inconsistencies within the circular economy system. The assessment of both the French standard body AFNOR and the British standard

[95] See https://www.fasb.org/jsp/FASB/Page/SectionPage&cid=1176156304264
[96] Masi et al. (2017)
[97] Wit et al. (2019)

body BSI's circular economy standards revealed differences between definitions, scope, and the end-use of circular economy, highlighting the need for nations to work together to increase uniformity.

The European Commission has created a monitoring framework[98]composed of key metrics capturing resource efficiency to strengthen and assess progress towards a circular economy. This is an opportune time to further develop the framework, with changes being made to the EU Green Deal and ensure alignment between CE standards and the EU monitoring framework. The EU could also build on the implementation of the International Financial Reporting Standard (IFRS) as a guide to successfully implement consistent global circular economy standards, with each nation understanding the value of convergence toward an international standard (see Figure 5).

C. **Circular economy standards should be made mandatory to measure and report progress toward a circular economy at a national level.** For nations to successfully measure and report progress, circular economy data should be collatable, comparable and reliable. By mandating circular economy reporting through a reporting infrastructure or standards with specific CE metrics, data will be consistent for nations to collect and measure national progress, whilst organisations will be required to contribute to wider circular economy goals.

With the advancement of technology, standardisation of reporting and data collection should enhance accessibility, enabling nations to identify additional circular economy opportunities. Companies' productivity is intrinsically linked to a nation's resource use. If mandated to report on circularity, company operations will become more responsible, transparent, and resilient, increasing the resiliency of a national economy.

Nations could mandate specific sectors or companies of a specific size (e.g., listed companies) to adhere to circular economy standards, in line with IFRS application and create a limited version of the standard for smaller companies. The tools and guidance for building on already exist.

To increase standardised reporting across the EU, it can be submitted for review to The European Semester (a multi-annual exchange between the European Commission and the Member States) as a reporting category for member states. The European Semester will provide recommendations, and it could lead to the subsequent coordination of CE reporting across the EU member states.

[98] European Commission (EC) (2018a)

4 (long term) Decide on absolute reduction targets for footprint metrics
At its core, the goal of a true circular economy means reducing the absolute quantity of natural resources that go into the economy and reducing the amount of waste that comes out. Only with smaller and slower cycles of material throughput will nations manage to stay within ecological limits and a safe operating space. Better product design and other measures, as emphasised in the European Green Deal, certainly aim in this direction. However, these measures should be more clearly linked to policy targets to realise their full potential and ensure that they reduce absolute resource use. Setting headline targets to halve national material footprints, as the Dutch government established in 2016, clearly raises the level of ambition.[99]

05 (long term) Agree on targets for CE and make their evaluation through a set of metrics legally binding. The designation of targets thus has a strong impact on the choice of metrics. National targets can facilitate a transition towards a CE in several ways, for example, by reducing resource use and waste, closing production loops, using resources more efficiently, or maximising the retention of the economic value of materials and products. Progress monitoring requires metrics based on comparable data to inform political decision-makers and society. To obtain these data, which are required from several levels of analysis (company, city, and national level), policymakers should agree on a manageable set of CE metrics aligned with a nation's framing of CE. Legal frameworks could form the required national legal basis for holistic CE monitoring.

[99] Friends of the Earth Europe, European Environmental Bureau, Vienna University of Economics and Business (2020)

CONCLUSION & OUTLOOK

CE metrics development is currently a very active field. There are many metrics suggested for the macro-level assessment of the outcome of a CE, which aims for global resource reduction. The objective of the report was to demonstrate that it is already possible to develop a practical, feasible set of metrics that thoroughly evaluates the progress of nations towards CE.

Therefore, outcomes and also activities that enable a national transition must be measured. However, metrics proposed to evaluate the transition process are still underrepresented in the current discussion, and many of these metrics require micro-level data. A standardised reporting of industries for which a CE is appropriate would be desirable to overcome these challenges. Currently, linkages of progress towards CE at (supra) national level and company-level CE monitoring (e.g., information on refurbishment) are not visible. For national monitoring, it is essential that the EU establishes a standardised process to obtain information on CE progress at the company level, as is the case for financial reporting.

A proposed set of CE metrics is of a subjective nature as a consistent understanding of CE is missing. On the one hand, the lack of a CE definition hinders the classification and data generation of national economic activities concerning CE. On the other hand, due to the lack of demarcation, many people can identify with the concept, promoting its dissemination and, hopefully, leading to more sustainability. To ensure the sustainable transition towards a CE, nations need to assess the global effects of their resource consumption. Therefore, footprint metrics assessing the impact of resource consumption throughout the value chain should be part of any national CE monitoring. In the long term, however, global monitoring will be needed to provide a holistic view of the systemic effects of CE.

Although it is already possible to measure or at least estimate the many potential outcomes of a CE promoted in policies, numbers do not show significant improvements towards sustainability, for example, in Germany. It is not enough to have metrics in place; absolute figures must improve, which can only be achieved by actions that follow ambitious targets. Current European policies claim, for example, that CE activities contribute to solving the climate crisis. To leverage the CE potential at a national level, new and ambitious targets are required, which meet an agreed definition for CE targets. These targets should go beyond the increase of

resource efficiency, which only leads to incremental changes, and should be complemented by national actions leading to sufficiency through an absolute reduction in resource consumption.

In conclusion, the findings of this report show that a practical, feasible set of CE metrics can currently be applied to support national policymakers in steering the transition and evaluating how far the right decisions for future CE activities have been made. Instead of hiding behind the argument of what is currently impossible to measure, placeholder metrics (proxies) should be used to approximate the desired effects. However, CE actions are not limited to national borders, as they involve global material flows through international operating companies and states. Therefore, global monitoring based on a global database, which a supranational operating institution regularly updates, will be required in the future. The current pandemic shows that metrics based on scientific evidence are essential for solving any kind of crisis. As CE is being promoted as one of the tools to solve the climate crisis, policymakers should learn the lessons from the current pandemic and start today with an assessment of the transformation towards CE with legally binding targets and metrics to achieve absolute resource reduction.

APPENDIX

APPENDIX A: TERMINOLOGY USED IN THIS REPORT

CE definition. The definition of CE used in this work is based on Kirchherr et al. (2017).[100] It includes the principles of the Ellen MacArthur Foundation as they are most frequently used to describe the CE concept. Based on the investigation, a CE can be summarised as "*[…] an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro-level (products, companies, consumers), meso-level (eco-industrial parks) and macro-level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers*".[101]

CE principles. The Ellen MacArthur Foundation (2015) identifies three principles according to which CE is described in line with biological and technical cycles.

1. Design out waste and pollution
2. Keep products and materials in use
3. Regenerate natural systems

R-Strategies. The CE principles are operationalised through resource value retention activities, called R-Hierarchies or R-Strategies.[102]

The 10R typology, therefore, has the highest level of differentiation. The number of strategies varies in the literature between 3Rs and 10Rs but are always sorted by priority. This results in a "circularity ladder", where R0 represents the highest strategy.[103]

From the consumption side, this strategy leads to the absolute reduction of consumption and, consequently, inputs. From the production side, the strategy leads to the avoidance of virgin intake of materials.[104]

Metrics definition. In this report, the explanation of the OECD (2014) is used, which defines a metric as a "*quantitative or qualitative factor or variable that provides a simple, and reliable, means to measure achievement, to reflect the changes connected to an intervention, or to help assess the performance of a development actor.*" The terms "metric", "index", "measure-

[100] Ellen MacArthur Foundation (EMF) (2013)
[101] Kirchherr et al. (2017)
[102] Blomsma and Brennan (2017); Potting and Hanemaaijer (2018); Reike et al. (2018)
[103] Potting and Hanemaaijer (2018)
[104] Reike et al. (2018)

ments" and "indicator", either singular or plural, are used interchangeably in the literature.[105] In this work, the term "metric" is predominantly used for CE measurements.

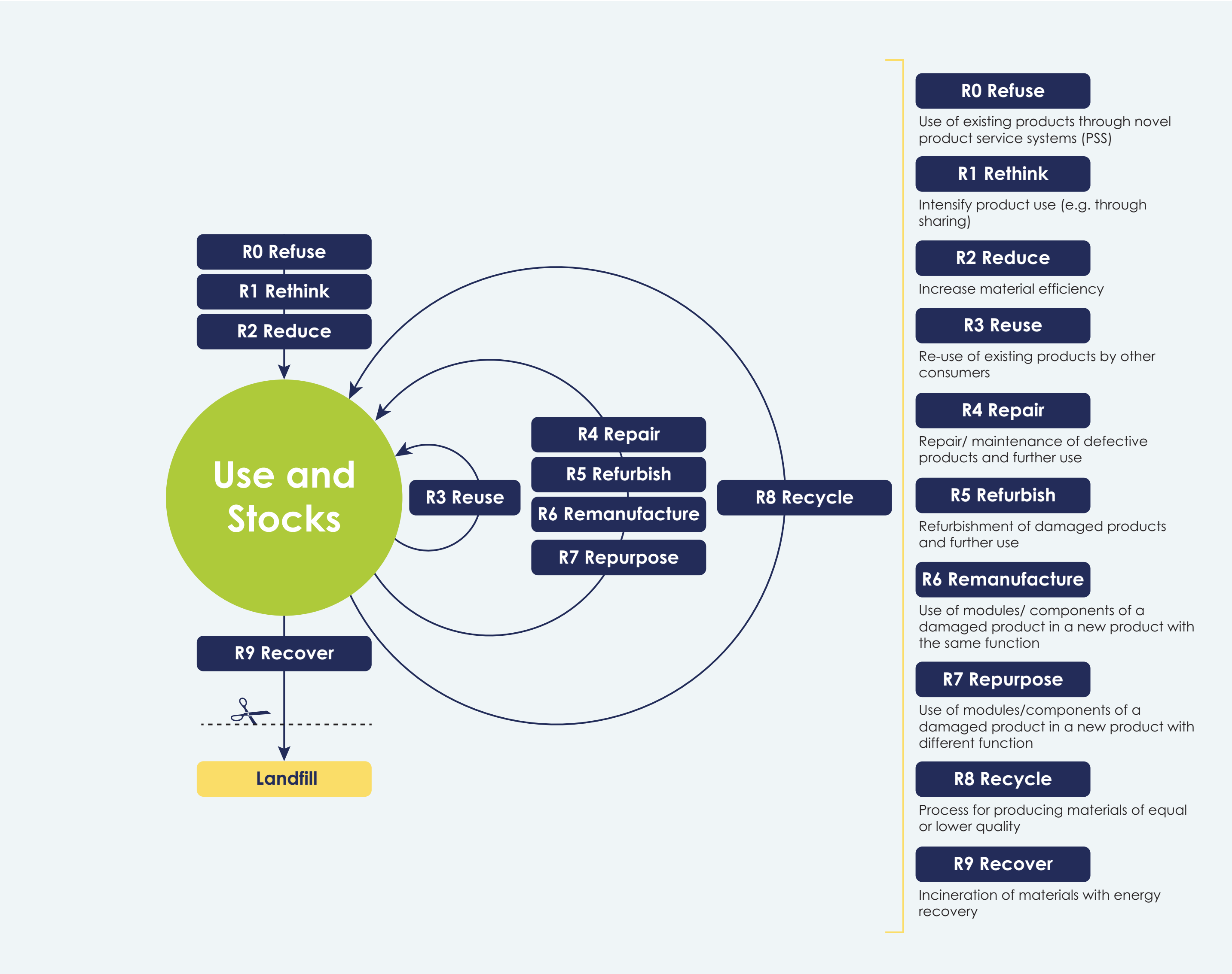

Figure 6: 10 R-Strategies for a CE
Source: Own illustration, elaborated from Potting et al., 2017; Potting & Hanemaaijer, 2018.

Proposed set of metrics. As stated in performance measurement theory, often, a set of metrics is used to evaluate progress.[106] This also applies to the evaluation of CE, as several authors claim that it is not possible to evaluate CE with a single metric.[107] Amongst others, one reason is the extensive definition of the concept resulting in different CE strategies and requirements (see chapter 2.1), which should be assessed.[108] Policymakers, therefore, also consider a set of metrics to be useful. For instance, the European Commission states: "[…] to assess progress towards a more CE and the effectiveness of action at EU and national level, it is important to have a

[105] Saidani et al. (2019)
[106] Carter (2002)
[107] Elia et al. (2017); European Environment Agency (EEA) (2016); Iacovidou et al. (2017); Pauliuk (2018)
[108] Avdiushchenko and Zając (2019); Moraga et al. (2019)

setofreliablemetrics”.[109]

Levels of analysis. CE metrics help to evaluate national targets as well as company visions and allow to compare circularity of nations, industries, and products. A distinction is made between three different levels of analysis where different metrics are being applied.[110] These are (1) micro-level metrics, (2) meso-level metrics and (3) macro-level metrics.

It is important to note that scholars delimit the levels of analysis in different ways and apply different definitions of what is part of the micro-, meso-, or macro-level.[111] In this work, the delimitation of the levels of analysis suggested by Kirchherr et al. (2017) is applied:

1) **micro-level metrics: organisation, products, and consumers.** On a micro level, metrics focus on companies, components and products. The longevity metric, for example, measures the quality by using lifespan estimations from statistical records to evaluate the durability of materials in products.

2) **meso-level metrics: symbiosis association, industrial parks.** Only a few metrics currently exist to evaluate circularity at the meso-level, which represents the regional level or inter-firm level, for example, industrial parks.[112]

3) **macro-level metrics: city, province, region, or country.** The circular material use (CMU) rate indicator is an example for measuring circularity at a macro level (e.g., for the EU as a bloc). The metric shows the share of materials recovered and fed back into the economy in overall material use. The higher this rate is, the lower the need for virgin raw materials.

To date, there is little research on how the different levels of analysis could be linked.[113] According to the purpose and scope of this study, the focus is more strongly on macro-level metrics for the CE transition.

[109] European Commission (EC) (2015a, p. 20)
[110] Ghisellini et al. (2016); Kirchherr et al. (2017); Moraga et al. (2019)
[111] Moraga et al. (2019)
[112] European Academies Science Advisory Council (EASAC) (2016)
[113] Alaerts et al. (2019)

APPENDIX B: RESEARCH METHODOLOGY

As the purpose of this study is to overview the knowledge base by collecting existing CE metrics and identify existing patterns, the integrative review method was chosen.[114] Figure 7 summarises the research design.

Figure 7: Research design
Source: Own illustration

To develop a framework consisting of relevant CE metrics, the insights and perspectives from literature and different topic experts are combined. Although China is very active in CE metrics development, only European publications were considered, as the approaches to CE and monitoring are different.[115] Subsequently, existing CE monitoring frameworks at a macro-level from the EU, France, the Netherlands, and Finland were included.

This work reviews academic literature and grey literature on macro-level CE metrics (e.g., scientific papers and governmental reports), as the concept of CE is receiving attention from academia and practice.[116] The focus is on peer-reviewed articles in English. However, German publications proposing relevant metrics to measure aspects of CE were included. The search was undertaken in the Web of Science and by using the Google Search Engine. In this study, search terms "CE" + "Metric" / "Metrics" / "Monitoring" / "Metrics" / "Assessment" were used. Although the search was limited to CE metrics, backward citation of these papers was used to identify additional papers as a secondary source. It resulted in an additional review of five[117] policy reports which do not specifically mention CE but include metrics on resource efficiency/

[114] Torraco (2005)

[115] Avdiushchenko and Zając (2019)

[116] Reike et al. (2018)

[117] OECD (2014), European Commission (EC) (2015b), Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (BMU) (2020), Deutsche Bundesregierung (2020), Ressourcenkommision am Umweltbundesamt (KRU) (2019)

sustainability. After removing duplicates, the search resulted in a collection of 58 publications that specifically mention CE metrics (please find a detailed literature overview in the supplementary material).

The search plan presented resulted in a sample of 58 publications, of which 42 articles mention national-level metrics. The initial focus of the literature review was on the abstracts and findings of identified articles before CE metrics were collected. The process resulted in a total of 232 CE metrics. As the number of metrics found is too high to derive a manageable set of metrics, further adjustments to the sample were necessary. Therefore, the selection criteria "level of analysis" was applied to produce an appropriate sample. Due to the scope of this study, micro-level metrics were excluded from further research. This approach led to a further reduction of publications considered in the analysis. It resulted in 207 CE metrics either developed to measure CE on a macro-level (201) exclusively or explicitly designed to evaluate CE on a micro and macro-level (six metrics). Many of the CE metrics appeared in several literature sources simultaneously. An example is the Domestic Material Consumption metric (DMC) proposed, e.g., by Eurostat (2020), European Environment Agency (2019), Mayer et al. (2019).

The literature review resulted in a collection of 165 metrics from 24 publications which are potentially suitable to evaluate progress in the transition towards CE at a national level. As a first step of the analysis, CE metrics were eliminated, which showed little semantic differences but aimed to measure the same processes or effects of a CE. An example of metrics which aim to evaluate the same outcome are "Persons employed" included in the EU CE Monitoring Framework[118] and "Employment in eco-innovation and CE" proposed by Smol et al. (2017). After that, the framework introduced by PBL Netherlands (2017) was chosen and extended to group metrics according to which critical aspects of CE they quantify. This step is required because no unified categorisation system defining critical aspects to group existing CE metrics on a macro-level has been established. To cluster metrics that could not be assigned to the critical aspects of the framework, additional categories, such as "competitiveness and innovation", were added. Such a categorisation system or framework enables visual interpretation and a clear overview of relevant categories. However, only under the condition that a limited number of metrics is included. Consequently, a further reduction of CE metrics was needed. In the next step, a feasible set of metrics was obtained by allocating national metrics to predefined requirements. The requirements are based on existing theory and European and German political objectives and are described in Table 2. The process is required to select available metrics from the available pool, leading to a practical and feasible set of CE metrics. The process resulted in the selection of 50 CE metrics that are relevant for nations and especially Germany, as metrics suggested in German strategies such as ProgRess III and DNS are included. This allowed for the categorisation of 50 metrics according to overarching themes, as shown in Table 3. The results of the integrative literature analysis were further discussed with experts in the field.

[118] European Commission (EC) (2018a)

APPENDIX C: CRITERIA FOR SELECTING THE RIGHT INTERVIEW PARTNER

Criteria	No. of interviewees
Being part of the CE Initiative Deutschland (CEID)	**2**
Being a (co-)author of an academic or working paper with a focus on the research field of CE (metrics) and/or resource efficiency, ideally highly ranked in terms of citations	**4**
Being a representative of a governmental organisation in the field of environmental economics either on a European or national level	**3**
Being a representative of a foundation or NGO involved in CE metrics developments and public decision making	**2**
Being part of public/ private research institutes involved in national/ supranational CE metrics discussions (e.g., Bellagio Process)	**2**
Being part of a standard-setting institution or association/ institution familiar with circular economy monitoring at a business level	**3**

Table 4: Criteria for selecting the right interview partner.

APPENDIX D: INVESTIGATED STANDARDS INCLUDING THREE SPECIFIC CIRCULAR ECONOMY STANDARDS FOLLOWED BY TWO WASTE STANDARDS INTRODUCING CIRCULARITY

There are currently three prominent and specific circular economy standards. Only two countries of the European Union introduced national norms for circular economy; Great Britain with the circular economy standard BS 8001:2017 and France with standard XP X 30-901. These standards in addition to a standard in development by International Organisation for Standardisation (ISO), an independent non-governmental organisation, are listed below:

- BSI 8001:2017 - Providing circular economy guidance for any organisation
- AFNOR XP30-901 - Providing project management assistance for any circular economy project
- ISO/TSC 323 - To provide standardised frameworks and guidance for any organisation. In development; due in 2021-2022.

In addition, two new waste standards were also examined as they introduce concepts of circularity.

GRI 306 Waste – Providing support to organisations in preparing a sustainability report and identifying and minimising the impact of waste in their value chain. Revised to reflect latest trends in waste management and prevention

DIN SPEC 91436 - To provide a reference model to establish a methodology for describing the zero-waste process.

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