PACE
Platform for Accelerating the Circular Economy

Circular Indicators for Governments

Accelerating action in the circular economy

WHO WE ARE

PACE is a global community of leaders working together to accelerate the transition to a circular economy. We bring leaders together from across business, government and civil society to develop a collective agenda and drive ambitious action.

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DISCLAIMER

Considering the highly dynamic nature of the field, findings included in this report may have changed at the time of publication. The authors can therefore not be held responsible for the completeness and accuracy of information beyond early 2021, which was when the literature review and stakeholder consultation for this report were conducted.The opinions expressed and arguments employed within are those of the authors, and do not necessarily reflect the official views of the organizations mentioned.

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FOREWORD

The need for transition to a circular economy has never been more urgent. More than 100 billion tons of resources enter the economy every year—everything from metals, minerals and fossil fuels to organic materials from plants and animals. Just 8.6% gets recycled and used again. Our use of resources has tripled since 1970, and could double again by 2060 if business continues as usual. We would need 1.5 Earths to sustainably support our current resource use. This rampant consumption has devastating effects for humans, wildlife, and the planet.

Investing in a circular economy will be crucial to helping us realize the social, environmental, and economic benefits of the 2030 Agenda and the Paris Agreement, as well as to build a sustainable economic recovery from COVID-19. But no single sector or organization can drive this transition alone. It requires systemic change across all sectors, with businesses, governments, and NGOs coming together in collective action on a global scale.

COUNT IT, CHANGE IT, SCALE IT

Collective action at scale can be accelerated by establishing an agreed upon vision with a common language and related metrics. This agreement can allow us to understand the current status on critical areas for action (count it), support new and greater actions (change it), and enable the focusing of resources and activation of new partners to maximize impact (scale it). Metrics are essential to defining and measuring progress and performance towards environmental, social, and economic impacts, and how circular economy approaches are making a tangible contribution to them. This publication focuses on key gaps in public sector metrics and provides opportunities for where action can be taken. Taken together with PACE's Circular Business Metrics report, this report provides the first clear picture of the current state of play on how governments are approaching metrics for the circular economy.

To help drive action forward beyond these reports, the PACE Secretariat and Circle Economy host the Circular Economy Indicators Coalition (CEIC), a space for leading stakeholders to exchange and coordinate metrics efforts, while addressing commonly recognized key gaps and challenges. The work is a vital foundation for providing the evidence needed to accelerate investments in the circular economy.

Momentum is building toward the adoption of circular economies. Along the way, we must ensure our priorities are in order and we hold ourselves accountable that our actions achieve our desired impacts. The prize for getting there is considerable: a cleaner, greener, fairer world.

David B. McGinty
Global Director, PACE

EXECUTIVE SUMMARY

Context

The need for the world to embrace a circular economy is both critical and urgent. If we want to see a more resilient economy and a healthier planet, we must urgently work to create a circular economy where waste and pollution are designed out, products and materials are kept in use, and natural systems are regenerated.

Positively, we can clearly see an increasing number of businesses and governments including transition to a circular economy as a core part of their vision, goals, and strategies. With enough momentum, this will result in society at large starting to embrace the long-term value and related positive outcomes of a transition. Although somewhat undervalued, the use of indicators as well as targets will be critical. After all, as the old adage goes: "what you can't measure, you can't manage".

Many efforts have arisen since mid-2019 to develop circular economy metrics for public or private sector use. Notwithstanding these laudable efforts, they have not yet resulted in an aligned metrics field. Key stakeholders are still speaking 'many languages' when it comes to indicator development. For indicators to be successful in supporting the transition to a circular economy, they have to be consistent, meaningful, widely accepted, and easy to use and understand. Together with a variety of challenges ranging from current limitations in indicator coverage to data availability and collection, the circular economy indicator field is still on its way towards maturity and not yet in a position to fully deliver on its potential to help accelerate uptake.

Moreover, if the promise of the circular economy lies in its ability to create transformational change at the system level, we have to be able to understand the impact of circular interventions on system outcomes. In practice, the majority of circular economy indicator efforts cannot yet translate progress and outcomes to impact areas that stretch beyond resource use; even though the circular economy is considered an important lever for mitigating dangerous climate change, and can equally create benefits for economic wellbeing, decent work, human health, and biodiversity.

This paper supports prospective developers and users of circular economy indicators by sketching out the current landscape, including contemporary thinking, current efforts, and state of play. Additionally, it provides high-level considerations on how the field can be further strengthened in the immediate and near future.

Vibrancy of the field

All in all, the findings in this paper point to considerable vibrancy in the circular economy indicator field. National and supra-national governments, statistical agencies, standards bodies, and NGOs in Europe and various countries beyond have embraced analysis and development of circular indicators for different purposes. The field benefits from a healthy and varied number of stakeholders proactively looking to advance. It is equally encouraging to see stakeholders increasingly starting to find each other to exchange or collaborate on further developing and aligning indicators and their frameworks, methodologies, and data.

Nonetheless, for those starting out on this journey, it can be challenging to know where to start and to get a good grasp of the latest thinking, without becoming at least somewhat befuddled by the wide array of publications and efforts out there. At the same time, for stakeholders ahead of the curve in thinking about and developing circular indicators, mechanisms and platforms providing opportunities to engage in cutting edge thinking on filling difficult indicator gaps and data needs are currently still quite nascent.

Recommendations

In this paper we put forward the following four improvement areas for immediate action. Each is considered a priority because it fulfils important near-future needs in the application and use of circular indicators:

1. **Common framework for measuring circular economy**

   A common framework is considered both a critical and feasible next step towards an aligned and

mature circular economy indicator field. Current initiatives have the potential to address this area, although there is a chance that multiple frameworks may emerge targeted at sub-sets of stakeholders. We therefore recommend that key stakeholders institute a regular exchange mechanism to ensure cross-fertilization and coherence, so that similar user groups are served through similar frameworks, and where user groups differ, that they benefit from alignment where relevant within and beyond Europe.

2. **Exchange mechanism for developers of circular economy indicators**

   Current explorative efforts have the potential to address this area, depending on how they eventually materialize and what the scope and reach of their target group is. As such, it is recommended that key stakeholders collect more granular data on the different needs and wants of developers (as well as users) of circular indicators in various sectors and geographies, to inform the outline and products of such formal exchange mechanisms.

3. **Harmonization and standardization**

   Current initiatives hold the potential to lead to greater convergence over time, although the pace may be slower than ideal for prospective end users. We recommend that key stakeholders keep a close eye on the needs, wants, and perceptions of their targeted end users, to ensure users understand the reasons and purpose of different approaches, and where interoperability or convergence is currently built in or strived for over time.

4. **Expansion of indicator coverage and data gathering and availability**

   Current initiatives aim to address some of the issues, but sticky challenges remain, and on some fronts there is limited pooling of knowledge towards solving them. We recommend that stakeholders further explore mechanisms that allow for active pooling of knowledge and efforts, as well as cross-fertilization, to more rapidly advance solutions towards solving some of these challenges.

In addition, three areas of improvement have been identified for further evaluation:

5. **Broad agreement on definitions and taxonomy of a circular economy**

   Although one definition for the circular economy may not be in reach any time soon, convergence of thinking is taking place alongside the first steps towards further building an EU circular economy taxonomy. Nonetheless, stakeholders should evaluate in due course whether the intended efforts have led to the desired outcomes, and if and how additional action might be necessary.

6. **Links between circular economy indicators across economic levels**

   Challenges in translation between indicators at macro-, meso-, and micro-economic levels are becoming acknowledged, although other aspects to making links and exchanging information may take longer to solve. Depending on where voluntary action and government policies are moving in the years ahead, such links may increasingly be established—or instead require dedicated action, as well as the exertion of stakeholder pressure.

7. **Setting circular economy targets underpinned by appropriate indicators**

   This action is highly dependent on the adoption of more comprehensive circular economy strategies, which would make target setting a logical next step. The next few years are critical, with an increasing number of jurisdictions and organizations expected to adopt circular economy strategies. If such uptake does not translate into an equal increase in momentum to set meaningful circular economy targets, deliberate action towards an uptake of target setting may be warranted.

Looking forward

A variety of actions can be taken up by different stakeholders under each area of improvement. Beyond individual solutions, we recommend that the circular economy measurement community continues and expands its efforts to create a more unified field that proactively exchanges, collaborates, and disseminates. This will not only serve its growing body of end users looking to develop and execute circular strategies and policies, but importantly also serves as 'proof of concept' for the broader sustainability and climate field, delivering the rigor and confidence that cements the circular economy's place as the linchpin for a sustainable, climate-proof and resilient world.

Introduction

Although thinking behind the circular economy has been around for a long time, the concept itself was only introduced two decades ago. The offshoot field of circular economy indicators started to flourish the past decade.

Many of the more prominent circular indicator efforts have been initiated in Europe, with a smaller number coming out of Asia and the Americas. Particularly in east Asia, the development of circular indicators preceded those in Europe. The various efforts and initiatives currently show a great deal of variety in their scope, purpose, and audience. They may for instance be purely academic in nature, represent the views of a group of corporates, serve a specific audience such as government stakeholders in a particular country, serve a specific purpose such as monitoring progress at macro-economic level, tackle a narrow scope such as material flows only, or aim to present a broad framework for classifying different types of indicators.

For indicators to be successful in accelerating the transition to a circular economy, they have to be consistent, meaningful, widely accepted, and easy to use and understand. Despite rapidly increasing interest and a growing number of efforts underway, no agreed framework and comprehensive, standardized or harmonized set of indicators is currently available in the public or private sector. As a result, interested stakeholders looking to adopt circular indicators for policy, due diligence, impact assessment, or accounting and reporting needs may have to conduct their own research and draw their own conclusions on which indicators would be most meaningful.

This paper aims to support them in that task by sketching the landscape of circular indicators including the vibrancy of the field, and by setting out high-level considerations for how the development of indicators could further be strengthened. The paper complements "Circular Metrics for Business" (Circle Economy & PACE, 2020) which provides an overview of the landscape of circular indicators for business. The main focus of this paper is to provide greater insight into the landscape and state of play of public sector circular indicators. The paper stems from two years of closely following the circular economy indicators field, starting with a PACE-led scoping phase in spring 2019, which assessed the landscape of circularity measurements and validated indicator needs. This was followed by ongoing efforts by PACE in 2020 and 2021 to convene key stakeholders, with a view to identifying how indicator needs can best be served using collaborative approaches, leading to the establishment of the Circular Economy Indicators Coalition (CEIC).

Section 1 of this report provides a technical analysis of circular economy indicators, briefly touching on different types as well as potential classifications (as put forward by various stakeholders), the availability of circular indicators across the product lifecycle, the availability of data, and the availability of circular targets. It closes with some additional considerations on measuring circular economy transition pending the development stage of the process.

Section 2 provides descriptions of a range of circular economy or closely related indicator initiatives as they have emerged in the past few years. It focuses predominantly on the public sector and related efforts at national or supra-national level, although it also includes an overview of various efforts by the private sector.

Section 3 builds further on this by taking a closer look at the vibrancy and maturity of the field, as characterized by the availability and application of circular indicators across a range of common categories, with a focus on indicators for public sector use.

Building on the analysis in Sections 1 to 3, Section 4 identifies a number of key areas where the current availability and usability of circular indicators can be improved. Section 5 provides recommendations on which of these areas should be prioritized for further action, and assesses the extent to which current and emerging initiatives have started to address them. It closes off with brief considerations for further strengthening the field in the years ahead.

1. The landscape of circular economy indicators

Indicators are here to inform, educate, monitor, and report. When it comes to indicators, it is key to acknowledge that they will serve different purposes for its users. These may include informing policy design, monitoring policy outcomes, or tracking progress towards a target. A variety of circular indicators is needed, each with a role to play in supporting and guiding stakeholders in the transition from a linear to a circular model. Some indicators will measure circular economy transition, while others measure the impact of the transition. Some will provide insights into the processes taking place in an economy, while others provide a picture of the outputs and changes in that economy. Indicators may also be focused on what happens within the boundaries of a unit, such as a jurisdiction, or include flows and impacts beyond that.

This section provides a high-level overview of some of the distinctions and considerations to take into account when developing or applying circular indicators, with particular relevance to the public sector. A more detailed analysis of the efforts stakeholders are currently undertaking, as well as the development and application of indicators within specific categories, is provided in Sections 2 and 3.

Circular economy indicator classification frameworks

Public sector stakeholders in Europe have put forward multiple classification 'systems' or frameworks for distinguishing between the different purposes of circular indicators, three of which are covered in this section.

EU RESOURCE EFFICIENCY SCOREBOARD FRAMEWORK

The European Union Resource Efficiency Scoreboard, developed in 2015, introduced a framework with three layers of indicators, inspired by how economic performance is typically measured. The first two layers of headline and dashboard indicators contain impact or performance indicators, measuring the impact of a circular economy on for example greenhouse gas emissions, resource use or employment. In addition, transition indicators help with better understanding the drivers for change and the progress made in influencing them (EC, 2020). This framework has been trialled in various circular economy indicator reports for particularly national and provincial governments, with some parties having altered or refined the classification to better reflect the purpose of the indicators covered under the three categories.

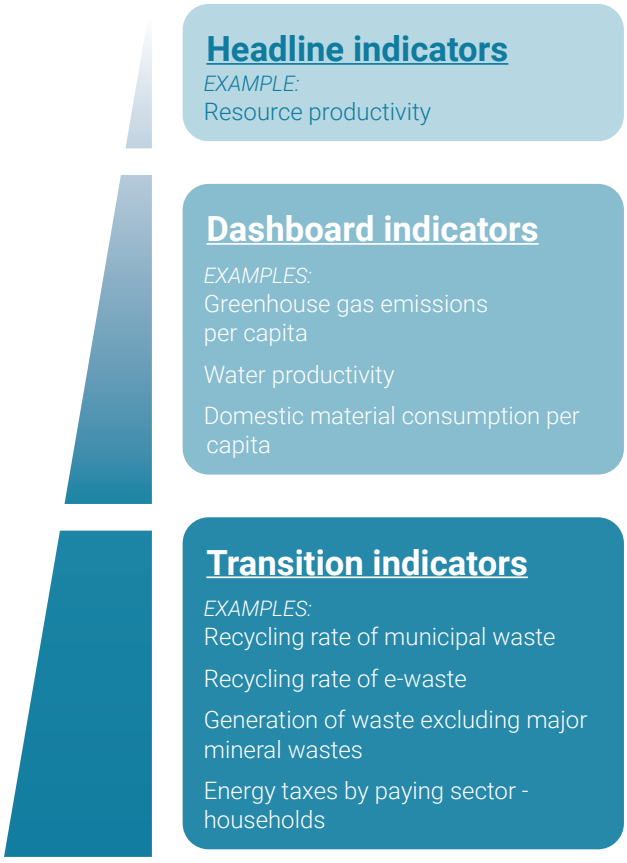
Headline indicators—provide an indication of the state of the economy

Headline indicators give a verdict: how circular is an economy? They can consist of a single indicator or a combination, but all highlight the desired end state of circularity and progress (or lack thereof) towards it. Typical headline indicators include the circularity of an economy expressed in percentages or resources consumed per unit. An example is the percentage circularity of an economy used in the Circularity Gap reports by PACE knowledge partner Circle Economy, which express an economy's materials metabolism represented by the materials flowing through and in long-term use. A disadvantage of a headline indicator is the limited level of detail it provides. For instance, a headline indicator for the reduction of a country's resource consumption will have to be further specified through dashboard indicators (next category) in order to be meaningful enough to ensure resource reduction focuses on scarce and/or high-impact materials.

Dashboard indicators—provide more context to the headline indicator

Dashboard indicators go a step further. They usually add further detail to the headline indicator(s), providing insights into various impact or performance aspects. They can inform on the pressure points of the current state and things that need to change. For instance, a common non-circular economy headline indicator is GDP as a measure of economic performance, with dashboard indicators breaking this down into specific aspects of economic performance. For the circular economy, some countries start using absolute resource consumption or resource productivity as a headline indicator, further broken down into indicators for different types of resources depending on their economic importance and security of supply.

FIGURE 1 • Indicative overview of different levels of indicators in the EU's Resource Efficiency Scoreboard



Source: European Commission, 2020

Instead of dashboard indicators, some parties refer to this category as performance indicators.

Transition indicators—provide more detailed insight in the transition process and changes in the structure of the economy

Lastly, transition indicators help stakeholders better understand the drivers for transition, and how to effect change. They can help understand the root causes of the current state of affairs, and progress made in influencing them. These indicators can be selected to track desired changes in human behavior, progress in tackling market failures, or the current phase of systems change. Overall, there is a wide variety of transition indicators to choose from, ranging from simple descriptive indicators such as whether a policy has been implemented, to more complex indicators giving insights into for example, citizen opinions of green alternatives.

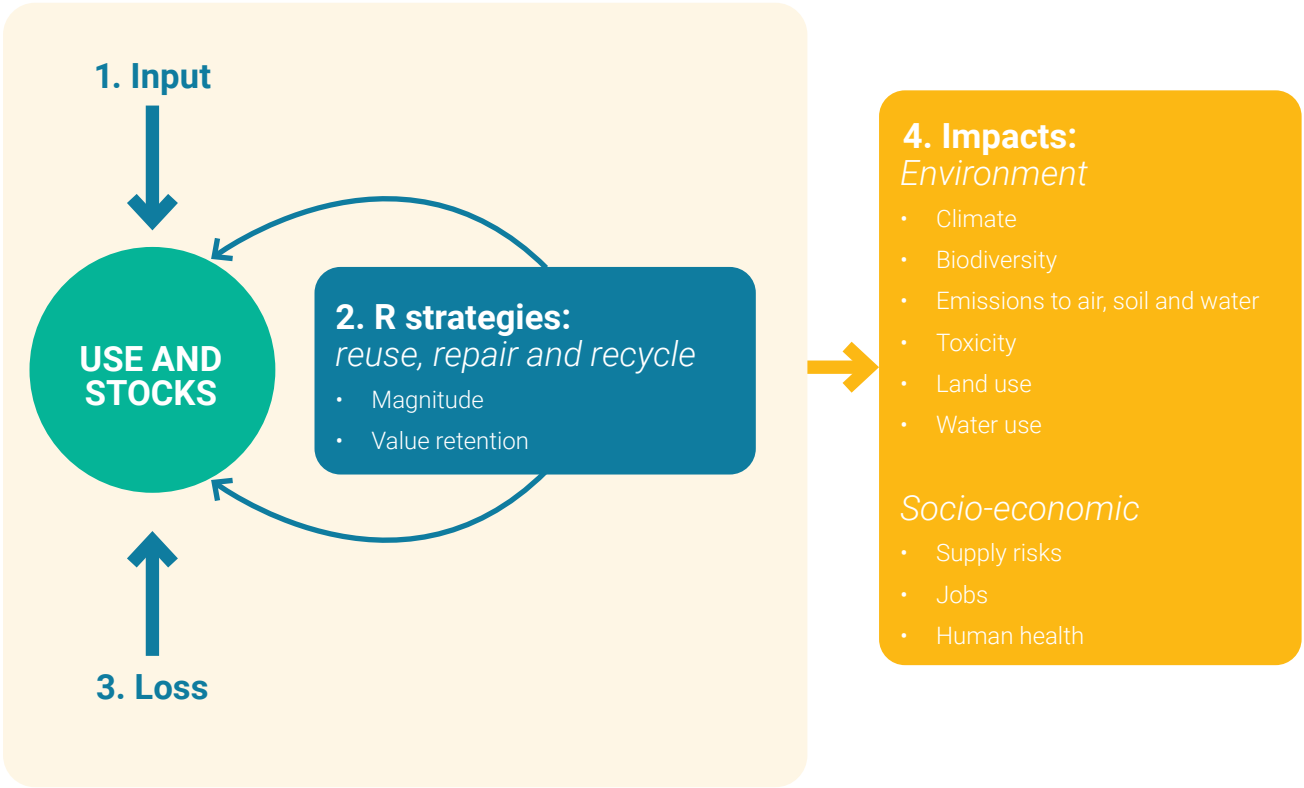
Instead of referring to this third category as transition indicators—with such indicators in theory also being able to feature as dashboard indicators or even as a headline indicator—one could alternatively add a third category focused on process indicators. Process indicators represent processes necessary to achieve the transition towards a circular economy and can be used to inform policies and programs, as well as to test whether they achieve their desired outcomes in terms of enhancing or accelerating the uptake of circular actions and relevant consumer behavior.

THE NETHERLANDS ENVIRONMENTAL ASSESSMENT AGENCY FRAMEWORK

The Netherlands Environmental Assessment Agency (PBL) has developed an initial framework for the circular economy indicator set currently being developed for the Netherlands, which distinguishes between three layers of indicators (Netherlands Environmental Assessment Agency, 2020):

- **Raw material use**: as represented by material inputs, use and stock levels, and outputs (see Figure 2).
- **The effects of raw material use**: differentiated by environmental and (socio)economic impacts.
- **The progress of the transition process**: particularly as related to the application of various "R-strategies" (R3-R8) such as reuse, remanufacturing, repair, and recycling. The full set of "R-strategies" as identified

FIGURE 2 • Schematic depiction of circular economy material flows and effects



Source: Netherlands Environmental Assessment Agency, 2020

by the Netherlands Environmental Assessment Agency is covered in the next section.

R-strategies are shown in Table 1 in general order of priority, starting off with three strategies (R0-R2) that prevent the unnecessary use of resources; followed by five that prolong the technical and economic lifespan of products in circulation (R3-R7); and finally at the bottom of the hierarchy the more well-known R-strategies of recycling and (energy) recovery (R8-9), which recover the materials (or their energetic value) from discarded products. These three types of strategies are also known as narrowing, slowing down, and closing the resource loop, respectively referring to using fewer resources per product, extending a product's useful life, and creating a circular flow of resources (Bocken et al, 2015).

THE BELLAGIO DECLARATION INDICATOR GROUPS

The Bellagio Declaration, which was published in March 2021 and came about as a collaboration between the European Environmental Agency (EEA), the environmental agency of Italy (ISPRA), and an advisory group with representatives from Finland, Ireland, Netherlands, Portugal and Slovakia, consists of a set of seven principles capturing the essential elements of a circular economy monitoring framework. It has identified four groups of indicators that every robust circular economy monitoring system should aim to have (EPA Network, 2021):

- **Material and waste flow indicators:** capture macro-level changes in the material lifecycle.
- **Environmental footprint indicators**: capture impacts across the full value chain of products and the full lifecycle of materials, such that spill-over effects are assessed and planetary boundaries respected.
- **Economic and social impact indicators**: capture positive as well as negative implications that may arise during structural changes of the circular economy transition, to ensure a just transition.
- **Policy and process indicators**: capture the implementation of specific circular economy policy measures and initiatives, in particular for some key sectors.

Circular economy indicator types

Different uses and thus categories of indicators also call for different types of indicators. In general, indicators may comprise for example input, output, production,

TABLE 1 • The "R-ladder", showing the hierarchy of nine R-strategies in order of priority

Produce and use in a smart way	R0 REFUSE	Make existing products obsolete by doing without or introducing alternatives
	R1 RETHINK	Intensify the use of products through shared use or multipurpose products
	R2 REDUCE	Produce and use more efficiently, with smaller quantities of (raw) materials
Prolong the lifespan of parts and products	R3 REUSE	Further use of the same product by another user
	R4 REPAIR	Repair and maintain for continued use by the same user
	R5 REFURBISH	Update an old product to meet today's demand
	R6 REMANUFACTURE	Take parts of an old product to make a new product with the same specification
	R7 REPURPOSE	Take parts of an old product to make another product
Make good use of materials	R8 RECYCLE	Take materials from waste for another use (higher or lower value)
	R9 RECOVER	Take materials from waste to generate energy

Source: Netherlands Environmental Assessment Agency, 2019; European Environment Agency, 2019.

throughput, process, or consumption (demand) indicators, often expressed as absolute numbers, percentages, or per unit or per capita, but the possibility of qualitative indicators should not be discarded. An example is those that relate to citizen behaviour and views on the circular economy, or to compensate for areas where quantitative indicators are not yet available.

In addition, we can distinguish between circular economy indicators measuring developments at the macro, meso (sectoral), and micro level. Governments, both national and municipal, typically adopt circular indicators at the macro level, whereas companies tend to apply micro level indicators. Within companies, indicators are also applied at different levels, from product level to business unit, to the company as whole. Even though the causal link between some imaginable transition indicators that do not focus on macro level output (e.g. input, process, micro, meso indicators), and the resulting evidence of circular economy progress at a national or supra-national level isn't always very strong, still there can be great value for a decision-maker in having such indicators.

For example, transition processes at macro level are often slow moving, and it can take a long time for measurable effects to be seen. Long product lifetimes may also result in a delay of noticeable effects for output indicators, as the release of resources will not take place for some time. A more valuable transition indicator for a policymaker could be one at micro or meso level and/or an input indicator that is able to quickly deliver feedback.

Depending on the transition phase a country (or company) is in, different indicators may also be more or less important. For instance, a country at the beginning of the circular economy curve with poor waste management will be able to derive a lot of value for policymaking from a waste diversion indicator, while a country that is ahead of the curve will require indicators further up the value chain to inform circular economy strategies and actions. This is further discussed in the last part of Section 1.

Production versus consumption-based approaches

Furthermore, there is a need for both production and consumption-based indicators, particularly related to impact, to capture the cross-boundary nature of resource use. As an example, a production-based circular economy indicator could make a country look particularly good (e.g. reduced emissions within country boundaries) or make it look worse (e.g. higher resource volumes per capita), even though at a systems level the outcome may look very different. In this case, a country may have outsourced a large share of its production to carbon-intensive countries (first example), or it may have started closing loops on resources by retaining them in-country rather than offloading end-of-life products onto other countries (second example).

At the moment in certain environmental performance fields—an example being the tracking of greenhouse gas emission reductions under the Paris Accord—there is a fairly strong bias towards production-based indicators, known as territorial emissions at country level, or Scope 1 and 2 emissions at organizational level. By ignoring the consumption component, created as a result of an organization's demand and often taking place in the value chain beyond country boundaries, parties run the risk (or convenience) of considerably underreporting the total footprint of their emissions and other environmental impacts.

Availability of circular economy indicators across lifecycle

As the circular economy indicator field is yet to reach maturity, further compounded by the data challenges of developing circular indicators in an economic system that predominantly generates 'linear' data, it is not too surprising that the most commonly available circular indicators currently do not span the full materials lifecycle, but rather focus on those phases for which we already tend to collect data as part of other, existing performance indicators. While here we discuss circular indicator availability in general, Section 3 considers specifically and in greater detail which indicators are nowadays typically being used by public sector parties.

A 2018 landscape analysis by the World Business Council for Sustainable Development (WBCSD, 2018) showed that, of the 140 businesses they reviewed for their use of circular economy or resource indicators across the lifecycle, a little under 50% applied indicators that relate to the internal operations or processes of a business.[1] Examples include indicators measuring absolute or relative levels of resource consumption, such as energy consumption per unit. Their proliferation is hardly surprising considering these types of indicators align with companies' regular operational performance indicators.

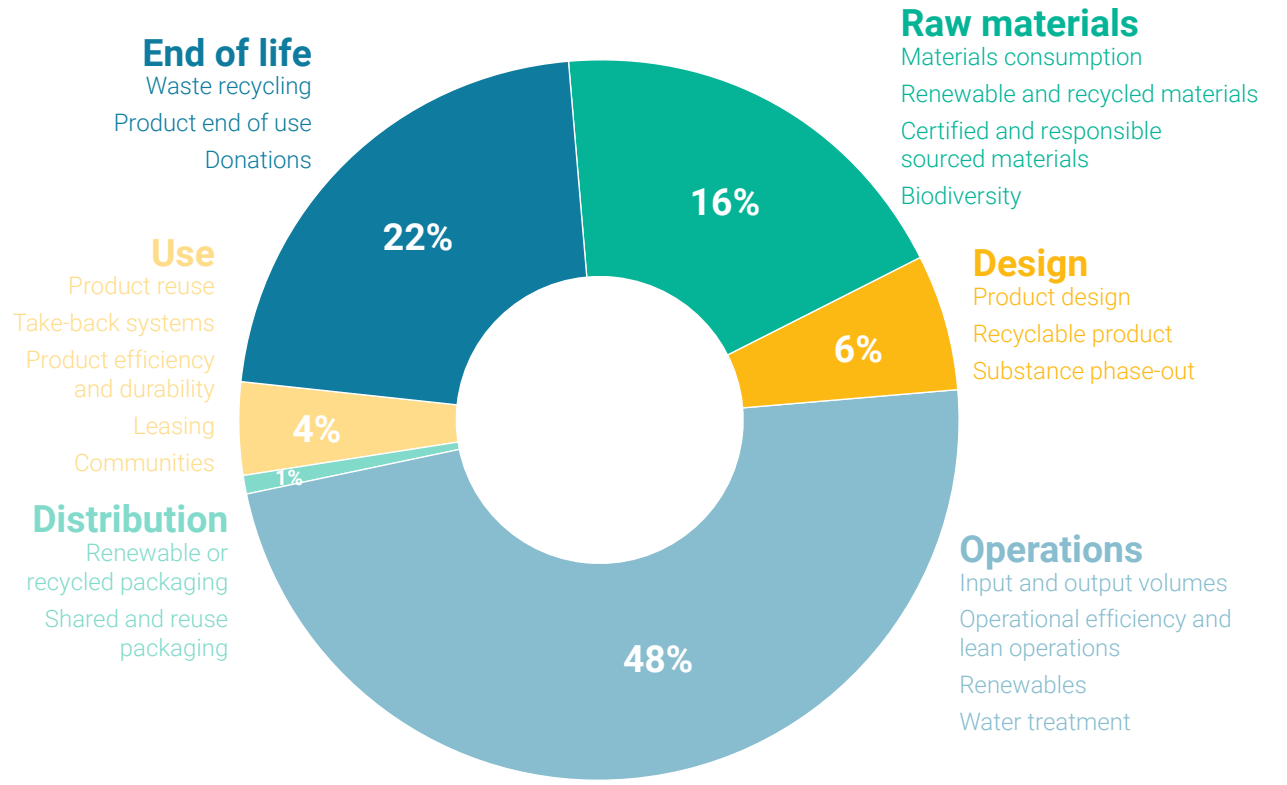
Around one-fifth of the chosen indicators focused on the quantity and quality of raw material input, such as the use of recycled or renewable materials; another one-fifth focused on end-of-life phases such as waste generation or diversion. Only a very small number related to the design, distribution, and use phase. These lifecycle phases (which correspond to the higher order R-strategies, as discussed in Section 1) are often more challenging to correctly measure, and require integration of relatively advanced levels of lifecycle thinking into a company's performance management and reporting systems (WBCSD, 2018). Although multiple circular indicator sets targeted at the private sector and addressing some of the omissions mentioned here have been launched since the WBCSD analysis came out (see Section 2 for more on this), applying indicators across the full range of R-strategies does remain relatively challenging.

Similar conclusions can be drawn for the state of play of circular or related resource indicator use in public policy circles. An example is the set of 10 macro-economic indicators developed by the European Commission as a monitoring framework for tracking EU progress towards a circular economy. The 10 indicators, which lean heavily towards different aspects of waste management and recycling as well as resource consumption, were selected because of existing data availability across EU member states (Eurostat, n.d.).

Although meaningful—because they tell us something about desired end states and progress towards these—the current monitoring set provides limited insight into how specific circular economy transitions are playing out and scaling up. This is further confirmed by a 2019 survey of indicator availability across EU member states, in which waste indicators and waste targets including recycling were equally overrepresented (followed by material flow account indicators, for which annual reporting is mandatory (European Environmental Agency, 2019)).

It is important to realize that business and country level indicators discussed so far focus mostly on the transition to a circular economy, as well as on a country or company's performance on materials—whether valued as inputs or discarded as waste—but not on the circular economy's impact on planetary boundaries and global

FIGURE 3 • Sample of the use of circular economy or related resource indicators by companies across the resource lifecycle



Source: World Business Council for Sustainable Development, 2018.

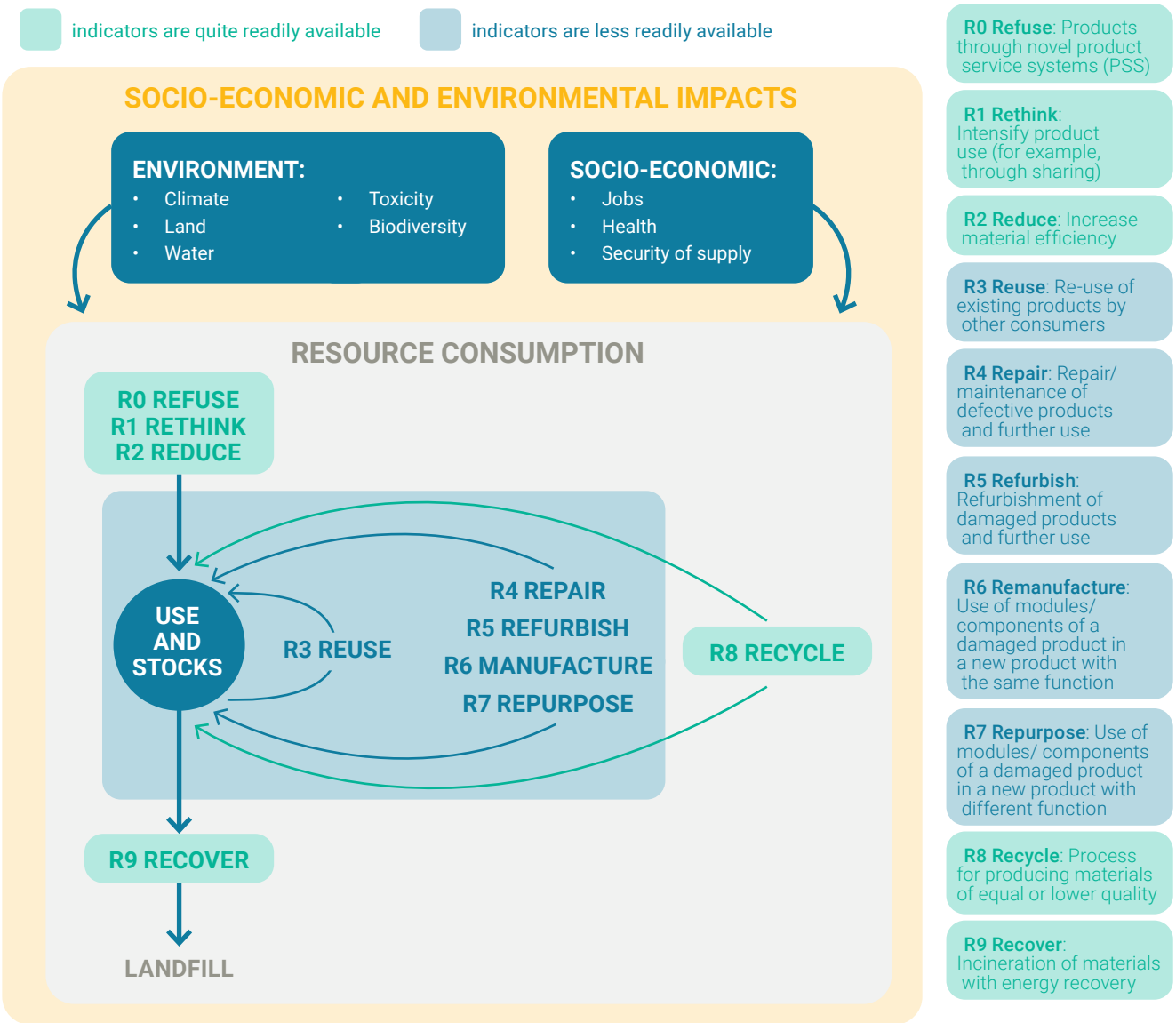
1. Since the 2018 review, several circular indicator sets targeted at the private sector have been launched, particularly in 2020 which saw the launch of Circular Transition Indicators (WBCSD) and Circulytics (Ellen MacArthur Foundation), as covered in Section 2. As a result, the percentages used in the analysis won't fully reflect the current (2021) situation.

commons. An example of the latter is the contribution of the circular economy to curbing dangerous climate change or reducing biodiversity pressures caused by resource production and consumption. Methodologies to calculate these contributions are often either underdeveloped, or simply don't yet exist. Where stakeholders have started developing methodologies, further uptake is hampered by a lack of sharing in the public domain, their relative complexity, and limitations in the collection and availability of data.

Finally, the use and availability of circular economy indicators at the meso level (i.e. a sector or product group) is generally sparse beyond those relating to, for example, stock—such as the number of residential buildings or number of passenger vehicles on the road (although data on the volume of materials these utilize may not be available), or relating to resource flows, such as the volume of plastic packaging and waste generated each year. At the same time, data availability isn't necessarily always a barrier for the use of meso-level indicators. As an example, vehicle use data such as passenger kilometers or vehicle occupancy tends to be quite readily available, but is not necessarily recognized as useful in the context of measuring the circular economy.

As per Figure 4, this leads us to the conclusion that indicators that tell us something about resource inputs or outputs are quite readily available. However, challenges lie with indicators that tell us something about the transition process—in product lifecycle terms mostly related to aspects such as the design, distribution, and use phase and how they are impacted by the various R-strategies—and indicators that consider the impacts of the transition to a circular economy.

FIGURE 4 • Availability of circular economy indicators to evaluate key dimensions of circular economy, adapted from Netherlands Environmental Assessment Agency



Source: Kick et al, 2021.

Availability of data

Our society has become increasingly adept at monitoring the production chains of the linear economy. However, much of the information relevant for an analysis of the circular economy, such as emissions, waste flows, or the value of urban stocks, is not monitored to the same extent. Most countries and large companies report on gross national product (GNP), gross annual turnover or annual profit, but information on, for example, product composition or depletion of natural stocks throughout the value chain is less commonly available. Barriers range from information not being recorded or tracked, to a lack of institutional frameworks or stakeholder pressure for governments and companies to collect and report on such data in a voluntary or mandatory manner (Circle Economy, 2020).

Recycling has been the subject of policy focus for many years, and many countries have fairly robust data on recycling flows. As far as the higher circular strategies for waste valorization are concerned (reuse, repair, remanufacturing, and so on), the circular transition process is in most cases still in an early phase, with interventions until recently receiving far less attention and with limited indicators developed, let alone being applied (Netherlands Environmental Assessment Agency, 2018). Some material flows also tend to get better coverage in typical data collection efforts by public and private sector stakeholders. For example, resource extraction is relatively well covered by existing data sets, but material flows within production chains much less so, while data on material stocks such as quantities of physical stocks captured in buildings and infrastructure is almost absent. The latter is also an important data gap: in the EU alone about one-third of extracted annual natural resources is used to accumulate stock (ECE, 2020). A number of initiatives, such as those focused on creating product passports and material registers, aim to address the gap in material stock data, although for now only a very small number of assets are covered by such initiatives.

Even as availability and reliability of data for the full resource lifecycle gradually improves, there is also an increasing need for indicators—and thus data—that say something about the uptake and outcomes of, for example, circular business models, circular product design, circular policies, and circular production and consumption patterns. Added to that is a need for indicators and socio-economic data that for instance say something about levels of green public procurement, the use of economic instruments, circular employment levels, value added, innovation, levels of circular research and development, and international dimensions of the transition including trade (ECE, 2020).

For a jurisdiction aiming to measure the circular economy, producing reliable data at regular intervals for a diverse number of indicators entails a number of key challenges. These include the cross-cutting nature of the circular economy concept, the scope of which cannot always easily be defined in statistical terms. Circular economy strategies and policies also cover many aspects that can be more difficult to capture data-wise, and may require reliance on a broad range of data sources. This cross-cutting nature calls for data that can easily be interlinked and combined, which further complicates the challenge (ECE, 2020).

With such data being scarce, indicators that may be fit for purpose to track a broader set of interventions may prove difficult to measure for the time being, and collecting data where it exists could turn out to be costly and cumbersome. Moreover, the quality of this data will pose an additional hurdle if the robustness or consistency is considered insufficient for publication. Finally, data may not be publicly available, and the sharing of data between entities can be met with resistance.

Companies with intentions of measuring circular economy in their operations may run into challenges obtaining data across their global supply chain. The outcomes of any such exercise, in terms of the company's eventual score on a set of circular indicators, are usually not disclosed to other parties. For example, a government interested in the circular performance of a specific sector is likely to face difficulties accessing such data—where it even exists—as companies don't publish it voluntarily or as a part of mandatory sustainability reporting requirements (e.g. the EU's Directive on Non-Financial Reporting). As such, the systematic monitoring of major parts of the transition and performance dynamics of the circular economy remains relatively uncharted territory. Nonetheless, these challenges are not unsurmountable, as other environmental fields with a longer history of measurement and data collection have shown.

The following overview loosely builds on the indicator categories identified by the Bellagio Process, supplemented by the R-strategies as per the Netherlands Environmental Assessment Agency (both covered in Section 1), to provide an indication of some of the data challenges currently faced for each category, with a focus on the public sector. CMUR refers to the Cyclical Material Use Rate—also known as the circularity indicator (percentage circular)—a key indicator under the material flows category. A cross between brackets indicates that this situation applies only to certain indicators or geographies. For example, EU member states deliver annual data on resource flows, with which Eurostat, the EU's statistical agency, calculates the CMUR for each member state. Beyond such mandatory mechanisms, the regular collection of data for and annual calculation of a country's CMUR is less common, and should be assessed on a country-by-country basis.

Availability of circular economy targets

Countries commonly set quantitative targets linked to their strategies, policies, and end goals. With an increasing number of governments developing circular economy strategies and policies, it is likely only a matter of time before they become involved in target setting as well. Targets have to be informed by solid indicators. This section provides a brief overview of the current availability and application of circular economy targets, focusing predominantly on Europe due to availability of data.

Based on a 2019 report by the European Environment Agency that sampled circular indicators and targets in 32 European countries, waste including recycling continues to be the area for which most countries have targets. Such targets were reported by 25 countries (European Environment Agency, 2019). This may refer to general waste targets, as well as targets for specific waste streams. A disadvantage of general waste targets is that they lump all waste materials together in a single indicator, without differentiating between their environmental effects or the scarcity of materials. Plastic packaging waste, for example, has a very different environmental footprint to food waste. An advantage of waste targets is that they are often easier to enforce than targets based on resource use. Governments can, for instance, resort to pricing or banning certain waste management practices, such as landfilling (Koch and Coelho, 2020).

TABLE 2 • Indication of data availability and challenges for different circular economy indicator categories

applies to certain indicators or geographies

applies to certain indicators or geographies

	Indicators							
Data needs	**Waste**	**Recycling**	**Material flows**		**R-strategies**	**Policy and process**	**Environmental impact**	**Economic and social impact**
			(other)	**Of which CMUR**	**(beyond recycling)**			
Regularly collected by statistical agencies	■	■	■					
Potential to be collected by statistical agencies, but to date not commonly done				■			■	■
May require access to multiple data sets, that can be combined and/or interlinked				■	■		■	
May require access to external data that are not publicly available (e.g. businesses, supply chains etc.)					■	■		
More likely to suffer from data quality or consistency issues				■	■	■	■	■

The next most common target, resource productivity, was reported by only eight countries, or a quarter of all countries sampled, a number that has hardly changed since the European Environment Agency's previous sampling report in 2016. This target and the progress towards it are usually expressed as gross domestic product (GDP) over domestic material consumption (DMC). Eurostat annually reports on this indicator, although the EU as a whole currently does not have a resource productivity target.

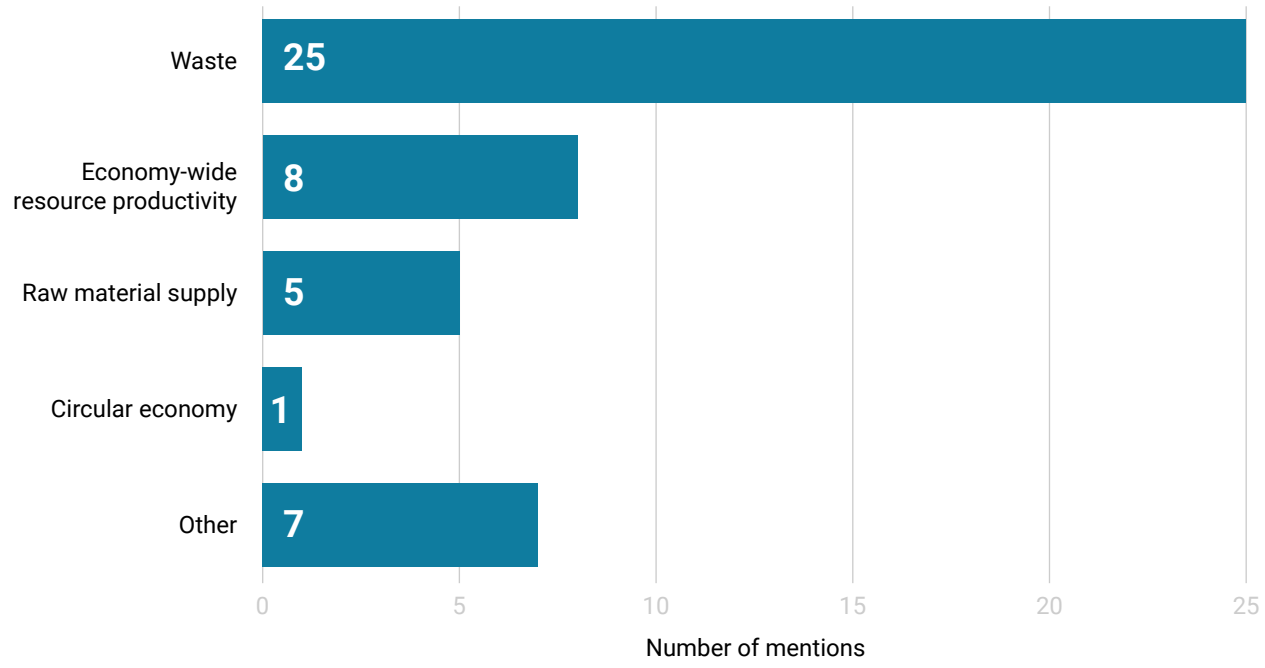
Surprisingly, only a few targets related to raw material supply were reported, given widespread concerns about reliance on resource imports and security of supply. Both the Netherlands and Belgium have absolute resource reduction targets. Only one target sampled was classified as circular economy specific, the reuse target set by Belgium (European Environment Agency, 2019). This overview shows that national targets that aim to secure more sustainable resource consumption and production patterns are generally still in their infancy. Although waste and recycling targets are a good start, they are not enough to put our rampant resource use on a more responsible path.

Moreover, resource productivity targets and their underlying indicators do not say anything about absolute resource consumption levels, which could still be increasing even when a resource productivity target is met. To this end, the Netherlands has set an absolute resource reduction target of 50% in primary abiotic raw material consumption by 2030. A disadvantage of using single indicator targets is that the mass of all materials is summed in a single metric. Materials differ in their environmental impacts, availability, scarcity, and origin. As such, it is important to further detail these targets through more granular indicators (as under development in the Netherlands) to ensure that the target is met foremost through reductions in raw materials that are scarce, whose supply is considered critical, and/or that are considered high impact from an environmental or social perspective. This would prevent a focus on high volume and heavy materials that may have few harmful effects or are plentifully available. An extreme example would be to focus on the efficient use of sand or aggregates to quickly make progress towards the target (Koch and Coelho, 2020).

Additional considerations on measuring circular economy transitions

Finally, it is important to briefly touch on how the different

FIGURE 5 • Overview of reported targets, by type, for 32 European countries



Source: European Environment Agency, 2019.

stages of circular economy transition can have an impact on which indicators are most fit for purpose. To describe the development of the transition process we can identify four phases: pre-development, take-off, acceleration, and stabilization (Hekkert and Ossebaard, 2010). This could be simplified to a formative phase (pre-development and take-off) and a growth phase (acceleration and stabilization), where the formative phase creates the right conditions for strong growth in circular products and services later on in the process.

In the formative phase, typical activities would include vision development, experimentation and innovation, the creation of new supply chain networks and relationships, new revenue and business models, the identification of new partners, and changes to existing organizations in line with circular models. The growth phase would be characterized by a rapid increase in the market share of circular products and services (Netherlands Environmental Assessment Agency, 2018).

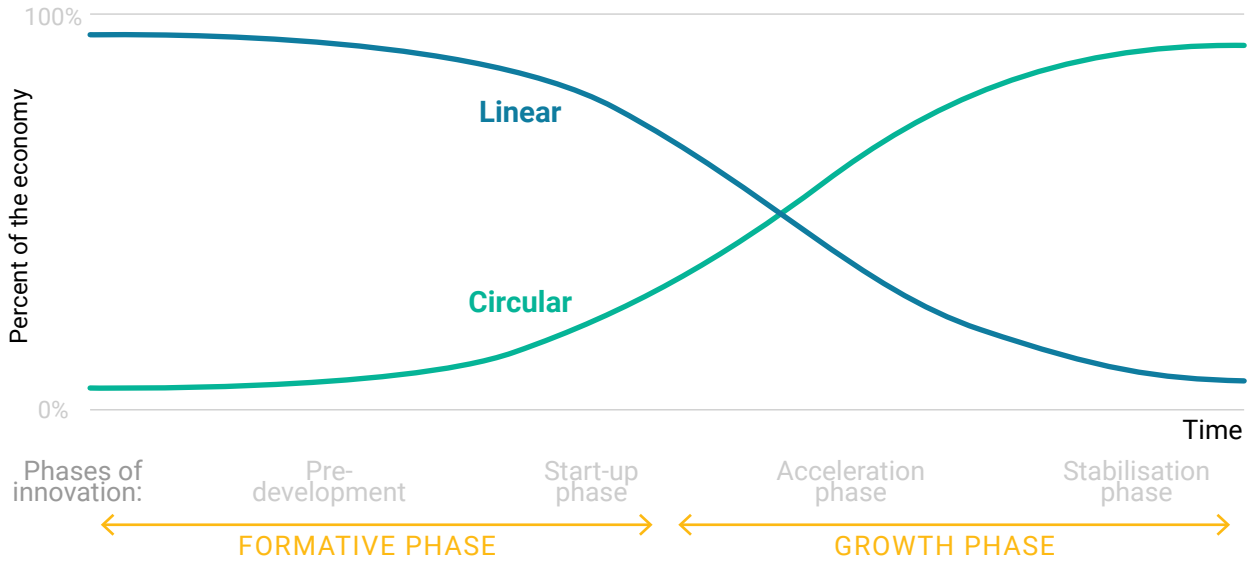
The exact starting point, as well as the speed of transition, is likely to vary depending on the sector and even the specific product group under consideration. To measure progress, it may be necessary to measure certain developments in society at a more detailed level than that of broad macro-level transitions. Figure 7 gives an example, translating circular transition to the effects it may have in specific sectors, and then aggregating this again to the economic, environmental, and social impacts experienced at national and EU level (Rizos et al., 2018).

At the same time, the distinction between a formative and a growth phase in circular transition has its own implications for measurement. In the formative phase—which can potentially be quite long—measuring transition is unlikely to display strong evidence of the circular economy's intended effects, such as reduced resource use and reduced environmental pressures. Impact monitoring therefore gains greater importance in the growth phase, although this does not take away the need for it in the formative phase.

In addition, when considering the distinction between measuring the *means* required for circular economy transition (inputs), *activities* undertaken (throughput) and *achievements* (output), formative and growth phases may at times want to fill this in through the use of different indicators. In the formative phase, for instance, indicators that measure circular innovation processes and levels can provide meaningful insights into the state and speed of the emerging transition. When referring back to the classification of headline, dashboard, and transition or process indicators, it becomes clear that the third category is particularly important in the formative growth phase, whereas the first two categories gain more importance in the growth phase. An example of policy and process indicators, that measure various transition dynamics across means, activities, and achievements, is provided in Table 3, Section 3.

The challenge, particularly in the formative phase, is how to translate these ideas into concrete, quantifiable

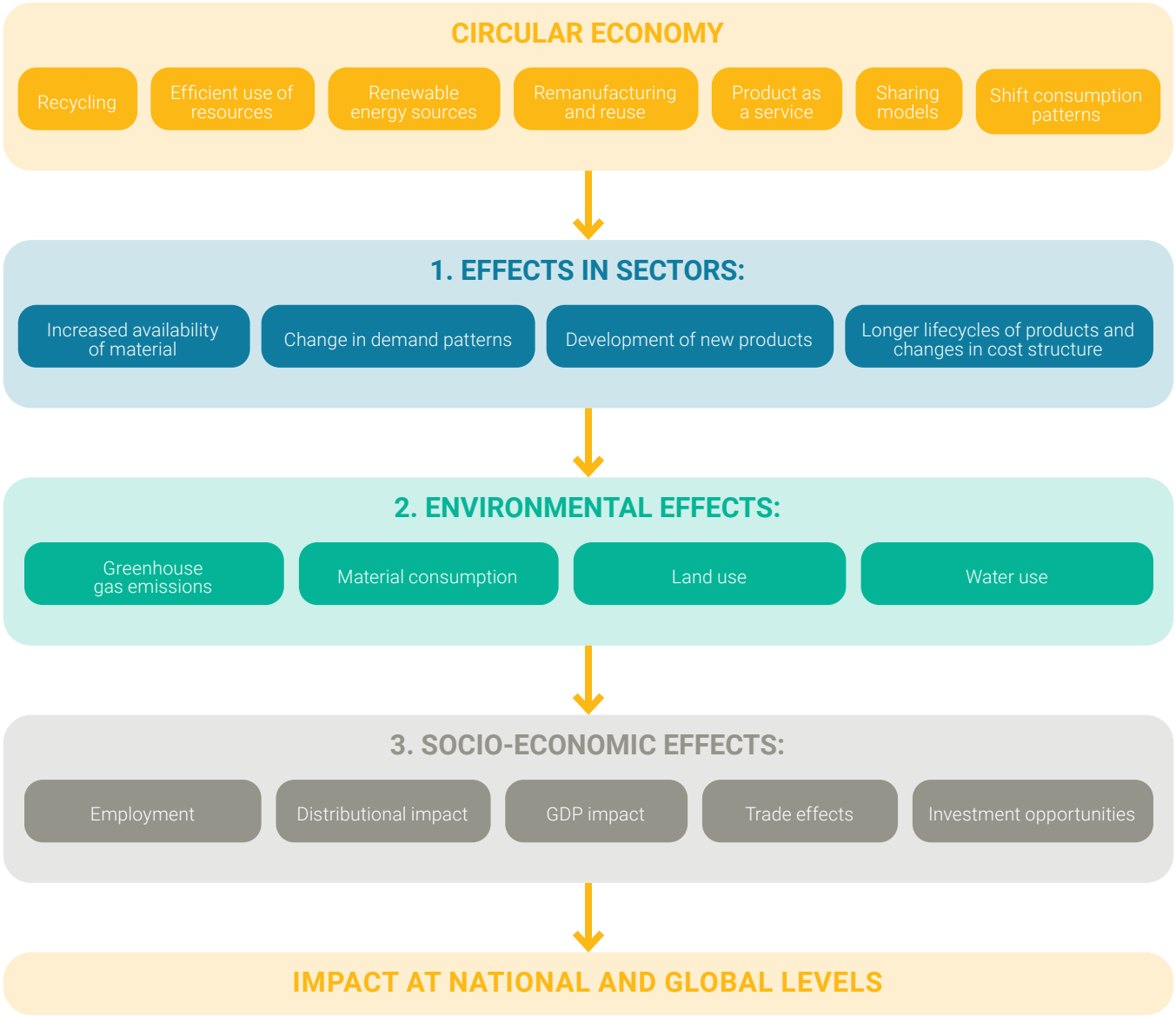
FIGURE 6 • Different phases in the transition process to a circular economy



Note: For illustrative purposes only.
Source: Netherlands Environmental Assessment Agency, 2018.

indicators that measure whether the monitored means, activities, and achievements contribute to the desired transition, and thus where the process of transition stands. Progress in materials recycling for instance is relatively easy to measure, across means (e.g. feedstock collected for recycling), activities (e.g. recycling capacity), and achievements (e.g. recycled feedstock). It becomes a bit more challenging when we consider progress in product lifespan extension or smarter product design for instance, and it can become outright difficult to quantify the implementation of specific circular value chain strategies such as how many products are being shared or reused. This is also exacerbated by the availability of data, or lack thereof (Netherlands Environmental Assessment Agency, 2018).

FIGURE 7 • Different phases in the transition process to a circular economy



Source: Netherlands Environmental Assessment Agency, 2018.

2. Concise overview of key circular economy indicator stakeholders and efforts

This section sets out to provide a concise overview of key stakeholders and efforts or initiatives in the circular economy indicator field. It does not intend to provide an exhaustive overview, and its main focus lies with stakeholders and efforts in Europe. It first describes a sequence of initiatives launched by or undertaken through the European Commission. This is followed by a number of countries in Europe, Asia, North and Latin America that are active in the circular indicator field, providing an indication of the scope of their efforts. Subsequently, a variety of other circular indicator efforts for the public good are described, such as the work by the OECD and the International Organization for Standardization (ISO). This is completed by a brief overview of mostly recent efforts focused on the private sector.

European Commission

Although several east Asian countries such as China and Japan preceded the EU with the development of circular economy indicators, the EU and its member states can currently be considered one of the most active regions globally. Within the EU, Eurostat has been tasked with collecting statistical information from EU member states on waste generation and treatment including recycling since the 1990s. Environmental accounts—referring for instance to material flows, environmental expenditure, and taxes—have been collected from the early 2010s onwards.

In 2013, the EC introduced the **EU Resource Efficiency Scoreboard**, with the purpose of macro-economic monitoring of the efficiency with which EU member states and the EU as a whole consume resources. The scoreboard uses 32 indicators establishing a hierarchy with three cascading layers: headline, dashboard, and transition indicators (see Section 1 for more on this). Resource productivity (measured as GDP/raw material consumption) is the Scoreboard's 'headline' indicator. Some parties however criticize the use of resource productivity as a key indicator, arguing that absolute resource consumption targets are more meaningful, with productivity indicators running the risk of showing relative progress even though absolute consumption levels may still be increasing (Kick et al, 2021).

Dashboard indicators of the Scoreboard include: domestic material consumption per capita; productivity of artificial land; built-up areas; water exploitation index; water productivity; greenhouse gas emissions per capita; energy productivity; energy dependence; and the share of renewable energy in gross final energy consumption. These are further supplemented by 21 thematic indicators (Eurostat, 2020). Two EU Resource Efficiency Scoreboard reports have been published, dating back to 2014 and 2015, while the online scoreboard provides annual updates, to the extent data is available (EC, 2020).

In 2016, the EC launched the **Raw Materials Scoreboard.** This Scoreboard is an initiative of the European Innovation Partnership (EIP) on raw materials, a cornerstone of the European Union Raw Materials Knowledge Base (EURMKB) and an integral and permanent part of its Raw Materials Information System. It presents quantitative monitoring data to inform different stakeholders, with a view to ensuring a sustainable supply of raw materials to the European economy.

In contrast to the Resource Efficiency Scoreboard, which has an online dashboard, the data collected through the Raw Materials Scoreboard is made public through a biannual report only. The 2018 Scoreboard consists of 26 indicators grouped into five thematic clusters: raw materials in the global context; competitiveness and innovation; framework conditions for mining; circular economy and recycling; and environmental and social sustainability (EC, 2018).

These two Scoreboards were followed in 2018 by the EC's approval of a set of **10 macro-economic circular economy monitoring indicators** to monitor progress and assess the effectiveness of action towards the circular economy in the EU and its member states. The development of a monitoring framework was first announced in the 2015 EU Action Plan for the circular economy. Drawing on and complementing the two Scoreboards, a set of indicators was subsequently identified to cover different phases of the circular economy for which data was in large part already available. Annual updates on indicator progress are published by Eurostat, which also produces data for most of the indicators in the framework. A few indicators are sourced from other services of the European Commission (ECE, 2020). The current set of indicators provides limited ability to measure progress of specific circular priorities and product groups or sectors (Eurostat, n.d.).

Acknowledging the need to further develop the EU's framework, in early 2020 the **Bellagio Process** '*monitoring progress in Europe's circular economy*' was launched, led by the Italian Institute for Environmental Protection and Research (ISPRA) and the European Environment Agency. The aim of the Bellagio Process has been to consolidate key principles and identify areas for future work to improve circular economy monitoring, with the initiative designed as a process of discussion and consensus building on 'What to Monitor' and 'How to Monitor'. The set of seven **Bellagio Principles** resulting from this process capture essential elements of a monitoring framework for the transition to a circular economy. They will form the basis for further developments around indicators and monitoring frameworks in support of the EC's second circular economy Action Plan.

In addition to the launch of a set of core principles, the Bellagio Process has highlighted the need to complement macro-level indicators with indicators at mesoand micro-level, to better understand processes within the economy, as well as to identify changes in 'push and pull' stakeholders who may facilitate circular transition. It also acknowledges that a good monitoring system encompasses the economy, its processes, and its impacts on people and the environment, within and beyond its jurisdictional boundaries. Finally, the initiative is considering the use and need for existing and new data sources from official

European statistics and other organizations to feed the development of new indicators (EPA Network, 2021).

Country-level efforts

In addition to the EC's efforts to develop circular economy indicators, a number of EU member states have started acting on circular economy indicators to advance thinking and development. Examples include the **Netherlands**, with the Netherlands Environmental Assessment Agency having a dedicated program for the development of a comprehensive set of circular economy targets and indicators at national level (Netherlands Environmental Assessment Agency, 2020). Through the Circular Economy Initiative Deutschland and partners, **Germany** has analyzed a wide range of existing indicators and put forward a few dozen as priorities to cover the full resource lifecycle and potential environmental, economic, and social impacts (Kick et al, 2021).

France published a first set of 10 indicators in 2017, based on data already available, while **Finland** is in the process of developing a set of 10 indicators with the aim that the results should be comparable with the EU's indicators, as well as relevant UN SDG ones. **Italy** has put forward a potential set of indicators, based on a distinction between macro (national), meso (region or sector), and micro (individual business) level. Belgium's **Flanders** government is developing a set of indicators consisting of a top layer of five macro-level components particularly related to resources (materials, land, water, soil, and energy), which provide an indicator of the progress of a circular economy transition, and underneath a layer of four meso-level components related to societal systems (housing, food, consumption goods, mobility), to provide more detailed insight. **Slovakia** has adopted the set of monitoring indicators established by the EC. In several other EU member states including **Czech Republic, Poland, Portugal, and Slovenia**, circular indicator efforts are at various stages of exploration or development (European Environmental Agency, 2019).

Beyond Europe, several countries in east Asia, such as **China** and **Japan,** developed circular indicators well before the topic gained prominence in Europe. In the Americas, **Colombia** recently published a set of 44 indicators, while **Chile** and **Canada** are actively considering potential circular economy indicators.

An indication of the scope encompassed by indicator efforts across a select range of countries, either launched, proposed, or under development, is provided in the following image as well as in the tabular overview in Annex A, building on

FIGURE 8 • Overview of EU circular economy monitoring framework consisting of 10 circular indicators

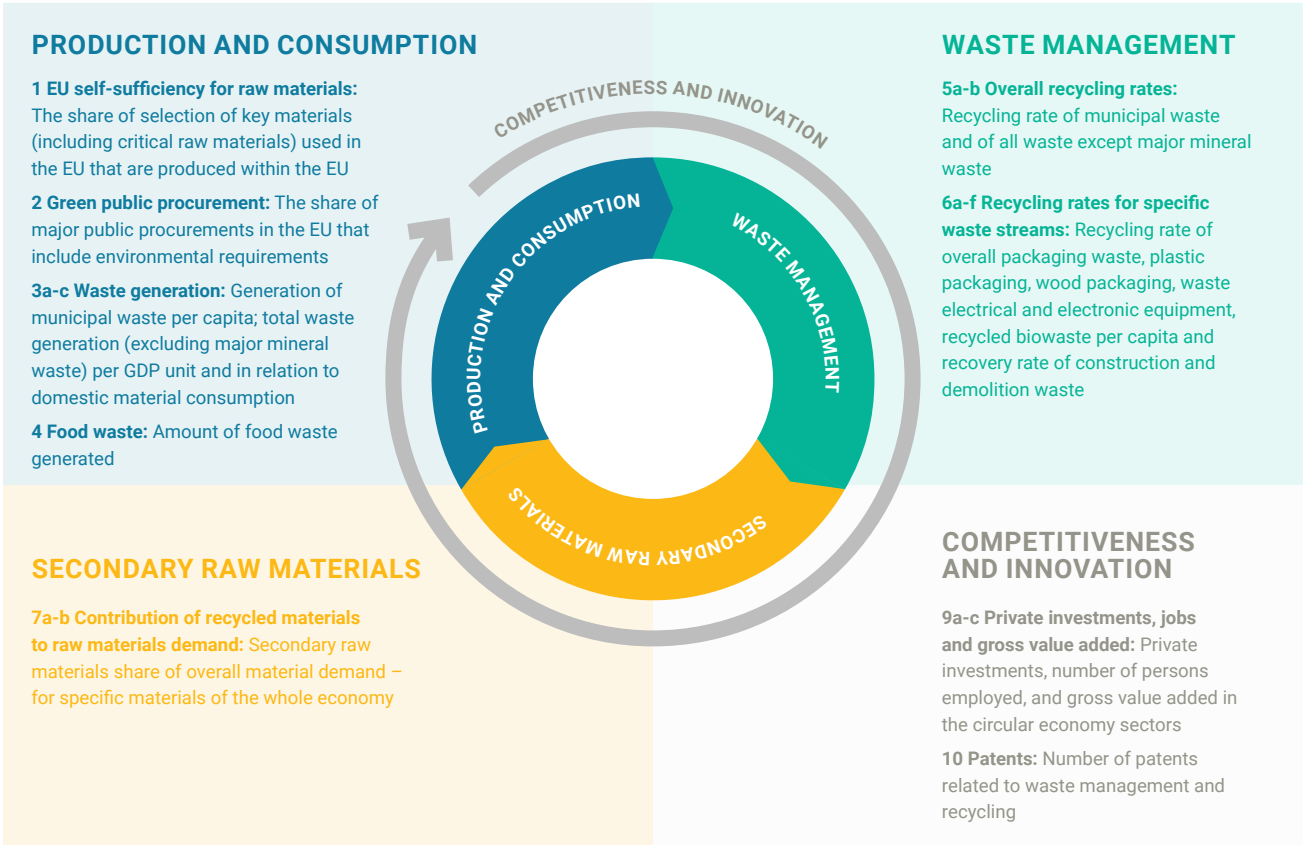


FIGURE 9 • The Bellagio Principles, encompassing seven principles for monitoring circular economy transition

1. Monitor the circular economy transition

Monitoring the transition towards a circular economy needs to holistically consider all relevant initiatives—public and private—across the economy. It should capture the full extent of changes happening to the material and waste flows, products over their lifecycles, business models, and consumer behavior, including the economic, environmental, and social dimensions of thse changes.

2. Define indicator groups

A robust monitoring system for the circular economy transition should include:

- Material and waste flow indicators to monitor changes throughout the material lifecycle, including resource efficiency dimensions
- Environmental footprint indicators to capture the impact across the full lifecycle of products and materials, so that spill-over effects are assessed, and planetary boundaries are respected
- Economic and social impact indicators to capture positive as well as negative impacts that may occur during structural changes of the circular economy transition
- Policy, process, and behavior indicators to capture the implementation of specific circular economy policy measures and initiatives, in particular for key sectors

3. Follow indicator selection criteria (RACER)

Indicators included in a transparent monitoring framework for the circular economy transition should follow RACER criteria: Relevant, Accepted, Credible, Easy to monitor, and Robust

However, development of innovative, experimental indicators should also be encouraged, even if not all RACER criteria may initially be fulfilled

4. Exploit a wide range of data and information sources

The data underpinning a monitoring framework for the circular economy transition may consist of:

- Official statistics from the European statistical system or national statistical offices, other data produced by EU institutions, national or local authorities, as well as from international organizations—exploiting and integrating official information sources
- Policy information—tracking policy developments and implementation including qualitative assessments
- New data sources—exploiting new information sources beyond official statistics, such as data from the private sector and trade associations, research models, or from new applications of digital technologies

5. Ensure multi-level monitoring

Monitoring should capture changes happening across all levels of the economy. It should address both public and private sector stakeholders, and different governance levels from global to local. A well-defined monitoring and governance structure is required to promote the development of coherent metrics that capture the multiple dimensions of the circular economy transition

6. Allow for measuring progress towards targets

Monitoring circular economy implementation should help assess progress to relevant policy targets and objectives, thus helping inform if the right policies are in place and well implemented, or if corrections or new policies are needed

7. Ensure visibility and clarity

A well-designed circular economy monitoring framework will inform policymakers, stakeholders and citizens. Appropriate indicators as well as user-friendly methods of communication, such as dashboards, should therefore be identified.

Where possible, open data principles should be followed, with data being made fully and freely available.

Source: EPA Network, 2021.

the indicator categories identified in the Bellagio Principles, and supplemented by the R-strategies as per the Netherlands Environmental Assessment Agency.

This high-level analysis confirms that there is no shortage of waste, recycling, and material flow indicators, for all of which data availability tends to be relatively high. Indicators for R-strategies are scarcer, and to the extent that they have been put forward (particularly related to reuse), calculation methods and data availability can be a challenge. Often equally scarce are policy and process indicators, which so far predominantly focus on green public procurement. These indicators are crucial to creating more insights into the transition process, helping steer government support and intervention, as the actual outcomes of circular economy activities only become visible at a later stage. Finally, only a few indicators are available—or under development—to evaluate the environmental or socio-economic impacts of circular economy interventions. Nonetheless, the circular economy is a means to an end, and understanding if, how, and how much it can contribute to areas such as climate mitigation or job creation will be crucial if we are to accelerate its uptake.

Select efforts by other stakeholders

Beyond circular indicator efforts led by jurisdictions, a number of organizations have developed or are in the process of developing circular economy or closely related indicators for the public good. These include the **OECD**, whose circular economy related efforts encompass both statistical and policy work. Its statistical work includes regular data collection on waste, waste management expenditure, and economic instruments related to waste and materials management, as well as stock accounts of mineral and energy resources. In addition, it supports development, calculation, and guidance on indicators related to waste and material flows and resource productivity. The OECD developed a set of material flow and resource productivity indicators in 2011, while also including selected waste and material flow indicators in the OECD core set of environmental indicators and the OECD set of green growth indicators.

A current focus is on the development of a methodology to produce harmonized data and indicators on demand-based material flows (or material footprints), in cooperation with Eurostat and UN Environment Programme (UNEP). Furthermore, the OECD has set up an expert group that aims to develop a conceptual framework for circular economy indicators for policymaking, as well as to prepare guidance on indicators needed for the transition to a circular economy (ECE, 2020).

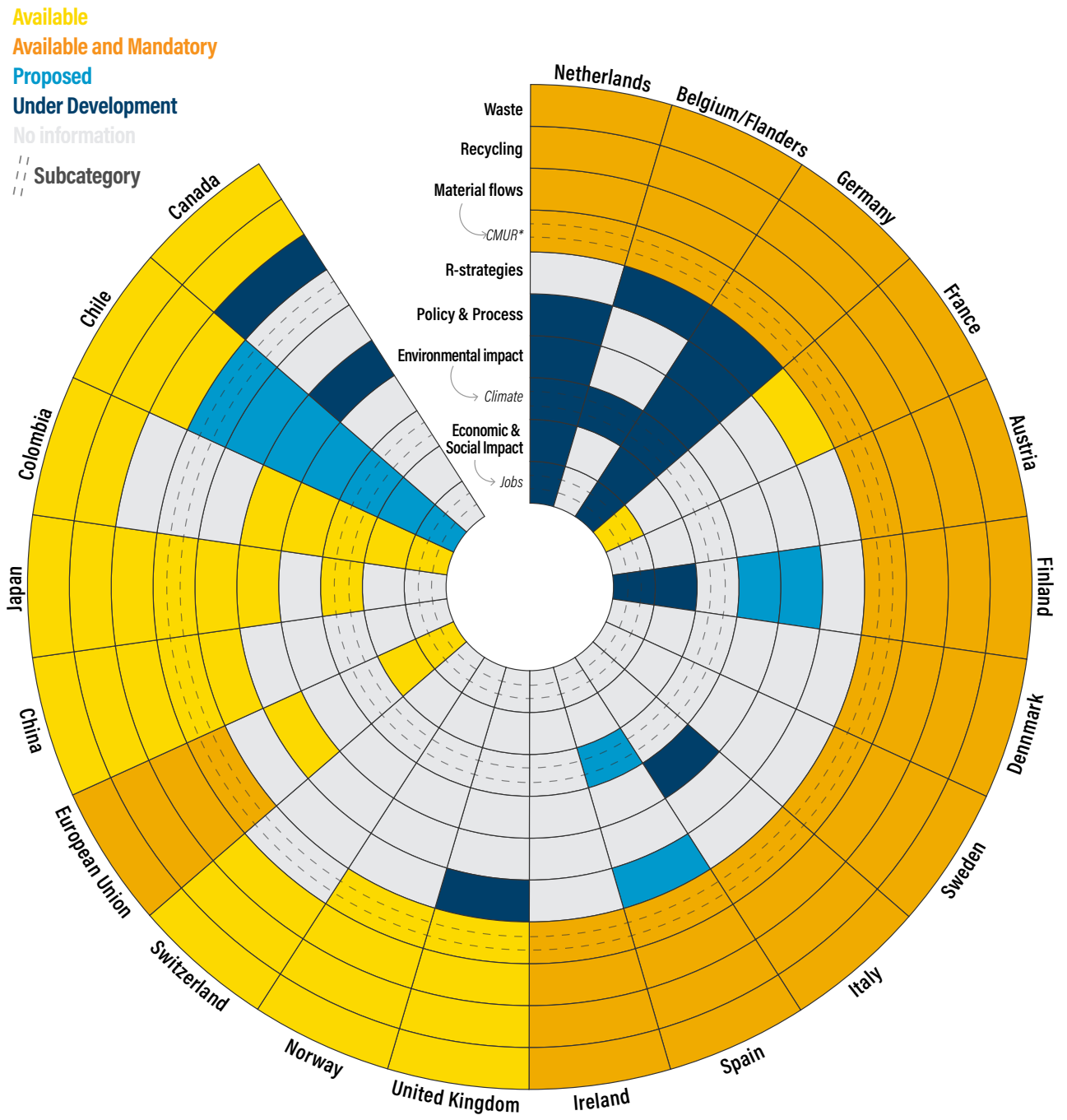
The **ISO** is also active in the circular economy field, with the development of standards within the Technical Committee 323 'Circular Economy' standard, which aims to cover different aspects of a circular economy including public procurement, production and distribution, end-of-life, as well as wider areas such as behavioral change in society. To this end, ISO Technical Committee 323 is currently in the process of developing three standards to define core circular economy principles and a common base language to enable meaningful exchange, with a view of publishing these by 2023. Each standard is governed by a working group, which includes external representation from expert organizations:

- ISO 59004 Standard 1: circular economy framework and principles for implementation.
- ISO 59010 Standard 2: circular economy guidelines on business models and value chains.
- ISO 59020 Standard 3: circular economy measuring circularity framework.

Another initiative comes from NGO **Circle Economy**, which in 2018 started publishing annual "*Circularity Gap*" reports for the world, as well as for specific countries. This annual global report is launched at the World Economic Forum meeting in Davos. To measure circularity, Circle Economy has introduced a strongly simplified conceptual representation of the global materials metabolism—materials flowing through and in long-term use by the economy—and uses this to measure the share of recycled materials as a proportion of total material inputs into the global economy every year. Circle Economy's "Circularity Gap" is the inverse of the Cyclical Material Use Rate (CMUR), with the CMUR—as used by several government organizations—describing how much of the economy is circular, whereas the Circularity Gap indicator describes how much of the economy is linear.

The 2021 report concluded that the world is currently less than 9% circular (Circular Economy, 2021). The 2020 edition also provided a graphical overview of how 176 countries perform on circularity of their material flows, from the view of maintaining an ecologically safe and socially just space for humanity. Each orbit in Figure 11 clusters countries that share a similar distance from the safe and just space, showing that no country is firmly on the path to achieving such a goal (Circle Economy, 2020a). The metric used in the reports has been widely picked up by public, private, and not-for-profit parties in their messaging around circular economy,

FIGURE 10 • Indicative scope of circular indicator efforts across a select range of European and non-European countries[2]



Cyclical Material Use Rate

and has emerged as the main indicator key stakeholders use to indicate the global 'pulse' of circular economy transition.

Launched in 2015 as part of the **United Nations**' Sustainable Development Goals (SDGs), *SDG 12* is concerned with *responsible consumption and production* patterns. SDG 12 consists of a monitoring framework with 11 targets and 13 indicators. Of those, at least partial data availability for tracking progress in the UN's SDG Tracker is achieved for only six of the 13. Most importantly, SDG 12 aims to achieve the sustainable management and efficient use of natural resources by 2030, shifting away from the current 'take-make-dispose' culture to a more circular approach—although current global resource consumption trends do not align with such a goal (UN, 2018).

2. The scope of countries' circular indicator efforts is dynamic and ever evolving, and not all efforts are equally visible. As such, this overview provides a snapshot based on available data and is subject to change.

SDG 12 indicators with at least partial global data availability, which are also commonly used in circular economy indicator sets, include the following:

- Indicator 12.2.1: material footprint, material footprint per capita, and material footprint per GDP.
- Indicator 12.2.2: domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP.
- Indicator 12.5.1: national recycling rate, tons of material recycled.

Finally, the **UNEP**, through the International Resource Panel (IRP), maintains a Global Material Flows Database with material flows and resource productivity data. Recently, together with Eurostat and the IRP, it developed a global manual on so-called economy-wide material flow accounts, providing guidance to experts in national statistics offices on how to build capacity at the national level and report progress towards the relevant SDG indicators. This represents an important step towards creating a global accounting standard for material flow accounts at the macro level (ECE, 2020). For further information on material flow indicators, see Section 3.

Private sector efforts

A report by Circle Economy published in autumn 2020 provides an indicative overview and high-level guidance on the availability and use of circular indicators for businesses. A summary of the core indicator sets currently available is provided in this section.

In early 2020, the World Business Council for Sustainable Development (WBCSD) published **Circular Transition Indicators (CTI)**, developed in collaboration with partners including KPMG. CTI aims to provide a simple, objective, and quantitative self-assessment framework that can be applied to businesses of all industries, sizes, value chain positions, and geographies. CTI can help them understand to what degree they are closing resource loops, optimizing material flows, and creating value from their resources. It looks at aspects such as the use of critical materials, circular material productivity and circular revenue, and allows companies to calculate their percentage circularity. The main application of CTI is to help companies create awareness of how they are progressing with their circular economy transition, and set a baseline for what should be changed by prioritizing certain actions and establishing SMART targets. CTI can be applied at multiple levels, from the company to the product level, and provides full public disclosure of its indicators and methodologies.

Around the same time as CTI, the Ellen McArthur Foundation launched **Circulytics**. Going beyond assessing products and material flows, this company-level measuring tool reveals the extent to which a company has achieved circular performance across its entire operations via a scorecard. It distinguishes between enabler and outcome indicators. Enabler indicators are grouped under five themes: strategy and planning, innovation, people and skills, operations, and external engagement. Outcome indicators indicate real world circular performance under six themes: products and materials, services, assets, water, energy, and finance. Outcome questions are tailored to the sector the company is in, and results are benchmarked on an industry level. Circulytics is designed to help companies build a broad picture of their circular performance, and can be used for example to identify blind spots, inform circular strategy, and communicate circular results to investors and other third parties. Eventually companies are provided with a score on a scale from A to E.

In mid-2020 the Global Reporting Initiative (GRI) published an update to its **GRI 306: Waste Standard** to include circular economy principles. GRI provides widely used standards for sustainability reporting on a range of economic, environmental, and social topics. Organizations that adopt the GRI standards can use its various modules to select the exact set of topics and indicators they would like to report on. The standard includes disclosures for organizations to report on waste generated throughout the value chain, its composition, and how the waste is managed. It helps organizations identify circularity opportunities and report steps they are taking to make their business model, operations, and products aligned with the circular economy. Organizations can use the data as input for their Circulytics or CTI assessments.

The Cradle to Cradle Products Innovation Institute offers **Cradle to Cradle Certified**, a globally recognized certification scheme and a mark of safer, more sustainable products made for the circular economy. Products are assessed for their environmental and social performance across five categories: material health, material reuse, renewable energy and carbon management, water stewardship, and social fairness. A product is assigned an achievement level (Basic, Bronze, Silver, Gold, Platinum) for each category. Its lowest category achievement also represents its overall certification level. The standard sets out to encourage continuous improvement over time by awarding certification on the basis of ascending levels of achievement, and by requiring certification renewal every two years (Circle Economy, 2020b).

FIGURE 11 • Graphical overview of countries' distance from a safe and just space for humanity to thrive

Source: Circle Economy, 2020.

3. Application of circular economy indicators

In this section we take a closer look at the vibrancy and maturity of circular indicator use and development in the public sector from a more granular perspective. This is done by assessing in more detail the current application of specific circular indicators across a range of common categories, as encountered across published indicator sets or those under development. The categories used are similar to those applied in Section 2 to compare country-level efforts. Instead of focusing on specific countries, here we focus on specific indicators.

The categories used loosely build on the circular indicator categories identified for the Bellagio Principles (see Sections 1 and 2), supplemented by a category for indicators that addresses R-strategies as per the Netherlands Environmental Assessment Agency (see Section 1). For each category, a guidance is provided of the extent to which indicators currently tend to be available and applied in the public sector, and what they entail. In general, the order in which the different categories are covered in this section reflects the maturity of indicator development and application from high to low.

Waste and recycling indicators

Indicators on waste and recycling are commonly available in many countries, including those that have not developed circular economy strategies and/or indicators. Common indicators include the volume of municipal/household waste being generated overall and per capita, and the volume of waste landfilled or recycled. Some countries have indicators for specific waste streams such as food waste, construction and demolition waste, and electronic waste.

More advanced indicators include those that measure the decoupling of waste generation from economic growth, indicators on waste prevention (such as through product lifetime expansion), the trade in recyclable raw materials, and the contribution of recycled materials to raw material demand, or the use of recycled materials in production processes. Apart from the last one, all these indicators have been included in the EU Resource Efficiency Scoreboard, the EU Raw Material Scoreboard, and/or the EU Circular Economy Monitoring Framework.

Material flow indicators

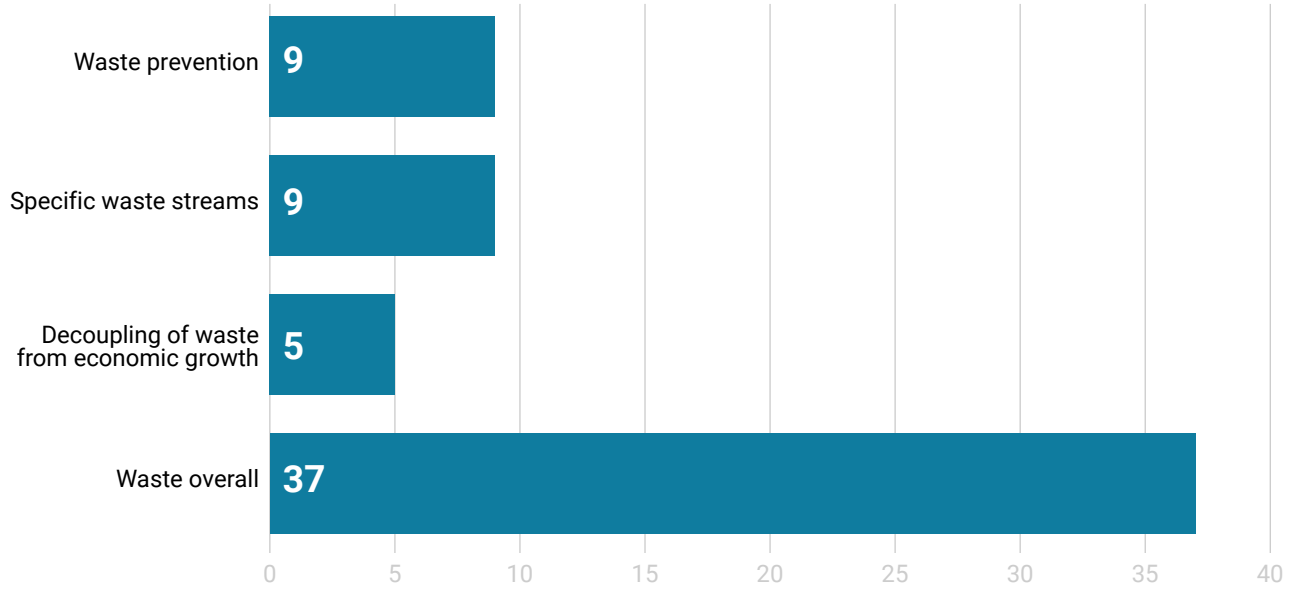
Core indicators in the majority of sets developed to date are those on material flows. Reporting on economy-wide material flow account-based indicators is mandatory for EU member states. This includes indicators such as domestic material consumption (DMC), which is calculated on the basis of total amount of material directly used in an economy equalling direct material input (DMI) minus exports. Eurostat integrates the reported data on material flow accounts, waste statistics, and external trade to calculate the Cyclical Material Use Rate (CMUR).

CYCLICAL MATERIAL USE RATE

The CMUR is a commonly used indicator in both the public and private sector, where it goes under somewhat different names, although it is often referred to as the circularity rate, or the inverse which is the circularity gap (also see Circle Economy's Circularity Gap initiative, as discussed in Section 2). Not all CMURs are calculated in exactly the same way, with differences between methodologies dependent on the choices of the author, as well as whether the country/economy or business level is targeted. Nonetheless, they all aim to measure the share of secondary raw materials in the total use of materials in an economy, respectively for a company. A disadvantage of the majority of CMURs is that for now they do not have full coverage of all relevant R-strategies that can keep materials cycling into the economic system for longer, and as a result of data availability generally include recycling only.

In the case of Eurostat, material flows for the CMUR are mapped based on whether they are considered biomass, metals, non-metallic minerals, or fossil fuels, although

FIGURE 12 • Overview of reported waste indicators, by type, for 32 European countries



Source: European Environmental Agency, 2019.

data sets currently lack sufficient detail to identify material flows such as plastics, glass, and paper. In 2018, Eurostat also published its first Sankey Diagram of Material Flows for the EU. With further updates in early 2020, it now acts as an interactive visualization tool and information repository, linking data on material flows to waste, energy use, emissions, and material imports and exports (European Environmental Agency, 2019).

RESOURCE PRODUCTIVITY

Another common material flow indicator is resource productivity, calculated as gross domestic product (GDP) per unit of domestic material consumption (DMC) or raw material consumption (RMC). The limitation of DMC is that it does not adjust resource productivity for the raw materials associated with goods and materials traded across borders. As a result, many countries have substituted DMC by RMC, the latter being defined as the annual quantity of raw materials extracted from domestic territory, plus all physical imports minus all exports. RMC is also referred to as the material footprint (European Environmental Agency, 2019).

MATERIAL FOOTPRINTS

RMC (or material footprint) accounts are compiled by Eurostat for the EU as a whole, underpinned by input-output modelling, while individual countries compile national accounts on a voluntary basis. These footprints represent the amount of material extraction required to serve demand for products by end users. Although highly relevant, the footprint indicator is currently not part of the EU's set of circular economy monitoring indicators, due to gaps in data availability and robustness (ECE, 2020), although Eurostat intends to start publishing material footprints in 2021.

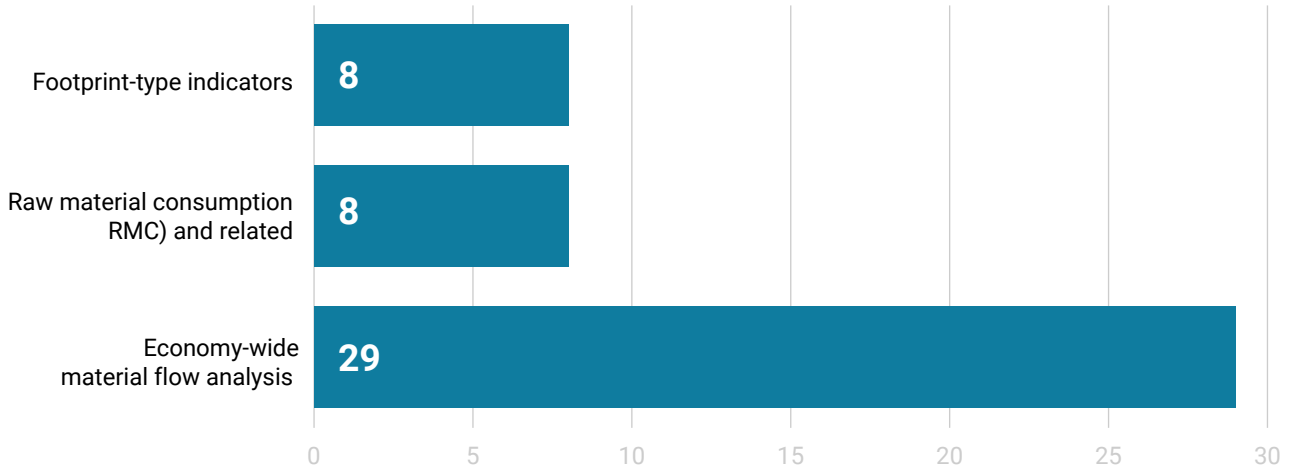
Nonetheless, in cooperation with Eurostat and UNEP, the OECD is developing, testing, and refining a methodology to produce harmonized data and indicators on material footprints for use in international work—with links to the relevant SDGs (SDG 8, decent work and economic growth, and SDG 12, responsible consumption and production). Using input-output modelling and OECD's Inter-Country Input-Output (ICIO) database, it estimates raw materials embodied in international trade (ECE, 2020).

R-strategies

As per Section 1, we can distinguish between nine different R-strategies (Netherlands Environmental Assessment Agency, 2019), of which recycling is the most well-known. Other R-strategies include reuse, repair, refurbish, remanufacture, and repurpose. By using indicators that provide insight into these R-strategies (beyond recycling), policy/decision-makers can gain direct insight into how and where progress towards the circular economy takes place, as well identify opportunities for improvement. Moreover, indicators on R-strategies can provide insight into the level of value retention of resources and products when keeping them circling in the economic system for longer and at their highest quality (Koch and Coelho, 2020).

The challenge with developing indicators for measuring the uptake of R-strategies is the level of data required,

FIGURE 13 • Overview of reported material flow indicators, by type, for 32 European countries



Source: European Environmental Agency, 2019.

calling for detailed and granular data at the meso and micro level for product categories and specific materials. Such data can be difficult to obtain, may not be collected on a regular basis or publicly available, and may suffer from data quality and consistency issues. As a result, R-strategy indicators are currently less commonly included in circular economy indicator sets.

Other examples of R-strategy indicators put forward by different actors include:

- A reuse potential indicator, as the share of product/material that is economically recoverable with current technology and market.
- The RRR rate, as an index for the prioritization of resources based on potential benefits from their reuse, recycling, or recovery, with the RRR benefit rate representing percentage of product lifecycle impacts that can be saved.
- A longevity indicator, as the sum of: (1) initial lifetime of the product, (2) the refurbished lifetime (as percentage of components), and (3) recycled lifetime (as percentage of materials).
- A material circularity indicator, as a material's actual cumulative service, divided by the maximum theoretical cumulative service.
- A utility factor indicator, as the product's lifetime divided by lifetime average, multiplied by the number of times a product is used to its full capacity divided by the average.
- The share of secondary materials in production processes.
- Percentage of materials sourced from non-virgin, renewable, regenerative, and/or sustainable sources.
- Percentage of materials suitable to be recirculated through reuse, redistribution, refurbishment, remanufacture, or recycling.
- Percentage of products designed along circular economy principles.
- Average number of product reuse cycles before end-of-life.

Note that these indicators require access to data at micro or meso level to be able to calculate them.

FIGURE 14 • Examples of proposed R-strategy indicators for circular economy monitoring in Germany

R1 Rethink	Number of new revenue models (Potting & Janemaaijer,2018)
R2 Reduce	Value-based resource efficiency indicator (Di Maio & Rem, 2017)
R4 Repair	Household spending on product repair and maintenance (Magnier et al., 2017)
R6 Remanufacture	Share of remanufacturing business in the manufacturing economy (EEA, 2016)
R8 Recycle	Recycling of all waste excluding major mineral waste (EC, 2018) Value based recycling index (Van Shaik & Reuter, 2016) Recycling process efficiency rate (Graedel et al., 2011), End-of-life recycling input rate (Graedel et al., 2011) Share of materials where safe recycling options exist (EEA, 2016) Material quality indicator (Steinmann et al., 2019)

Source: Kick et al, 2021.

Policy and process indicators

When using macro-economic circular monitoring indicators such as material consumption, it can take years before significant changes start to show. To proactively inform policies and programs, government decision-makers benefit from indicators that can deliver relatively quick feedback. For example, indicators that reveal something about the availability and implementation of circular economy policies, and about processes in society that provide an indication of how the transition to the circular economy is progressing.

The most commonly used policy indicator at the moment is green public procurement (GPP), as a proxy for market creation for circular economy products and services. GPP numbers on their own (as percentage or volume) may say little about the actual circularity of what is being procured. The procurement of an electric vehicle for instance would be classified as GPP, as would an energy efficient device. At a minimum, one would therefore have to identify the R-strategies being supported through GPP, and preferably also gain insight into the type of circular economy criteria being applied.

Another indicator, included in the EU's set of 10 circular economy monitoring indicators, is the number of patents related to recycling and secondary raw materials as a proxy for innovation. Some stakeholders have raised doubts about the relevance of this indicator as it does not cover all aspects of circularity, and neither does circular innovation automatically lead to a patent, for instance where it concerns innovation in business models.

France's set of 10 circular economy indicators includes an indicator on the number of industrial ecology projects as a guide to the uptake of (residual) resource exchange between industries.

The Netherlands Environmental Assessment Agency has divided the circular economy transition process into *means, activities* and *achievements* to help determine what is necessary to achieve the circular economy goal, such as choice of stakeholders and amount of financing. Information about activities provides insight into whether all relevant stakeholders are engaged, while achievement information indicates whether the activities actually led to the intended outcomes. Table 3 provides an overview of some of the indicators the Netherlands Environmental Assessment Agency has put forward to gather quantitative information about the circular economy transition process, particularly as fueled by innovation processes, and to provide input into policymaking and implementation (Netherlands Environmental Assessment Agency, 2018, 2021). These indicators may need to be adapted to fit specific priority themes or product groups.

Much of this information is not typically collected by statistical agencies, and some indicators can be quite challenging to measure, requiring stakeholders at micro and meso level to provide this type of data.

Environmental impact indicators

So far, we have mainly covered indicators that aim to say something about circular economy transition and its progress. However, circular economy is a means to an end, pointing to an additional need for impact indicators that provide insights into beneficial or adverse outcomes of the transition. The evaluation of environmental as well as socio-economic impacts, however, is often rather complex to measure.

The environmental impact indicator attracting the most interest is potential carbon mitigation from a transition to a circular economy. A limited number of studies have been conducted to estimate the carbon potential of certain circular economy interventions in specific geographic areas, although calculations can be quite complex and standardized methodologies—for example, a greenhouse

TABLE 3 • Indicative overview of potential circular economy policy and process indicators

	Capacity (able to)	Permission (allowed to)	Motivation (want to)
Means (input)	For increasing circular knowledge and expertise, e.g.: ◆ No. of circular economy researchers (in FTE) ◆ Investment in research (in Euros) ◆ No. of circular economy courses ◆ No. of circular economy research projects *& main R-strategy/ies they focus on*	For developing circular regulations and changing 'linear' regulations, e.g.: ◆ No. of circular policy advisers (in FTE) ◆ No. of circular advisers in branch organizations (in FTE)	For developing circular visions and transition agendas, e.g.: ◆ No. of people actively working on this (in FTE)
Activities (throughput)	Related to knowledge and expertise, e.g.: ◆ No. of circular innovation projects ◆ Share of circular projects in total no. of innovation projects ◆ % gov. budget for innovation and market creation going towards circular economy ◆ No. of circular economy knowledge events ◆ No. of network meetings for circular economy projects ◆ No. and type of circular economy actions by government and other key stakeholders ◆ No of successful coalitions with serious circular economy business cases ◆ No. of project submissions for circular economy knowledge/ innovation subsidies *& main R-strategy/ies they focus on*	Related to developing circular and changing 'linear' regulations, e.g.: ◆ Policy process for new circular laws and regulations ◆ Negotiations for circular standards ◆ Volume of government investment for circular economy policy implementation	Related to increasing motivation for circular economy e.g.: ◆ No. of vision-forming meetings ◆ No. of awareness campaigns ◆ Type of awareness campaigns ◆ Development of new laws and regulations that discourage linear practices (e.g. resource tax, circular public procurement, materials passport)

TABLE 3 • Indicative overview of potential circular economy policy and process indicators (Cont'd)

	Capacity (able to)	Permission (allowed to)	Motivation (want to)
Achievements (output)	Knowledgeand expertise-related activities, e.g.: ◆ No. of circular economy publications ◆ No. of circular economy patents (technology, product design) ◆ No. of new revenue models ◆ No. of new circular products ◆ Share of circular products in total no. of products ◆ No. of circular start-ups	New and changed regulations that permit circular initiatives, e.g.: ◆ No. of legal and regulatory barriers to the circular economy removed ◆ New standards and regulations introduced	Results of activities that increase motivation for circular economy, e.g.: ◆ No. and description of vision documents ◆ No. of circular economy media reports ◆ Consumer perception of circular economy ◆ No. of consumers buying circular economy products (beyond second-hand) ◆ Market volume of circular public procurement ◆ No. and description of new laws and regulations that discourage linear practices and price-in externalities (e.g. resource tax, public circular procurement, resource passport)

Source: Netherlands Environmental Assessment Agency, 2018.

gas protocol for identifying high-impact materials and sectors—are currently not available.

Other environmental indicators currently attracting interest include general environmental footprint indicators either for products (lifecycle analysis) or jurisdictions (input-output modeling), the water and land footprint of the circular economy, as well as the reduction in plastic pollution as a result of circular economy interventions. The development of indicators to capture environmental impacts is still in its early days, further complicated by methodological and data challenges.

Socio-economic impact indicators

It is assumed by many decision-makers that a circular economy transition will have beneficial socio-economic impacts, although there is considerable risk of potentially adverse impacts, depending on how the transition is managed. Even though monitoring of socio-economic impacts is of critical importance to ensure a just transition and improved quality of life, the indicators to assess these effects are to date somewhat neglected and require further development.

The key indicator attracting interest is the number of jobs created through the circular economy. The EU's set of 10 circular economy monitoring indicators for example includes an indicator on private investments, employment, and gross value added in circular economy sectors. Several countries have also proposed or introduced an indicator to track the number of full-time or equivalent (FTE) jobs held in economic activities that form part of the circular economy. NGO Circle Economy is starting to look into the dimensions and indicators for SDG 8 on decent work in relation to circular economy transition. Although measuring circular economy jobs is quite straightforward when it concerns relevant categories captured by statistical data, such as the recycling industry and the number of jobs created by it, it becomes more difficult to capture when it concerns a shift of jobs towards the circular economy within a sector, for instance an electronics company that starts offering refurbished devices.

Other aspects in the socio-economic impact category may include indicators around the impacts on societal wellbeing of, for example, circular economy education and training, protection of health by using more benign materials in products (which also facilitates reuse and recycling), and through new forms of and increases in collaboration and participation in value creation (e.g. prosumers, co-creation, repair cafes). Economic value creation through the circular economy is further complemented by aspects such as the opportunities a circular economy transition creates for businesses, for increasing a country's self-sufficiency for certain materials, or the potential for increased competitiveness of companies, sectors, and countries. Similar to environmental impacts however, the development of indicators to capture the economic added value of a circular economy transition is still quite nascent, and with its fair share of challenges.

4. Areas for improvement in circular economy indicator application and coverage

This section identifies several main areas for improvement in availability and application of circular indicators, with relevance for the public sector. These main areas broadly reflect other subject matter where global public and private sector alignment is sought, such as in aligning corporate environmental, social and governance (ESG) reporting with various private sector needs and public sector requirements. In general, while the reasons behind them are varied, the areas of improvement identified in this section can be considered typical for a field that is still very much under development. Reasons include stakeholders pursuing incongruent and uncoordinated efforts, efforts being 'opaque', resulting in low visibility for other parties with similar interests, or simply efforts focusing mostly on circular economy transition but not (yet) on measuring environmental and socio-economic impacts.

The order in which topics are covered reflects the fundamentals of circular economy measurement, i.e. from having basic definitions and a taxonomy in place to an overarching framework for how to think about circular economy measurement. This is followed by exchange between developers of circular economy indicators, and their eventual convergence towards greater levels of harmonization. Within this is a need to further expand coverage of circular economy indicators, as well as the data that underpins them, and to create better links between indicators at different economic levels. Finally, circular indicators play a central role in target setting as countries expand their circular economy strategies and policies.

Broad agreement on definition and taxonomy of the circular economy

The multiple distinct definitions of the circular economy and lack of consensus on related definitions in general poses a challenge for the establishment of circular indicator sets, and can also create hurdles in terms of comparability of the outcomes of certain indicators. A 2017 review for instance identified no less than 114 definitions of circular economy (Masi et al., 2017), although many do converge towards a similar scope. Similarly, there is currently no agreed taxonomy of circular economy actions and interventions to build on for measurement purposes. Having an agreed taxonomy in place is even more important when aiming to translate the outcomes of circular economy transition into environmental and socio-economic impacts.

Common framework for measuring the circular economy

Establishing a common framework for how we think about measuring the circular economy can provide considerable benefit for both the further development of indicator sets, and for communicating with stakeholders and enhancing their understanding of circular economy measurement (WBCSD, 2018). Such a shared view on the fundamentals, principles, and boundaries would provide the conceptual underpinning for circular economy measurement. This may include stakeholder alignment on the minimum set of 'must-have' indicators when aiming to measure circular economy at, for example, national or company level.

A framework could also define applicability of circular indicators—i.e. their purpose and in which context they can or should be used—as well as exploring the need for cross-cutting indicators, such as the CO^2 emission impacts of circular interventions, with the latter building on a taxonomy. Finally, a framework would address availability and suitability of data for measuring these aspects (ECE, 2020). The European Commission's recently completed Bellagio Principles, discussed in Section 2, could probably be considered a first valuable step towards a framework for circular economy measurement for the public sector.

Exchange mechanism for developers of circular economy indicators

With an increasing number of parties looking to either develop their own circular indicators or adopt existing ones, it has been observed that many stakeholders repeat similar exercises in which they map the current field of indicators and analyze existing sets, list and classify available indicators, and try to understand the detailed thinking behind them. In doing so, they often duplicate others' work, either without realising it due to a lack of transparency on who else is involved in similar efforts, or because the outcomes of such efforts are not freely shared between stakeholders. A dedicated convening and communication vehicle for exchange between stakeholders, an online repository, and/or the publication of guidance could support those starting out or further advancing their efforts.

Harmonization and standardization

Governments, intra-governmental bodies, NGOs, academics, and companies have all tried their hand at developing circular economy indicator sets. Some of these sets have broad application in the market and have become quite prominent, while others have been developed for very specific purposes, such as for use by a national government in a particular country. Some sets are more comprehensive than others, and may be targeted at companies, cities, countries, or other stakeholder groups. Nonetheless, in general it can be concluded that the majority of the still expanding body of circular economy indicator sets are inconsistent in their scope, objectives and possible applications, even where they serve similar goals and/or user groups.

The Netherlands Environmental Assessment Agency conducted a comparison of the methodologies used to calculate the Cyclical Material Use Rate (also known as its inverse: the 'circularity gap') by the Dutch statistics office, Eurostat, and the NGO Circle Economy—identifying methodological differences between them and the pros and cons of each approach (Netherlands Environmental Assessment Agency, 2020).

It is a disadvantage to the advancement of the circular economy when parties report on different indicators, whether the main differences are in their names, purpose, scope, and/or methodology. The current situation of a large and growing pool of circular indicators with limited alignment hinders transparency, as stakeholders are required to understand the specifics and intricacies of each indicator in order to compare and track progress across multiple organizations or jurisdictions.

When we consider learning from the field of financial accounting, in which a long history of discussion and debate eventually led to the global convergence of standards, one can note that on the whole the benefits of having a universal language outweigh the cost, and having stakeholders speak a shared language offers many advantages. These include *increased transparency,* making both reporting and its disclosure easier to understand.

A standard equally has a positive effect on *consistency* and *comparability,* which is especially appreciated where parties operate or collaborate at an international level, such as within the EU or the OECD, as well as at the level of major international businesses. Incidental benefits of switching to international standards have been the *reconsideration of processes, policies, and practices*, which may lead to new ideas or improved ways of doing things. Finally, it has been widely noted that an international standard can be more *dynamic,* as it is continuously revised in response to an ever-changing environment versus having numerous local or proprietary sets of indicators, whose developers may or may not have the capacity to continuously evolve and update over time. Nonetheless, the endorsement process for establishing any common standard is critical to establishing legitimacy (Kick et al, 2021).

Expansion of circular economy indicator coverage

As discussed in Sections 1 and 3, not all phases of the product lifecycle are well covered by circular economy indicators. To the extent that indicators are available, many tend to focus on waste and recycling practices and performance, as well as material flows and footprints. Nonetheless, particularly where it concerns *higher-order R-strategies* such as reuse, repair, refurbishing, remanufacture, and repurposing, most circular economy indicator sets fall short. In addition, only limited indicators cover *policy or process aspects* of a circular economy transition, think for example of the policies and processes in place that support and enable the R-strategies. A key reason lies in the greater challenges of measuring such practices, including the added cost and time implications, leading stakeholders to favor the use of 'straightforward' and easy to measure indicators.

Another observation is that existing indicators focus primarily on physical parameters, and are frequently weight-based (SUMMA, 2018). The weight of a certain amount of material however says nothing about its *economic value* or its *environmental and socio-economic impacts*. NGO Circle Economy has made a start in their annual Circularity Gap reports (see Section 2) to develop mass-carbon-value Sankey flow charts to show high-carbon resource hotspots, and assess their monetary and material relevance. Nonetheless, consideration of the economic value aspect of resource use remains uncommon in circular economy indicators.

Moreover, few indicators published so far aim to measure the impact of circular economy interventions and transition on our planetary boundaries or socio-economic institutions. Although in this case identifying impact indicators is relatively straightforward, it is the methodologies that can prove challenging. Translating "total circular procurement" or even "tons recycled" into proxies of impacts can be art as much as science. Nonetheless, it will be critical to account for both the beneficial and adverse impacts resulting from the circular economy in order to establish a credible indicator framework (WBCSD, 2018). Moreover, it will be important to develop both *productionand consumption-based* impact indicators in order to properly capture the cross-boundary nature of resource use.

Data gathering and availability

Data availability is a challenge common to many sustainability indicator conversations, not only those focused on circular economy. The development of circular indicators has so far mostly focused on those where data can be readily and easily gathered. The limitation of this is that it leads to a focus on indicators that can be measured with data derived from the predominantly still linear economy.

Although general waste generation and recycling have been the subject of policy focus for years, with many countries having fairly robust data, much of the information relevant for an analysis of the circular economy is not monitored to the same extent. Barriers range from information either simply not being recorded or tracked, to a lack of institutional frameworks or stakeholder pressure for governments and companies to collect and report on such data in a voluntary or mandatory manner (Circle Economy, 2020).

Producing reliable data at regular intervals for a diverse number of circular indicators entails a number of additional challenges, including the cross-cutting nature of the circular economy concept, the scope of which cannot always easily be defined in statistical terms, and may require data that can easily be interlinked and combined (ECE, 2020). With such data being scarce, collecting data where it exists can be costly and cumbersome. Quality can pose an additional hurdle if the robustness or consistency is considered insufficient for publication. Finally, not all data is publicly available, and the sharing of data between entities can run into considerable resistance.

Links between circular economy indicators across economic levels

Circular economy indicators can be developed at the macro-, meso-, and micro-economic level, with most activity currently concentrating at the macro-economic level for governments, and at the micro-economic level for businesses.

As governments further expand their circular economy indicator efforts, they are likely to gain an increased interest in the use of data and indicators at micro (companies) and meso (industries, sector) levels to help inform policymaking, as well as policy review. The current lack of such data, as well as time and effort constraints, are key barriers that hinder the linking of indicators between different levels (SUMMA, 2018). A national government interested in the circular performance of a specific sector is likely to face difficulties in both the lack of alignment between similar types of indicators at micro, meso and macro levels, as well as in accessing that data. On the one hand, companies frequently run into difficulties obtaining data across their entire value chain. On the other, a company's eventual score on a set of circular indicators is, at least at the moment, usually not disclosed. As a result, the systematic monitoring of major parts of the transition and performance dynamics of the circular economy remains relatively uncharted territory.

Setting circular economy targets underpinned by appropriate indicators

As Section 3 showed, quite a few countries have waste reduction targets in place, either as general targets that lump all waste materials together in a single indicator, or as targets for specific waste streams such as plastic packaging. Resource productivity targets, although not very common, have been introduced by some as well. These have the disadvantage, that, if not used in combination with indicators and targets that also track absolute resource consumption, they may paint a positive picture of progress even in cases where absolute resource demand continues to go up. Nonetheless, in general we can conclude that national and supra-national targets that aim to secure more sustainable resource consumption and production patterns are for a large part still in their infancy.

As more countries and companies set out circular economy strategies, they will need to couple these not only with indicators that can measure progress, but also with targets that set the goal posts of what we are aiming for. Setting circular economy targets requires careful consideration of the underlying indicators, and can help spur their further development. Consider for instance a general resource reduction target that does not specify any priority materials. This could lead to a perverse incentive to focus mainly on reducing consumption of abundantly available, low-impact resources in order to meet the target. By making such a target more granular, the development of suitable and matching indicators may receive a boost/

5. Recommendations

Section 4 identified several areas of improvement in the application and coverage of circular indicators, particularly in the public sector. This final section provides recommendations as to which areas should be prioritized for near-future action, based on stakeholder feedback regarding their urgency. It does so by first providing an indication of whether and how the field is currently addressing these challenges or omissions, and subsequently considers the way forward. The section closes with some high-level considerations for moving forward.

TABLE 4 • Recommendations which areas should be prioritized for near-future action

Areas for immediate action
1. Common framework for measuring the circular economy
2. Exchange mechanism for developers of circular economy indicators
3. Harmonization and standardization
4. Circular economy indicators coverage and data gathering and availability
Areas for further evaluation
5. Broad agreement on definition and taxonomy of the circular economy
6. Links between circular economy indicators across economic levels
7. Setting circular economy targets underpinned by appropriate indicators

Recommendations for immediate action

Not every area of improvement is considered equally important to address the near-future needs of (prospective) users. Those areas where we see a need for immediate action are briefly covered in this section. We focus foremost on the public sector perspective, where relevant touching on the private sector as well.

AREA OF IMPROVEMENT:

1. Common framework for measuring the circular economy

Status:

A **common framework for measuring** the circular economy is considered by all consulted stakeholders to be fundamental. The *European Commission*, having published its initial set of 10 indicators for monitoring the circular economy, as well as more recently the Bellagio Principles, will further update and expand its set of monitoring indicators. Equally, it aims to establish a permanent partnership to oversee the implementation of the Bellagio Principles in member state countries. The *OECD* is in the initial phases of developing a conceptual monitoring framework, with a view to creating a set of indicators for tracking progress as well as guidance on how to produce, use and communicate them at the international level, while the *ISO* through the process of developing ISO Standard 59020 "Measuring circularity framework", intends to arrive at an internationally widely supported (pay to access) framework for measuring circularity at different economic levels. To do so, it will aim to develop a common basis across macro, meso, and micro levels, as well as generic tools to enable greater comparability between the different levels.

Together, this points to a high level of interest in and recognition of the need to arrive at a common framework. At the moment, it remains to be seen which dimensions some of these frameworks will capture, how they will exchange amongst each other, and whether the end results will be sufficiently applicable beyond their immediate target groups. In general however, the Bellagio Principles may be a useful tool for countries outside the EU as well, particularly for those starting on their journey to develop circular indicators and looking to apply a minimum set of requirements to strive for.

Recommendation:

A common framework is considered both a critical and feasible next step towards an aligned and mature circular economy indicator field. Current initiatives have the potential to address this area, although there is a chance that multiple frameworks may emerge targeted at sub-sets of stakeholders. It is therefore recommended that key actors institute a regular exchange mechanism to ensure cross-fertilization and coherence, such that their user groups are served through aligned frameworks.

AREA OF IMPROVEMENT:

2. Harmonization and standardization

Status:

An often-mentioned barrier to greater uptake of circular economy indicators is the limited level of **harmonization and standardization**, with both the public and private sector publishing an ever-expanding array of circular indicator sets and methodologies for their respective user groups. Only some of these have built in a level of interoperability with other relevant initiatives, an example being the interoperability created between the updated *GRI* 306: Waste Standard, *Ellen MacArthur Foundation*'s Circulytics, and *WBCSD*'s Circular Transition Indicators. Although we understand the need to develop different indicator sets to address specific target groups or to serve unique needs, it is at the same time not surprising that prospective users may feel confused when trying to get a better grasp of the subject. Even more so when indicator names suggest similar purposes, but come with very different methodologies.

The solutions to this range from greater **interoperability** between different sets, which several users have started acting on, to creating one **standard** for measuring, disclosing and/or benchmarking the circular economy in a particular sector. This has already been witnessed in various other climate or sustainability fields, leading to standards such as the Greenhouse Gas Protocol, the Global Reporting Standards, and the Science Based Targets. Any effort to arrive at one unified standard is likely to take multiple years of intense collaboration, as experience from other fields has shown. For the public sector, the *European Environment Agency* and *Eurostat* are taking steps to support greater alignment on indicators, methodologies, and their data collection, in collaboration with EU member states and international organizations. The *ISO* on the other hand is uniting particularly private sector actors, including prominent NGOs, for the collaborative development of ISO Standard 59020 on measuring circularity, which will provide generic guidelines for measuring and assessing circularity. The expectation is that these two processes over time may lead to greater convergence on what and how we measure particularly transition to a circular economy.

RECOMMENDATION:

Current initiatives hold the potential to lead to greater convergence over time, although the pace may be slower than ideal for prospective end users. It is recommended that key stakeholders keep a close eye on the needs, wants, and perceptions of their targeted end users, to ensure users understand the reasons and purpose of different approaches, and where interoperability or convergence is currently built in or strived for over time.

AREA OF IMPROVEMENT:

3. Circular economy indicator coverage and data gathering and availability

Status:

Other critical areas for further improvement include **circular economy indicator coverage**, as well as **data gathering and availability**, to feed into the calculations of specific circular indicators. Both areas of improvement are multifaceted, as described in Section 4. Individual actors, such as the *Netherlands Environmental Assessment Agency*, *Circular Economy Center Flanders* in Belgium, the *Circular Economy Initiative Deutschland* in Germany, the *Canadian* as well as the *Colombian* government and others are considering different aspects and studying or developing approaches to address some of the circular indicator coverage and data areas of improvement specifically for their jurisdiction. The *European Commission,* as a follow-up to the Bellagio Process, is collaborating and exchanging with proactive member states to advance solutions to some of these aspects.

At the private sector level, some circular indicator sets have started to (partially) cover one or more of the indicator or data areas of improvement. Data collected by the private sector can also be an important source for public sector indicators. To ensure that the thinking behind and outputs of such initiatives can cross-fertilize other efforts, and that parties have a platform to jointly tackle 'sticky' issues if they so desire, formal exchange mechanisms as mentioned later on in this section can play an important facilitation and dissemination role here.

Recommendation:

Current initiatives aim to address some of the issues, but sticky challenges remain, and on some fronts there is limited pooling of knowledge towards solving them. It is recommended that stakeholders further explore mechanisms that allow for active pooling of knowledge and efforts, as well as cross-fertilization, to more rapidly advance solutions towards solving some of these challenges.

AREA OF IMPROVEMENT:

4. **Exchange mechanism for developers of circular economy indicators**

Status:

Effective **exchange between developers of circular economy indicators** is a critical prerequisite to address nearly all other areas of improvement. With no central repository, the time and effort spent on creating overviews of available indicators may take away from the resources stakeholders have available to experiment with more novel circular indicators and their data collection. Stakeholders benefit in general from mechanisms that help them exchange as well as communicate and disseminate their efforts and outputs to a broader audience.

The *European Commission's* proposed permanent partnership to anchor the Bellagio Principles is expected to play a role in allowing continued exchange and access to resources for its member states. To serve the dual purpose of cross-fertilization and allowing a wider audience to gain better access to insights and the latest thinking, the Circular Economy Indicators Coalition aims to provide a formal, structured mechanism for stakeholders working in different areas of indicators to exchange and align on topics of shared interest and urgency, complemented by a convening and dissemination function to serve the broader and global field.

Recommendation:

Current explorative efforts have the potential to address this area, depending on how they eventually materialize and what the scope and reach of their target group is. As such, it is recommended that key actors further deepen their understanding of the different needs and wants of developers (as well as users) of circular indicators in various sectors and geographies, to inform the outline and products of potential formal exchange mechanisms.

Recommendations for further evaluation

AREA OF IMPROVEMENT:

5. **Broad agreement on definition and taxonomy of the circular economy**

Status:

Another area of improvement identified in Section 4 concerns **the broad agreement on definition and taxonomy of the circular economy**. At the same time, stakeholder feedback suggests that the lack of one shared circular economy definition should not significantly impede the further development of circular economy indicators. Rather than aiming to reach consensus on the exact definition of a circular economy—which could be an extremely challenging task—it may be more worthwhile to align on a joint vision of the key areas where we consider the circular economy makes a positive contribution. In other words, to create a shared understanding and agreement on the circular economy's purpose, remembering that after all, the circular economy concept is a means to an end.

Nonetheless, the *ISO* Standard 59004 currently under development will build on and take inspiration from the existing circular indicator efforts of well-known NGOs such as *Circle Economy*, *Ellen MacArthur Foundation*, and *WBCSD* to arrive at a definition of circular economy and of aspects such as circular resource flows for incorporation in the standard. Meanwhile, it is anticipated that in the near future the *European Commission* may take further steps to develop a circular economy taxonomy to inform circular economy policies and programs going forward, building on the categorization system put forward by the Expert Group on Circular Economy Financing in 2020.

Recommendation:

Although a single definition for the circular economy may not be in reach any time soon, convergence of thinking is taking place and steps towards further building of an EU circular economy taxonomy are in preparation. As such, no recommendation for immediate action is put forward. Nonetheless, stakeholders should evaluate in due course whether the intended efforts have led to the desired outcomes, and if and how additional action might be needed.

AREA OF IMPROVEMENT:

6. Links between circular economy indicators across economic levels

Status:

As governments in particular expand their circular indicator efforts, they are likely to gain increased interest in the **use of data and indicators at multiple economic levels**, to help inform and track the effect of circular economy policies. Multiple challenges currently make it difficult to obtain and exchange data, or to compare the outcome of indicators across macro, meso, and micro levels. Although the reasons for many of the differences in data use and availability, as well as differences in methodologies between for example government and company levels are quite straightforward, a problem particularly occurs when parties are insufficiently aware of such differences. This could lead to the incorrect use of data or comparisons between indicators at different levels.

An indicative example would be to directly compare percentage circularity of a country with that of a company, if the parties do not account for the considerable methodological differences between the respective macroand micro-economic indicators. As a first step, *Circle Economy,* responsible for the macro-economic Circularity Gap indicator, and *WBCSD,* which has incorporated a circularity indicator as part of the micro-economic CTI indicator framework, are currently considering how they may be able to create interoperability between the two indicators.

In terms of data sharing from the micro to the macro level, a potential avenue can be found in identifying ways that would allow companies to benefit from making data available, for instance if this enables them to better compare their own performance to the sector they are operating in. Another approach could be through increased focus by governments on environmental performance, which could make it more strategic for companies to voluntarily become involved in data sharing than to wait and see what more stringent policies may hold.

Recommendation:

Challenges in translation between economic levels are becoming acknowledged, although other aspects to making links and exchanging information may take longer to solve. Depending on where voluntary action and government policies are moving in the years ahead, such links may increasingly be established—or instead require dedicated action as well as potentially the exertion of stakeholder pressure.

AREA OF IMPROVEMENT:

7. Setting circular economy targets underpinned by appropriate indicators

Status:

Finally, we come to the relative **dearth of circular economy targets** beyond waste targets. Many countries and companies do not have specific resource reduction targets in place, let alone targets for other aspects of the circular economy. An outcome is that limited attention goes towards the development of suitable indicators for target setting. As Section 4 showed, a circular economy target such as resource reduction will have to be made SMART through the right indicators to ensure a focus on what truly matters, and that the target can contribute to meaningful outcomes. This challenge is not easy to solve, because it depends on countries having circular economy strategies in place, and particularly strategies that go beyond waste and recycling and take more of a lifecycle approach to resource management. Once countries have such strategies, target setting becomes a logical next step. To this end, the *Netherlands Environmental Assessment Agency* is currently looking into the further development of relevant circular indicators to support the country's resource reduction target.

Recommendation:

Highly dependent on the adoption of more comprehensive circular economy strategies, which would make target setting a logical next step. As such the next few years are critical, with an increasing number of jurisdictions and organizations expected to adopt circular economy strategies. If uptake of the circular economy in general does not translate into an equal increase in momentum for meaningful circular targets, deliberate action towards an uptake of target setting may be warranted.

Looking forward

The circular economy indicator field is highly dynamic and constantly evolving. Although there are clear benefits to having a diverse field engaged in many different activities and efforts related to measuring circular economy transition and (for the time being) to a lesser extent measuring its impacts, none of the initiatives covered in this paper either offers or has been designed with the intention of providing a comprehensive solution to tackle the challenge at hand. Rather they should be seen as pieces of a complex jigsaw puzzle of the circular economy measurement universe. It is therefore vital that they increasingly start treading on

each other's toes, cross-fertilize, co-create, inspire and find synergies. The resulting insights and outputs can be woven into a compelling framework that tells the story of circular transition—and the contributions of the circular economy to the major environmental and socio-economic challenges of our time.

By continuing to proactively establish coalitions of the willing towards a shared goal—of which the Bellagio Process and the ISO Standard currently under development are clear examples—it is expected that stakeholders can increasingly leapfrog towards solutions for some of the persistent circular economy indicator gaps and challenges that either require or will greatly benefit from the pooling of knowledge and efforts by multiple stakeholders. In doing so, the end users of circular economy indicators equally benefit, as their needs will be served more quickly and in a more aligned manner. That in turn may help accelerate the uptake of the circular economy.

This is crucial if we consider that, despite the circular economy's tremendous potential, roughly a decade after its introduction it has yet to deliver at scale. Although the current diverse field helps fuel innovation, the relatively scattered state of circular indicator development may not optimally serve the external perception and delivery of evidence to those considering whether and how to embrace the circular economy. Especially if such parties have a tendency to compare the circular economy to other more mature and unified fields, for which a greater body of data and evidence is available. This might particularly hold true for the climate change community, whose longer history has allowed it to arrive at clear standards, protocols, and targets to define what constitutes success and track progress towards it. Despite the circular economy representing an absolutely critical lever to curb dangerous climate change, a considerable number of climate change practitioners have yet to embrace it. The circular economy's role in reducing emissions remains, for the moment, insufficiently acknowledged.

Beyond the individual and tailored solutions that can be put forward to fill specific circular economy measurement gaps, we recommend foremost that the circular economy measurement community continues and expands its efforts to create a more unified field that proactively exchanges, collaborates, and disseminates. This will not only serve its growing body of end users looking to develop and execute on circular economy strategies and policies, but importantly also serves as 'proof of concept' for the broader sustainability and climate field, delivering the rigor and confidence that cements the circular economy's place as the linchpin for a sustainable, climate-proof and resilient world.

Annex A

This tabular overview complements Figure 10 in Section 2, providing an indication of the scope encompassed by circular economy indicator efforts across a select range of countries, either launched, proposed, or under development. The indicator categories build on those identified in the Bellagio Principles, and are supplemented by the R-strategies as per The Netherlands Environmental Assessment Agency).

For indicators that have been launched, a distinction is made between indicators that are in use/available (A), and those that have in addition been made mandatory (A(M)) for EU member states to annually report on. At European Union level a number of indicators are currently in use that do not feature in the individual sets of circular economy indicators used or proposed by individual member states, and for which a complete set of data across the Union may not always be available.

Indicators that have been proposed (P) or that are still under development (D) have not yet been officially approved as part of a (country) set of indicators.
GPP refers to the use of an indicator on green public procurement as the main indicator in the policy and process indicator category currently being proposed or under development by a number of countries.

Country	Note
Netherlands	Netherlands Environmental Assessment Agency is in the process of further developing a set of 31 indicators, which cover resource use and its environmental and socio-economic effects. A progress report including data for 24 of the indicators was published in early 2021.
Belgium/Flanders	Flanders is developing indicators for a select range of 'societal systems of demand'. These include four macro level systems: materials, land use, water, land, and energy, and five meso level indicators: housing, food, consumption goods, and mobility. The set should be complete by end 2021.
Germany	The Circular Economy Initiative Deutschland, through acatech and SystemiQ, has analyzed 230 indicators, of which 50 have been proposed as a priority
France	In 2017, France was one of the first countries to present a set of 10 indicators for monitoring transition to a circular economy, taking into account which indicators and their data were already available.
Austria	Austria's three-yearly Resource Efficiency Report presents at-a-glance results of environmental accounts to provide insights into material consumption trends.
Finland	Finland aims to develop a set of 10 circular economy indicators, comparable with the EU's circular economy indicators as well as UN SDG indicators.
Denmark	Denmark has a Denmark Without Waste Strategy (2017) and a Danish Action Plan on the SDGs (2017), which contain a number of circular economy relevant indicators related to waste streams and resource productivity.
Sweden	Sweden has a Generational Goal to hand over to the next generation a society in which the major environmental problems have been solved, without increasing environmental and health problems outside its borders. To this end it has established Environmental Quality Objectives and Milestone Targets including improved resource management.
Italy	Italy has identified circular indicators, divided into those at the macro (waste and resources), meso, and micro level (material flows; lifecycle analysis; recycled, recyclable and bio-based products), published in a 2018 report.
Spain	Spain published a proposal in 2017 with 20 indicators to measure the circular economy. The Circular Economy I Action Plan indicator set is based on available indicators provided in the Spanish Circular Economy Strategy and by the National Institute of Statistics.
Ireland	No specific targets or indicators have been developed so far, although the intention is to integrate with indicator approaches being developed at EU level.
UK	As part of its waste prevention strategy and clean growth strategy, the UK monitors a number of waste and resource indicators, including the gross value added by the repair and reuse sector.

	Indicators									
	Waste	Recycling	Material flows		Rstrategies	Policy and process	Environmental impact		Economic and social impact	
			(other)	Of which CMUR	(beyond recycling)		(other)	Of which climate	(other)	Of which jobs
	A(M)	A(M)	A(M)	A(M)		D	D	D	D	D
	A(M)	A(M)	A(M)	A(M)	A	-		D	-	A
	A(M)	A(M)	A(M)	A(M)	D	D (GPP)	D	D	D	D
	A(M)	A(M)	A(M)	A(M)	A	-	-			A
	A(M)	A(M)	A(M)	A(M)						
	A(M)	A(M)	A(M)	A(M)	-	P	P	P	D	D
	A(M)	A(M)	A(M)	A(M)	-	-	-		-	
	A(M)	A(M)	A(M)	A(M)	-	-	-		-	
	A(M)	A(M)	A(M)	A(M)	-	-	D (LCA)		-	
	A(M)	A(M)	A(M)	A(M)	P			P		
	A(M)	A(M)	A(M)	A(M)	-	-	-		-	
	A	A	A	A	-	-	-		-	

Country	Note
Norway	Norway's national objectives are monitored through growth in waste generation relative to economic growth, expressed as change in GDP, and the proportion of non-hazardous waste recovered.
Switzerland	Switzerland adopted the Green Economy Action Plan in 2013. A 2016 initiative for a Sustainable and Resource-Efficient Economy was rejected by voters. As a result, no quantified targets and subsequent indicators have been adopted beyond those in the 2013 Plan, which includes targets on waste and recycling.
European Union	In 2013 the EC launched the Resource Efficiency Scoreboard, with a set of 32 indicators categorized by headline, dashboard, and transition indicators. In 2016 it launched the Raw Materials Scoreboard, with 26 indicators grouped into five thematic clusters: raw materials in the global context; competitiveness and innovation; framework conditions for mining; circular economy and recycling; and environmental and social sustainability. Subsequently in 2019, the EC approved a set of 10 indicators for monitoring progress towards the circular economy.
China	China was one of the first countries to launch circular economy indicators, back in 2007. Its most recent set of indicators (2017) includes three types: Comprehensive Indicators, which are similar to the EU's 'headline' indicators and focus on resource productivity and recycling rates; Work Indicators, which focus on the productivity of auxiliary inputs, such as land, energy, and water, as well as on utilization rates of several waste products; and Reference Indicators, which relate to waste generation and disposal. The three sets rely as much as possible on indicators for which data is quite readily available.
Japan	Japan has created a framework to monitor progress made in establishing a circular economy. Its first plan for a sound material-cycle economy was published in 2003, with the fourth dating from 2018. The Fourth Plan includes primary and supplementary indicators and their targets.
Colombia	Colombia has determined the development of a Circular Economy Information System as a strategic pillar of its national circular economy strategy, launched in 2018. A set of 44 indicators was published in 2020, classified into four components: extraction of environmental assets; production of goods and services; consumption and use; and closing and optimizing materials and product loops, based mainly on statistical data and surveys.
Chile	In December 2020 Chile published its draft Chilean Circular Economy Roadmap. A circular economy indicator exercise in 2019 continues to inform their thinking around measuring the circular economy.
Canada	Canada publishes data every two years on waste and recycling based on data from its biennial Waste Management Industry survey. Currently surveys are being redesigned to provide improved data on circularity. Canada also measures the economic contribution of environmental and clean technology (ECT) products in terms of GDP, employment and other variables.

	Indicators									
	Waste	Recycling	Material flows		Rstrategies	Policy and process	Environmental impact		Economic and social impact	
			(other)	Of which CMUR	(beyond recycling)		(other)	Of which climate	(other)	Of which jobs
	A	A	A	-	-	-	-		-	
	A	A	A	-	-	-	-		-	
	A(M)	A(M)	A(M)	A(M)		A			A	A
	A	A	A	A	(A)	-	-		-	
	A	A	A	A	A	A		A		
	A	A	A	-		A	A	A	A	A
	A	A	A	P	P	P (GPP)	P	P	P	P
	A	A	D			D (GPP)				

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