The CIRCULARITY GAP report

An analysis of the circular state of the global economy

January 2018

CIRCLE ECONOMY

ACKNOWLEDGEMENTS

Authors

Marc de Wit	Circle Economy
Jelmer Hoogzaad	Shifting Paradigms
Shyaam Ramkumar	Circle Economy
Harald Friedl	Circle Economy
Annerieke Douma	Circle Economy

Further contributors*

Andrea Brown	WBCSD
Dr. Willi Haas	Alpen-Adria Universitat
Markus Laubscher	Royal Philips
Alberto Pallecchi	World Resources Institute
Franziska Reh	Accenture Strategy
Elmer Rietveld	TNO
Alexandra Soezer	United Nations Development Programme

Graphics & lay-out

Kay van 't Hof	Circle Economy

* Contributors are listed in alphabetical order

January 2018

ABOUT US

At Circle Economy, we believe in a visionary future for our planet — one in which we do not have to compromise to achieve economic, social, and environmental prosperity. As an impact organisation, we connect and empower a global community to create the conditions for systemic transformation. With nature as our mentor, we work alongside businesses, cities and governments to identify opportunities to make the transition to the circular economy, and provide a powerful combination of practical and scalable solutions to turn these opportunities into reality.

Our mission is to empower a global community of businesses, cities and governments to accelerate the transition to the circular economy through practical and scalable insights and solutions that address humanity's greatest challenges.

IN SUPPORT OF THE **CIRCULARITY GAP** REPORT:

Peter Bakker
President and CEO at ***World Business Council For Sustainable Development (WBCSD)***

"Moving towards the circular economy will be critical for addressing climate change and resource overuse. This report is a promising step forward in understanding our global progress on this front. Business will be essential in building momentum as we work to decouple economic growth from resource use. WBCSD's circular economy program – Factor10 – brings global companies together to speed up the transition and deliver circular solutions, faster."

Frans van Houten
CEO at ***Philips*** *and Co-chair* ***Platform for Accelerating the Circular Economy*** *(PACE) at* ***World Economic Forum***

"The traditional "take-make-dispose" economic model endangers the achievement of the globally agreed Sustainable Development Goals. SDG Goal 3 - "Healthy lives and well-being for all at all ages" - is at the core of the Philips mission and relies on "Sustainable consumption and production patterns" (SDG12) to be achieved. I therefore welcome this first step towards a global circularity metric. This will allow us to better measure the material flows of the global economy and provide insights about key levers for moving to a circular economy."

Dr. Willi Haas
Social Ecologist at ***Alpen-Adria Universität***

"The big question remains if the circular economy will enfold as a marketing opportunity or as a game changer at a systemic level. The touchstone being, if sharing, reusing, refurbishment, remanufacturing and recycling enables a radical reduction in both primary resource use, waste and emissions. If this remains out of reach, a continued overstretching of global sources threatens reasonable living conditions for a majority of the global population. A successful circular economy holds manifold promises for meeting the SDGs via a concerted and integrated action. This report pushes in this direction and enables the tying up of the most crucial loose ends."

Kate Raworth
Author of the book ***'Doughnut Economics'*** *and Senior Visiting Research Associate at* ***Oxford University's Environmental Change Institute*** *and Senior Associate at the* ***Cambridge Institute for Sustainability Leadership***

"The twentieth century was ruled by the metric of money, which demanded endless growth. This century calls for new metrics - natural and social - that enable humanity to thrive within the means of the planet. This fascinating report presents just the kind of powerful numbers needed to start making that new economy real."

Jyrki Katainen
Vice-President for Jobs, Growth, Investment and Competitiveness at ***European Commission***

"This report gives a very concrete and tangible analysis and way forward for the circular economy and is a good contribution, supporting the efforts of many policymakers. The European Commission is very dedicated towards the achievement of the SDGs and is committed to transforming the European economy towards a more sustainable, low carbon, resource efficient future. We are convinced that we can only achieve this together through a broad collaboration of all stakeholders - across national borders - to make our systems fit for the challenges of today. This report illustrates how much more effort is still needed."

Dominic Waughra
Head of Public-Private Partnership, Member of the Executive Committee, ***World Economic Forum***

"The economic case for shifting to a circular economy is compelling and the concept has gained tremendous momentum in the past few years. With the advent of the 4th industrial revolution, we have a suit of innovations and technologies that can enable resource decoupling, yet we still live in a world where natural resource demand is growing dramatically. What we need now more than ever is collaboration and partnerships between business, government and civil society to move the circular economy from idea to action at scale. This report nicely sketches a roadmap for change that can help mobilize the global community."

Feike Sijbesma
CEO at ***DSM***

"DSM, as a science-based company, collaborates across the value chain to rapidly redesign and scale up "closed loop" solutions for some of the biggest waste problems in the world. We are committed to working with others to measure and monitor circularity and to underpin collective actions towards a circular economy, where waste will be something from of the past."

Dr. Andrew Steer
President and CEO at ***World Resource Institute***

"Rapid population growth and a growing middle class is putting unprecedented strain on the World's natural resources. The concept of a Circular Economy, one in which waste products become valuable assets, has recently gained traction as a solution that would lessen the burden on natural resources while encouraging economic growth. Its main concept is simple: minimize the need for virgin resources by keeping existing materials in the production cycle. Corporate and government leaders need to look at ways to strengthen our societies' resilience, measure and reduce the environmental impacts of human activity, and create a truly circular economy that works for the people and the planet."

Abdeluheb Choho
Deputy Mayor at ***City of Amsterdam***

"Cities leaders are increasingly taking a centre stage addressing key societal, economic and environmental challenges, as all these issues come together in the urban environment. The need to measure progress in moving the needle to a circular city is therefor evident."

Achim Steiner
Administrator at the ***United Nations Development Programme***

"Only 14% of all plastic packaging is recycled and vast quantities escape into the environment, resulting in a loss of USD 80 to 120 billion per year, and the possibility of more plastic than fish (by weight) in the ocean by 2050. We have an opportunity with the circular economy to rethink how we use resources like plastic and become a more responsible custodian of the planet. By using resources more efficiently and creating policies and economic infrastructure that encourage recycling and reuse, we can advance both Agenda 2030 and the Paris Agreement."

Naoko Ishii
CEO and Chairperson for the ***Global Environment Facility,*** *co-chair of the* ***Platform for Accelerating the Circular Economy***

We stand at a defining moment for the future of the planet and human well-being. To stay within the planetary boundaries, a radical transformation of key economic systems will be required to significantly reduce their environmental footprint. Our current linear "take-make-waste" system is simply not sustainable for the environment, the way we live or the economy. As this new report makes clear, economic prosperity depends on a healthy global environment, which goes hand-in-hand with the circular economy approach.

Martin Frick
Senior Director at the ***United Nations Framework Convention on Climate Change*** *secretariat*

"Material extraction, processing, usage and disposal are accounting for over 50% of global greenhouse gas emissions. To implement the Paris Agreement as well as to achieve sustainable consumption and production, circular economy is pivotal."

Isabelle Durant
Deputy Secretary-General at the ***United Nations Conference on Trade and Development***

"As a global economy, we need to move from a mercantilist model of resource trade, where some nations accumulate materials which are costly to reprocess in their own territories, to a model in which resources flow back to regions with comparative advantages to recycle. Negotiating agreeable conditions for all countries to do so is essential to make the circular economy the core of less wasteful economic growth strategies with social inclusion."

Dr. Mari Pantsar
Director, Carbon-Neutral Circular Economy at Finnish Innovation Fund ***SITRA***

"Climate crisis, overuse of natural resources and deteriorating functional capacity of ecosystems are forcing us to radically change how we are producing and consuming energy and natural resources. Transition to the circular economy is not only a must – it can also provide a huge opportunity to rethink our well-being and build more just and inclusive economies. Unfortunately, today we are far from the target. We must urgently create a common vision, roadmap and metrics: most of all we need global collaboration towards the vision."

Prof.dr. Arnold Tukker
Scientific Director and Head of the Department of Industrial Ecology, Institute of Environmental Sciences (CML) at ***Leiden University***

"What you don't measure, you can't manage. So, circular economy policies need sound indicators. The 'circularity gap' is a nice, simple, intuitive metric. It shows our economy is just over 9% circular. Such a powerful message of what still needs to be done! The indicator may not be perfect, but we have to start somewhere. A great start to the discussion on how to build the most policy-relevant circularity metric!"

Peter Lacy
Global Managing Director – Growth, Strategy & Sustainability at ***Accenture Strategy,*** *Author of* ***'Waste to wealth'***

"The circular economy is an enormous opportunity for companies and the advances of the 4th Industrial Revolution. By spanning digital, physical and biological technologies it offers innovative ways of producing and consuming products to help businesses rise to the challenges of the Paris Agreement and the UN's SDGs and ensures that the world has enough, for all, for ever. In that context, the proposal of a global metric to measure circularity is an important step in guiding public and private sector action to accelerate the transition to a circular economy."

Prof.dr. Louise E.M. Vet
Director at ***Netherlands Institute of Ecology (NIOO)***

For the first time the circular state of our global economy has been analysed. And it is frightening: our economy is only 9% circular! What a contrast with nature. 'Waste' is not in nature's dictionary, nor part of nature's fully circular economy. 3.8 billion years of research and development in nature teaches us that instead of solving problems we should rethink the blueprint. This important Circularity Gap Report not only gives us the data underlying this alarming circularity gap but it also defines crucial steps to bridge it and speed up the necessary transition.

Kees van Dijkhuizen
CEO at ***ABN AMRO***

"The transition to the circular economy is crucial, because our current consumption pattern is already beyond the limits of what the planet can provide. With a growing global middle class, the gap will widen even more. This report shows that we need to take action on a global level and the best way to bridge the gap is by working together. As a bank, we strongly support this forward momentum and wholeheartedly want to contribute to a futureproof society."

Mark Watts
Executive director at ***C40***

"Circle Economy's 'The Circularity Gap Report' marks an important step in rethinking traditional linear resource management in order to transition to innovative models of continual reuse. The report underlines the key role for cities in this transition, supporting C40 research that improved waste and materials management is a vital area of intervention for mayors and an urgent priority for preventing the worst effects of climate action. The report sets out important strategies and next steps to progress towards a circular economy and to ensure consumption without waste."

EXECUTIVE SUMMARY

Our world economy is only 9.1% circular, leaving a massive 'Circularity Gap'. This alarming statistic is the main output of this first Circularity Gap Report, in which we launch a metric for the circular state of the planet. Taking the United Nations' *Emissions Gap Report*[1] as inspiration, the Circularity Gap Report provides a framework and fact-base to measure and monitor progress in bridging the gap, year on year. Being able to track and target performance via the Global Circularity Metric will help us engage in uniform goal-setting and guide future action in the most impactful way.

Closing the circularity gap serves the higher objective of preventing further and accelerated environmental degradation and social inequality. The transition to circularity is therefore a means to an end. As a multi-stakeholder model, a circular economy has the ability to unite a global community behind an action agenda, engaged and empowered both collectively and individually. Its systemic approach boosts capacity and capability to serve societal needs, by embracing and endorsing the best humankind has to offer: the power of entrepreneurship, innovation and collaboration.

The circular transition thereby provides actionable ways forward to contribute to reaching the Sustainable Development Goals and the Paris Agreement. Our linear model is effectively no longer fit for purpose, failing both people and the planet. Circular economy strategies have the potential to be instrumental in the push to mitigate the associated climate impacts, given that majority (67%) of global greenhouse gas emissions are related to material management.

The report shows how key societal needs are met and the resource reality behind the delivery. For key needs like housing, mobility and nutrition, the Report reveals the global material footprint. It shows which needs consume what resources. Our global metabolism visual illustrates what happens with products and materials after their functional use in society. In particular, it uncovers the modest flow of resources cycled back into the economy and helps us estimate how much material goes wasted beyond recovery. This exposes how deeply our linear system is still ingrained in our daily lives.

Bridging the circularity gap requires intervention across the full breath of society and action in nations, sectors, supply chains and cities. Major trend corrections are needed to get the global economy on a pathway towards circularity. This Report identifies key levers at a global level and points to 'inconvenient truths' that provide systemic challenges for moving to circularity by mid-21st century.

4 STEPS TO TAKE ACTION IN BRIDGING THE CIRCULARITY GAP THROUGH LEADERSHIP AND ACTION

1. **Build a global coalition for action,** comprised of front-running businesses, governments, NGOs and academics, that will input and convene an authoritative annual report on the circular state of the global economy and measure progress towards its implementation.
2. **Develop a global target and action agenda** by working with all relevant stakeholders to agree clear goal-setting and alignment with the SDGs and emission-reduction targets.
3. **Translate global targets into local pathways** for circular change, taking big-picture directions and interpreting these for nation states, individual sectors, supply chains, regions and cities to embed strategies in their specific context and align with incentives and mandates.
4. **Improve our understanding** of how different levers for circular change affect aspects such as material saving, value retention and climate mitigation. Also consider fully the dynamics of international trade and employment, plus implications for education, training and future skills, both for young people today and the next generations of tomorrow.

JOIN THE CONVERSATION

#CircularityGapReport

www.circularity-gap.world

TO BRIDGE **THE CIRCULARITY GAP** WE NEED TO:

Stop extracting **Stop wasting** **Optimise what we already have** **Cycle more and better**

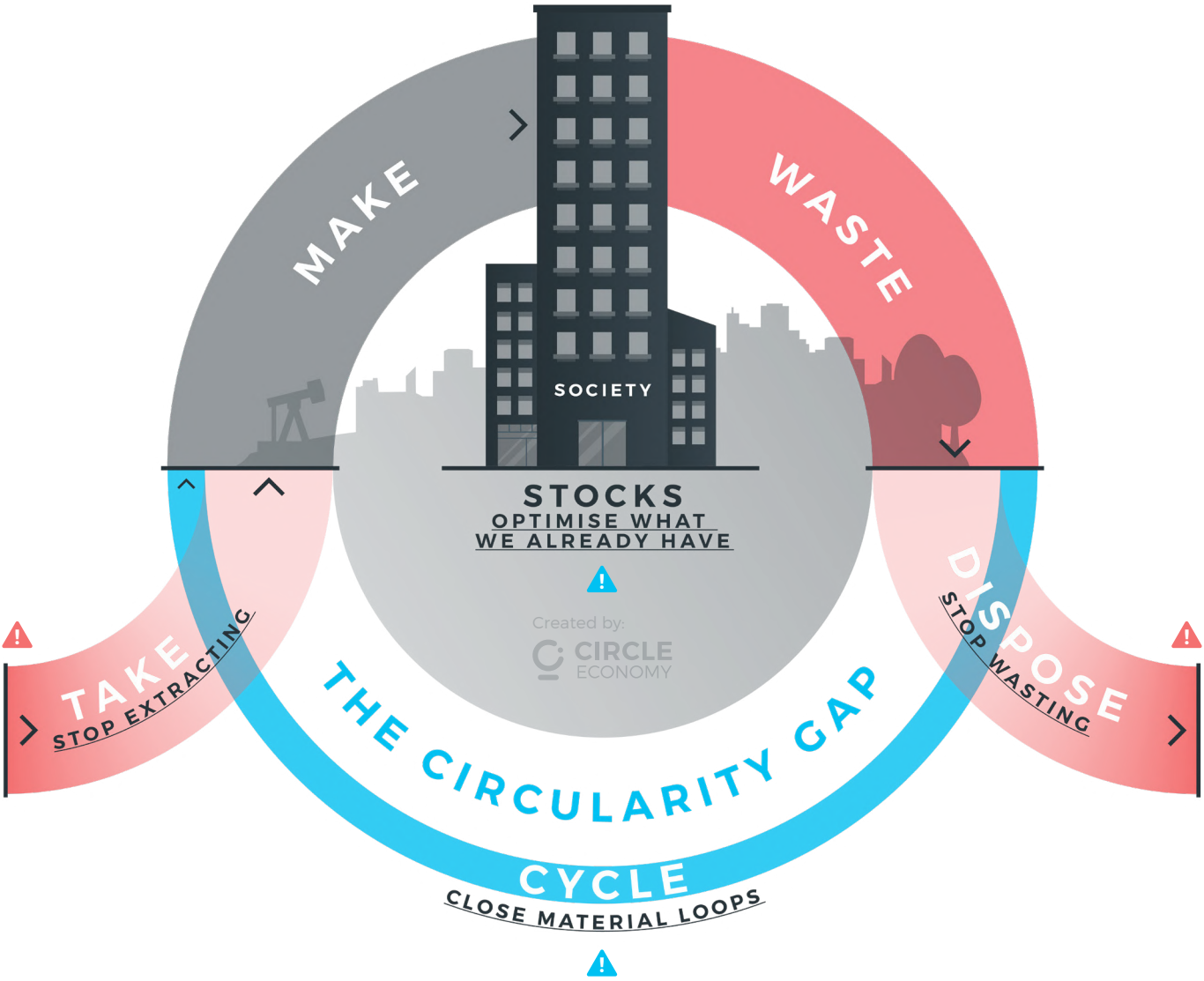


Figure 1. How to bridge the circularity gap.

TABLE OF CONTENTS

1 FROM A WORLD IN CRISES TO A CIRCULAR ECONOMY

The world is in crisis. The year 2018 started with an alarming message from the world's chief diplomat, the Secretary-General of the United Nations, António Guterres, who issued a "Red Alert for the World", which he describes as having gone in many ways into "reverse" in the last 12 months.[2] The New Year's resolution proposed by Guterres came in the form of a call-out to humanity, challenging us all to: "Narrow the gaps. Bridge the divides. Rebuild trust and bring people together around common goals!"

Systemic failure of the linear economy: How society now stands at a crossroads

What has got us where we are today, in every sense, is the linear economy. Over decades, even centuries, since the boom of the Industrial Revolution, it has delivered tremendous living standards, wealth and comfortable lives to some people, in some parts of the world, at certain times. It has done so, though, at high cost. That cost continues to be extracted from the planet and many of the people on it, with neither the gain nor pain distributed equally. Embedded deep within the 'take-make-waste', tradition of the linear economy lies a toxic cocktail of negative consequences, ranging from social inequality, to depletion of natural resources, environmental pollution and worsening of the risks and effects of climate change. As a result, in a resource-constrained world with high-impact megatrends of rapid population growth and widespread urbanisation, that flawed linear model is no longer fit-for-purpose.

Society, therefore, finds itself standing at an historic economic and cultural crossroads. In order to answer, not just hear, the call of a *Red Alert for the World*, we are faced with a choice: crisis, or change. Do we continue to tweak and tamper with our broken linear model, cognisant of the consequences and liable by default; or do we pivot to a circular economy and with fresh minds and new tools pursue a desirable and deliverable paradigm shift? This report sets out the pathways towards practical and scalable implementation of a circular economy that takes Nature as its 'mentor' to better meet societal needs, so achieving more equitable prosperity within planetary boundaries.

Like it or not, in the 4.5-billion-year history of Earth, mankind arrived late to a planet already functioning in a fully circular manner. In the natural world, the infinite cycling of the ecosystem means there is no such thing as 'waste', which is essentially a social, human construct. This optimal resource-efficiency found in nature serves to inspire and inform more circular approaches to problem-solving and design philosophies like biomimicry. With the advent of the anthropocene, however, the era starting roughly 200 years ago during the Industrial Revolution, humankind has itself became a geological force for the first time in history. This has led to human-made climate change caused by the burning of fossil fuels, with consequences including rising sea levels, the prospect of the mass extinction of species due to ever-expanding urbanisation and non-sustainable agriculture. The ultimate goal of a circular economy should therefore be a fundamental redefinition within the economic language, as well as a new, reconnected relationship between the dominant economic realm and other spheres in society and nature.

Circular Economy: climate change and the Sustainable Development Goals

In truth, momentum is already building towards adoption of circular economic models. We are witnessing circular economy strategies being embedded within businesses - ranging from multinational corporations, to start-up companies disrupting the incumbents - and adopted into government policies, for example in China, Sweden and the Netherlands (several countries such as Slovenia, Italy and others have adopted "country-wide circular economy roadmaps"), plus with the circular economy package in the European Union. On the global level, two recent examples of international collaboration, in particular, have accelerated the mainstream political and business agenda: climate change and the United Nations Sustainable Development Goals (SDGs).[3] The launch in September 2015 of the SDGs introduced 17 interrelated Goals, encompassing some 169 targets designed to provide a framework for action to improve social welfare and wellbeing worldwide, whilst preventing global overshoot through transgression of our planetary boundaries.[4] In tandem with the SDGs, the signing of the Paris Agreement that same year at COP21 established near-consensus on the need for mitigation of human-made climate change and its impacts, via collective policy and practice.

Central to both the vision of a circular economy and key global SGDs is the ambition to tackle two of the main negative effects of a linear model: waste and excessive extraction of primary resources. Waste production and disposal, associated greenhouse gas emissions, unequal access to resources and large-scale resource extraction are all activities which aggravate many of the issues which the SDGs and underlying indicators[5] aim to address. While transition to a circular economy cannot guarantee progress on all Goals, its transformational ambition represents an opportunity to inspire positive

RESOURCE EXTRACTION INCREASED 12-FOLD BETWEEN 1900 AND 2015, FUELLING STEEP ECONOMIC GROWTH, WITH FURTHER DOUBLING FORECAST FOR THE NEXT 35 YEARS TO 2050

Material extraction has fuelled economic growth since the Industrial Revolution. In fact, over the last four decades, the global use of materials almost tripled, from 26.7 billion tonnes in 1970, to 84.4 billion tons in 2015. Not only has material use been increasing - it has been accelerating, as witnessed in the first decade of the 21st century and ongoing. The IRP forecasts that by 2050 material use will amount to between 170 and 184 billion tonnes[10,11] (see figure 2, BAU). A prime factor driving up environmental pressures, this increased and accelerated material use is to a large extent driven by rising prosperity levels globally. Whist elevating people out of poverty is a desirable, even essential outcome, the associated material use is not.[12,13] The circular economy has a key role to play in decoupling growth from material extraction, thereby creating the conditions for sustainable development to deliver more prosperity for a larger population, but with diminishing use of primary resources.

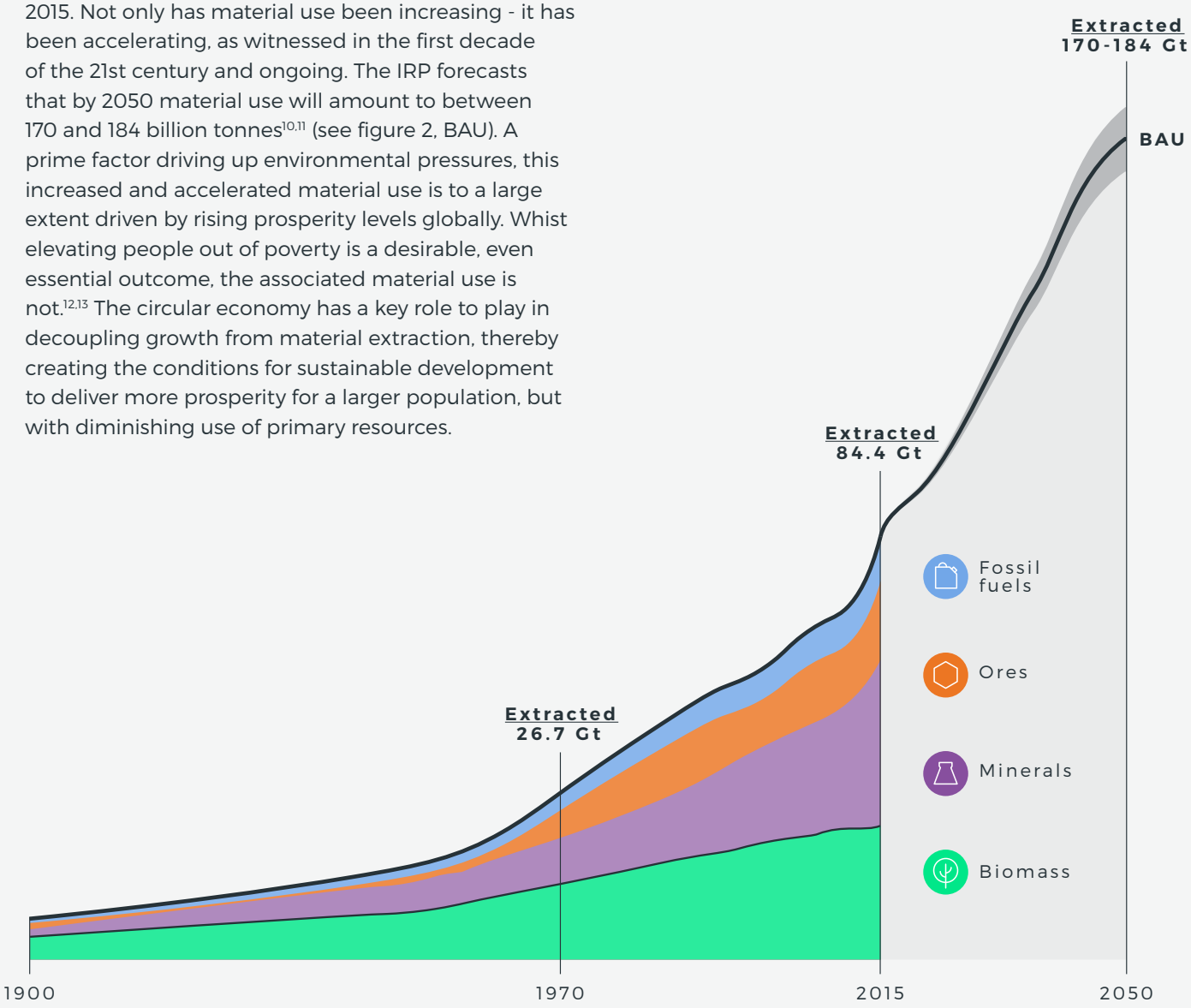


Figure 2. Material extraction of fossil fuels, ores, minerals and biomass between 1900 and 2015 when total material extraction amounted to 84.4 Gt. Forecasts show that expected material use is likely to increase to between 170 and 184 Gt in 2050 (BAU).

Created by: CIRCLE ECONOMY

change across a range of environmental, and socio-economic indicators, in all countries.

Circular thinking is also critical to aspirations around climate change mitigation, in turn underpinning many of the SDGs. Our existing energy system supports the linear economy, but also forms a clear linear component of the global metabolism (explained further in Chapter 3). Fossil fuels are extracted and combusted with the release of greenhouse gasses into our atmosphere. Since, 67% of global greenhouse gas emissions are related to material management[6], climate change mitigation requires implementation of circular strategies and solutions to address the linear use of both materials and energy.

The International Resource Panel has estimated that a resource-efficiency development trajectory could reduce our natural resource use (excluding water) by 28%, whilst also cutting greenhouse gas emissions a staggering 72%, yet still support economic growth.[7] This shows that embedding circular strategies into the heart of the economy – for instance, by way of prioritising regenerative resources, circular design and use of waste as a resource – can reduce our material and carbon footprint beyond even the climate policies proposed under the Paris Agreement[8]. It does so, especially because it introduces systemic solutions that take inclusive societal needs as a starting point and considers how to best meet them through a combination of political leadership, technological innovation and behavioural change, rather than considering just incremental improvements and isolated efficiencies.

An action agenda empowering people for good

To measure economic sustainability only from an environmental perspective, however, is to miss the point and misunderstand the purpose. By definition, managing an economy is the art and science of 'how we run our global household'. An economy should be designed and run to the needs of the participants of the household, provide stability, keep societies together and the household going for future generations. In short, any successful economic model must meet the needs of the society it serves, not merely manage responsibly the natural resources it uses – it is a matter of people and planet, together.

The circular economy is therefore an action agenda with measurable impact framework that extends beyond the remit of mere resource efficiency. As a multi-stakeholder model, its systemic approach boosts capacity and capability to serve societal needs, by embracing and endorsing the best humankind has to offer: the power of entrepreneurship, innovation and collaboration.

The radical inclusivity and holistic interconnectedness of a circular economic framework aligns with a vision of a more resource-aligned people-centric future. It is both aspirational and equitable, entrepreneurial and responsible. One thing it is not, however, is easy. Transitioning to a circular economy calls for intellectual rigour and creative innovation in systems design, combined with resolute determination in collaborative implementation across and within value chains. It also challenges us all to show commitment and asks influencers to exhibit leadership. Change is a tough, but necessary choice, if we hope to bridge the circularity gap and progress to a more sustainable, resilient and happy society.

Report objectives

In response, the Circularity Gap Report aims to deliver the following contributions:

1. **Launch of a global circularity metric** that measures the state of the world economy;
2. **Provision of high-level insights** into the global metabolism;
3. **Identification of key levers** for transitioning to circularity at a global level by mid-21st century, as well as 'inconvenient truths' with potential to form systemic blockages;
4. **Formation of a global, cross-sector group** of stakeholders from academia, businesses, NGOs and governments that will input and convene an authoritative annual report on the circular state of the global economy and measure progress towards its implementation.

THE INSPIRATION: THE UNEP EMISSIONS GAP REPORTS

Within the Paris Agreement[8], countries reached an accord on the ambition to keep global warming below 2˚C until 2100. The periodic **UNEP gap report**[9] translates this collective ambition into a global emissions trajectory and compares this with both current emission levels and the future impact of the emissions-reduction ambitions by the governments which support the Agreement. The 2017 edition concluded that all commitments together do not yet add up to a decrease in greenhouse gas emissions that will secure a future without climate change exceeding 2˚C by 2100. The difference between the target ambition and the trajectory forecast has become known as the 'emissions gap'.

2 THE CIRCULAR ECONOMY: GROWING PROSPERITY WITHIN PLANETARY BOUNDARIES

At the heart of the circular economy is the idea of moving away from linear value chains that we have had in place for more than 200 years. It means breaking with the 'take-make-waste' tradition and transitioning towards a circular approach that is much less heavily reliant on raw material extraction and much more focused on minimising and eliminating waste. The broader benefit of this circular model is to separate things we do want from our economic system - such as equally distributed prosperity and a bright future for the next generations - from those we do not want – like wasteful use of scarce natural resources and adverse effects on our environment and society. A circular economy is thereby a decoupling strategy aimed at growing prosperity, whilst intelligently managing resources within the boundaries of our planet.

Building on schools of thought

As a concept, the circular economy[14] has a long, strong and complex history, involving a rich mix of seminal contributors. Driven by a passionate cohort of champions active across all sectors of society - from government and academia, to industry and community – the idea has gradually been gaining traction in mainstream circles since the late 1970s.[15] Examples of influencers and schools of thought on which the concept builds include Cradle to Cradle,[16] the Blue Economy,[17] the Performance Economy,[18] Industrial Ecology[19] or Industrial Symbiosis[20] and Biomimicry.[21] Over the last decade (and recent years in particular), the circular economy has attracted growing attention as a concept that seeks dynamic opportunities, provides for a positive and aspirational future, plus considers interaction and complexities in the global economy holistically.

The circular economy paradigm

Definitions of a circular economy typically refer to either a desired end-state, or transitional (implementation) strategies that help move towards such a goal. Terminology used to describe these desired end-states includes 'waste free', 'regenerative' or 'closed loop'.[23,24,25] Implementation strategies often involve novel business models that could facilitate faster adoption of circular practices, for instance by shifting incentive structures across supply chains. A much-used example for traditional manufacturers of capital goods is the shift from selling products to the delivery of services, whereby the producer remains incentivised to cater and budget for repairability and end-of-use value. Another important set of transition strategies include (supranational) government policies that alter incentive structures, for instance by pricing-in externalities, such as carbon, or opening the door to labour-intensive circular business models, by lowering employment taxes.[25]

More than a closed-loop economy

When it comes to descriptions and definitions, the distinction between a circular economy and a closed-loop economy is often less well made and understood. In principle, closing the loop on material cycles means nothing is wasted. In practice, however, even assuming an energy system running exclusively on renewable resources, a fully closed-loop economy would be challenging to achieve under current conditions and circumstances. There is always loss of material quantity or quality in the process of recycling (see textbox).

In addition, whilst moving away from the linear take-make-waste model clearly informs crucial aspects of circular thinking, it is not enough in itself to address more fundamental and less sustainable dynamics ingrained in our current economic system. These might include, socio-economic structures that result in an unequal distribution of prosperity and opportunity amongst people and communities, affecting needs such as access to sanitation and healthcare.[26] Achieving a paradigm shift towards a truly circular economy calls for engagement with a broader set of stakeholder needs and environmental concerns.

Systemic solutions: doing fundamentally better, not fractionally less bad

Another important consideration in a circular economy is how resources - cycled or extracted - are put to use to provide maximum value in satisfying the functional needs of our society. It is particularly important to consider redesign strategies to go beyond merely increasing efficiency and effectiveness of production processes. For example, policy efforts for car transportation have focussed a lot on driving down emissions per kilometre. These policies led to lightweighting of vehicles, plus cleaner and more efficient engines. These incremental improvements, however, failed to tackle key challenges, such as the fact most cars stand still 95% of the time. Moving to different modes of transportation (modal shift), car-sharing and electric transport represent more

fundamental redesign options that have recently become real disruptors - albeit only in progressive and dense urban settings.[27]

Ethical trade-offs and incentive structures

Ethical considerations and trade-offs raise further important questions regarding the transition to circularity and potential for unintended and even unsustainable consequences. For instance, do we use scarce water resources for production of food for the local community, or cotton for the global textile marketplace? In this context, it is interesting to observe that resources are not only used to satisfy the (basic) needs of society but increasingly the wants.[28] For example, although a healthy diet requires 2500 kcal per day, in some countries and sectors of society the average intake is substantially higher, whilst in other parts of the globe and community malnutrition remains common. Going beyond just closed-loop thinking, or mitigation of linear risks, the circular economy is ultimately about achieving a fundamental, structural and cultural shift.

7 ELEMENTS OF THE CIRCULAR ECONOMY

In an effort to identify a common language for the circular economy, Circle Economy has mapped the various terms and definitions used by over 20 organisations – such as NGOs, government agencies, academia and consultancies - working on elements of the topic. After interpreting and grouping these various articulations, 7 key elements[29] emerged that capture the majority of ideas expressed. These 7 elements determine what we need to do for a circular economy as follows:

Figure 3. Seven key elements of the circular economy.

- **Prioritise Regenerative Resources:** Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way.
- **Preserve and Extend What's Already Made:** Maintain, repair and upgrade resources in use to maximise their lifetime and give them a second life through take-back strategies, where applicable.
- **Use Waste as a Resource:** Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.
- **Rethink the Business Model:** Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services.
- **Design For the Future:** Adopt a systemic perspective during the design process, to employ the right materials for appropriate lifetime and extended future use.
- **Incorporate Digital Technology:** Track and optimise resource use and strengthen connections between supply-chain actors through digital, online platforms and technologies.
- **Collaborate to Create Joint Value:** Work together throughout the supply chain, internally within organisations and with the public sector to increase transparency and create shared value.

3 THE GOAL OF MEETING SOCIETAL NEEDS AND THE RESOURCE REALITY BEHIND IT

This section presents the global material footprint behind meeting key societal needs, such as housing, mobility and nutrition. It shows which needs, consume what resources. The overview also explains how materials are refined and processed in our global economy to become the products which respond to our needs. What happens at end-of-use sheds light on the relatively modest flow of resources cycled back into the economy and helps us estimate how much material goes wasted beyond recovery. This chapter provides a clear starting point to identify where different sectors, supply chains and regions should focus their strategies going forward.

Global metabolism per resource type

The 92.8 billion tonnes of resources (excluding water) entering the global economy annually equates to almost 34.4 kilograms of raw materials per person per day. Of this global resource bill, 37.8 billion tonnes comprises minerals such as sand, gravel and limestone used in construction; 28.7 billion tonnes is biomass for nutrition, construction materials and fuel wood; 16.6 billion tonnes is fossil fuels combusted for energy and transport and a key input for the chemical industry; with 9.5 billion tonnes being metal ores used for the production of various metals and for energy.[30] These extracted materials go through a variety of steps - take and extract from the environment, process and refine for production, produce to create products, and provide in the form of services - before they meet the various needs of society, such as housing, nutrition and mobility (see textbox).

APPLYING CIRCULAR ECONOMY PRINCIPLES IN DIFFERENT NATIONAL CONTEXTS

The circular economy concept is gaining traction both in developed and developing countries, with national strategies and legislation being formulated and implemented worldwide, from the EU , India and China, to Lao PDR , Albania and the Caribbean . There are distinct differences between the developed and developing world in terms of resource use and footprint per capita. As many households in emerging economies enter the middle- or high-income earnings bracket globally, consumption patterns must adapt to enable a circular economy to keep reducing humanity's planetary impact. For such countries, the circular economy represents an opportunity to leapfrog, applying circular principles and practices in the design of their infrastructure and buildings, rather than to follow the slow incremental path taken by industrialised countries. Developed economies, on the other hand, have accumulated stocks in recent decades and now face the challenge of fixing an inherently broken, linear, system. Examples of this lock-in situation include a tax system with a focus on turning natural resources into capital, poorly insulated buildings with no possibilities for significant reuse of building materials, a waste processing system focussed on landfill and incineration, or a dominance of privately-owned vehicles for urban transportation, hindering for example the transition to mobility-as-a-service at scale.

In all countries, development of local industries, job creation and reduction of dependence on imported resources constitute important drivers behind the circular economy. Much like renewable energy, provided by decentralised and sometimes community-owned generation, the circular economy promotes use of locally-available resources. There is, though, a risk of a decline in resource efficiency if economic development implies that wages increase faster than resource prices. In response, governments and private initiatives can sustain and protect existing circular practices. This could include, professionalising artisan recycling and repair practices, starting with improving labour conditions. It may also include a reform of the tax system to support job creation, reduce the costs of labour-intensive activities like product repair and reverse logistics, and which may tempt people to step out of the informal economy.

KEY SOCIETAL NEEDS AND THEIR RESOURCE FOOTPRINT

Here we describe the 6 key societal needs and consumables that represent the largest material footprint globally.*[31]

Housing and infrastructure
The need that represents the largest resource footprint, with 42.4 billion tonnes, is for construction and maintenance of houses, offices, roads and other infrastructure, especially in the developing world.

Nutrition
The second biggest category in terms of resource use is the need for nutrition. Agricultural products such as crops and livestock require 21.8 billion tonnes yearly. Food products have short lifecycles in our economy, being consumed quickly after production.

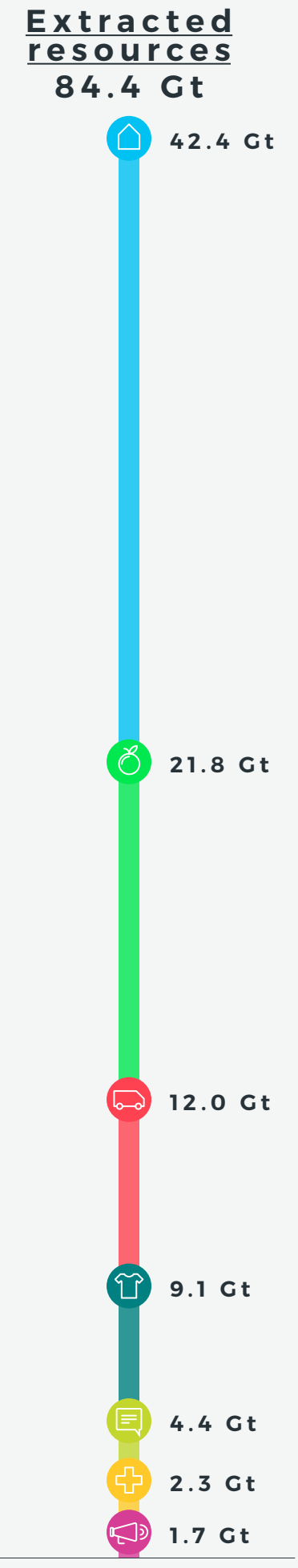
Mobility
A considerable resource footprint is taken up by our need for mobility. In particular, two resource types are used: the materials to build transport technologies and vehicles like cars, trains and airplanes; plus, predominantly, the fossil fuels burned to power them.

Consumables
Consumables are a diverse and complex group of products - such as mobile phones, refrigerators, clothing, cleaning agents, personal care products and paints - that generally have short to medium lifetimes in society. Textiles including clothing also consume many different kinds of resources such as cotton, synthetic materials like polyester, dye pigments, and chemicals.

Services
The delivery of services to society ranges from education and public services, to commercial services like banking and insuring. The material footprint is modest in total and typically involves the use of professional equipment, office furniture, computers and other infrastructure.

Healthcare
With an expanding, aging and, on average, more prosperous population, healthcare services are increasing globally. Buildings aside, typical resource groups include use of capital equipment such as X-ray machines, pharmaceuticals, hospital outfittings (beds), disposables and home care equipment.

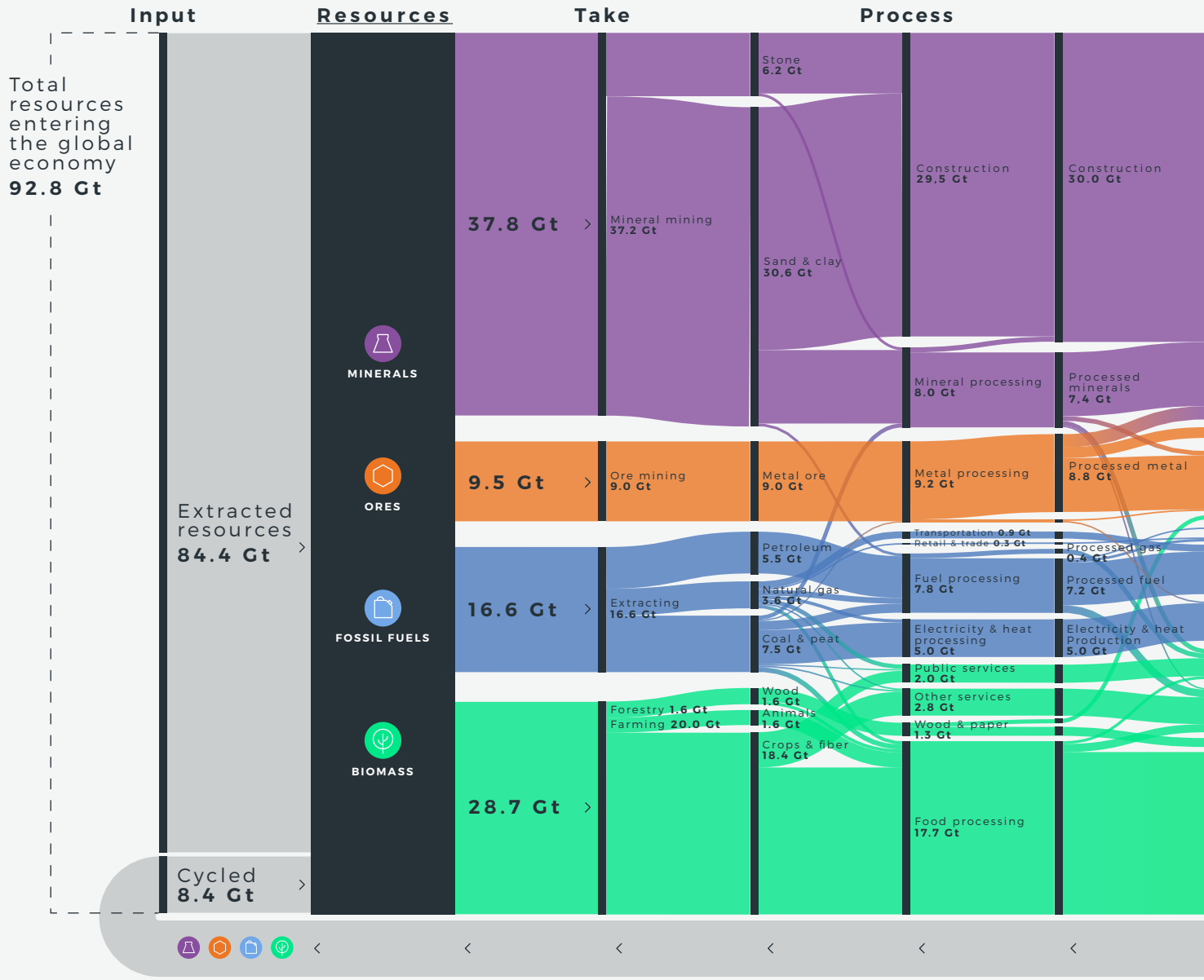
Communication
Communication and connectivity is becoming an ever-more important aspect of today's society, provided by a mix of equipment and technology ranging from personal mobile devices, to data centres. Increased connectivity is also an enabler of the circular economy, where digitisation can make physical products obsolete, or enable far better use of existing assets, including consumables, building stock or infrastructure.



* It is good to consider that the environmental impact of these needs requires more aspects than the material footprint alone.

THE GLOBAL RESOURCE FOOTPRINT BEHIND SATISFYING KEY SOCIETAL NEEDS

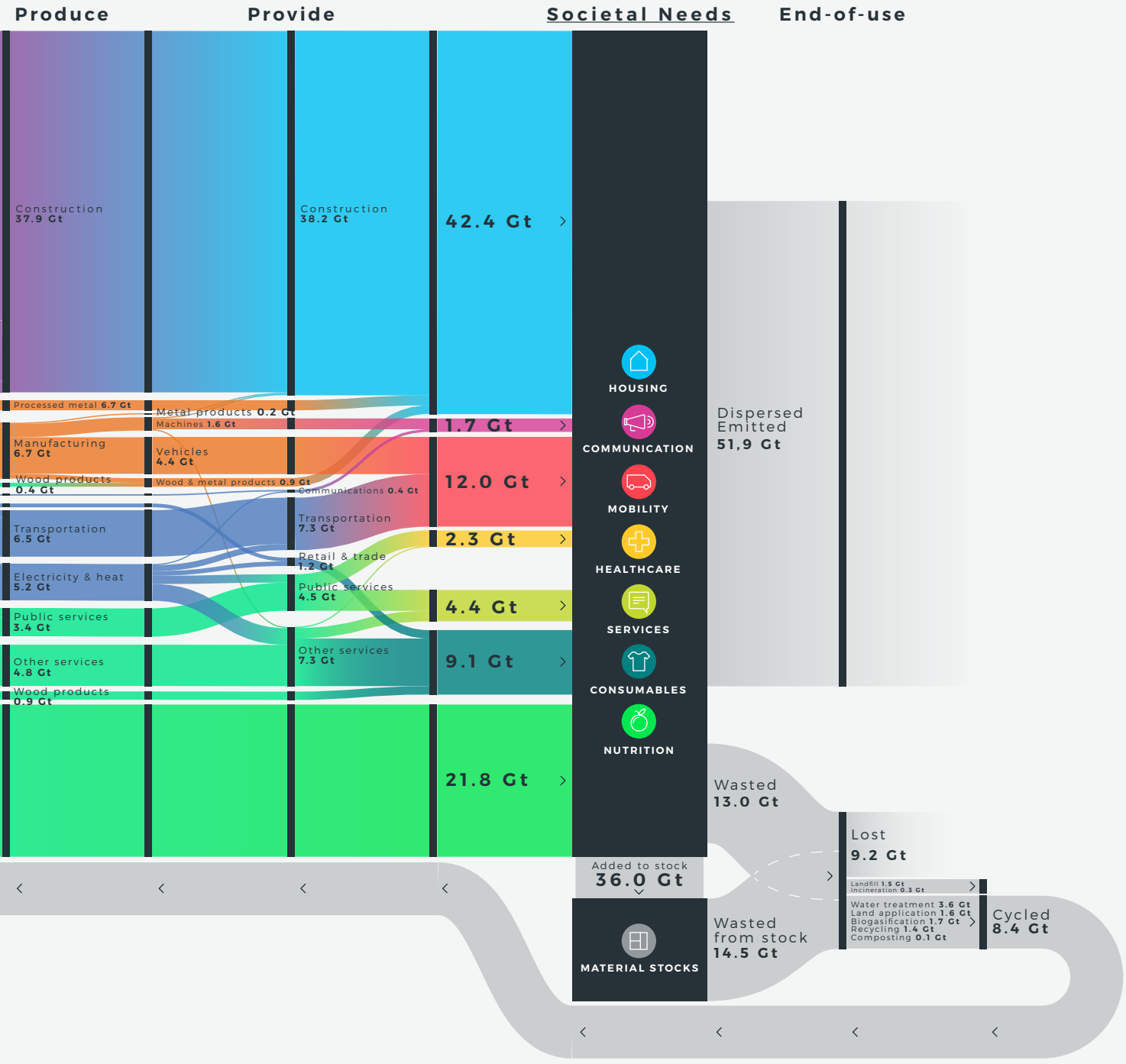
The figure shows the global material footprint linking how four **Resources** groups (minerals, metal ores, fossil fuels and biomass) satisfy 7 key societal needs. From left to right, the figure shows the extraction of resources (**Take**), for example through the mining of minerals or metal ores, the drilling for petroleum, the production of crops by agricultural activities or forestry to produce timber for construction. These extraction processes result in raw materials like wood, petroleum or sand. The raw materials typically undergo processing (**Process**), for example in the production of metals from ores, cement from limestone, or refined sugar from beets. Subsequently, these refined materials can be used for the



Created by:
CIRCLE ECONOMY

Figure 4. The global resource footprint behind satisfying key societal needs.

manufacturing (**Produce**) and assembly of products like automobiles from metals, plastics and glass, or the construction of roads and houses, or production of fashion garments. These finished products can, in turn, be used to (**Provide**) services and access to products that can satisfy **Societal needs**. Essential to identifying and addressing opportunities for a more circular economy is what happens to products and materials after their functional use in our economy (**End-of-use**). How are materials processed (if at all) after they are discarded, rather than ending up as waste, emitted or dispersed into the environment?



Apart from looking at how resource groups satisfy societal needs, the metabolism also presents insights into what happens to resources after use **End-of-use**. Of the total material inputs of 92.8 billion tonnes, 36.0 billion tonnes were put into long-term stock in the form of capital equipment, buildings, and suchlike. From that same stock, 14.5 billion tonnes of materials were removed, leaving a net addition of 21.5 billion tonnes per year.[32]

Of the short-lived products that were consumed by the global economy, the majority, 51.9 billion tonnes, remains unaccounted for and is assumed dispersed into the environment as emissions and unrecoverable wastes. In total, 19.4 billion tonnes of materials are collected as waste. The majority of this waste, 13 billion tonnes, comes from short-lived products,[33] combined with the 14.5 billion tonnes is waste coming out of long-term stock,[34] for example as demolition material, or metal from old cars. Of the 19.4 billion tonnes of materials classified as waste, only 8.4 billion tonnes or 9.1% of total material use of society is cycled, with the remainder incinerated, landfilled, or dispersed into the environment.

Figure 5. The global resource footprint behind satisfying key societal needs, end-of-use.

Mandy barker, SOUP: Refused. www.mandy-barker.com

4 METRICS: GLOBAL CIRCULARITY & THE CIRCULARITY GAP

This section builds on insights presented on the global metabolism and suggests a metric for circularity. A key challenge in implementing circular economy into government policy and business strategy is the lack of a consistent framework for measurement. Therefore, the real value of a circularity metric for the global economy lies in being able to track changes over time and measure progress, put main trends into context, engage in uniform goal-setting and guide future action in the most impactful way.

Conceptualising global materials flows and stocks

As pointed out in the first chapter, a truly circular economy is more than a closed-loop economy. Taking the (global) material metabolism as the starting point, we explore and suggest a metric for circularity. This report introduces a strongly simplified conceptual representation of the global metabolism - materials flowing through and in (long-term) use by the economy.

The figure shows the **extracted resources** that in 2015 amounted to 84.4 billion tonnes.[35] As discussed above, four resource groups are considered; minerals, fossil fuels, metal ores and biomass. To oversee all annual **material inputs** to our economy, the extracted resources are complemented by **cycled resources.** In 2015, 8.4 billion tonnes of **cycled resources** were reused by the global economy which brought the total **material inputs** to 92.8 billion tonnes. Of these materials entering the global economy yearly, the majority (56.8 billion tonnes) are being used by society as **short-lived products** reaching their end-of-use typically within a year. The remaining 36.0 billion tonnes mentioned earlier, enters into **long-term stock.**[36] After meeting the needs in society, **resource outputs** originate in the form of municipal waste, emissions, dispersion. A large part of the waste comes from long-term stock, for example, demolition waste from infrastructure and housing or scrap from capital equipment.

Objectives and strategies: defining the Global Circularity Metric

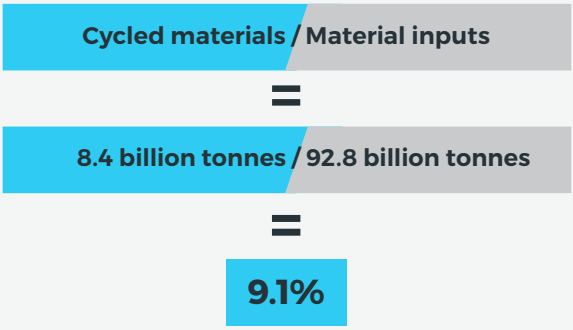
Based on this analysis and conceptual representation, four fundamental dynamics of a circular economy can be identified - the first two describe the objectives, whereas the latter two are the means to improvement:

OBJECTIVES AND STRATEGIES

- **Objective 1: Resource extraction from the lithosphere is minimised** and biomass production and extraction is regenerative;
- **Objective 2: The dispersion and loss of materials is minimised** meaning all technical materials have high recovery opportunities, ideally without degradation and quality loss; and with emissions to air and dispersion to water or land prevented;
- **Strategy 1: Utilisation of stocks is optimised** which means current stocks-in-use such as buildings and machinery are employed to their full potential, with most material in active use, limiting the stocks temporarily not in use (hibernating), or mobilising materials to reenter the economy (urban mining); plus
- **Strategy 2: Material cycling for reuse is optimised** requiring improved collection infrastructure and wide-scale adoption of best-available technologies for (re)processing of resources.

GLOBAL CIRCULARITY METRIC [%]

When we consider the four fundamentals above it becomes apparent that the last one, the cycling of materials is a key factor. For a metric that captures this essential dynamic we therefore suggest the circularity metric to be the share of cycled materials as part of the total material inputs into the global economy every year. Applying this definition to the numbers in the diagram results in a **GLOBAL CIRCULARITY METRIC of 9.1%** for 2015.



CONCEPTUAL REPRESENTATION OF GLOBAL RESOURCE FLOWS AND STOCKS

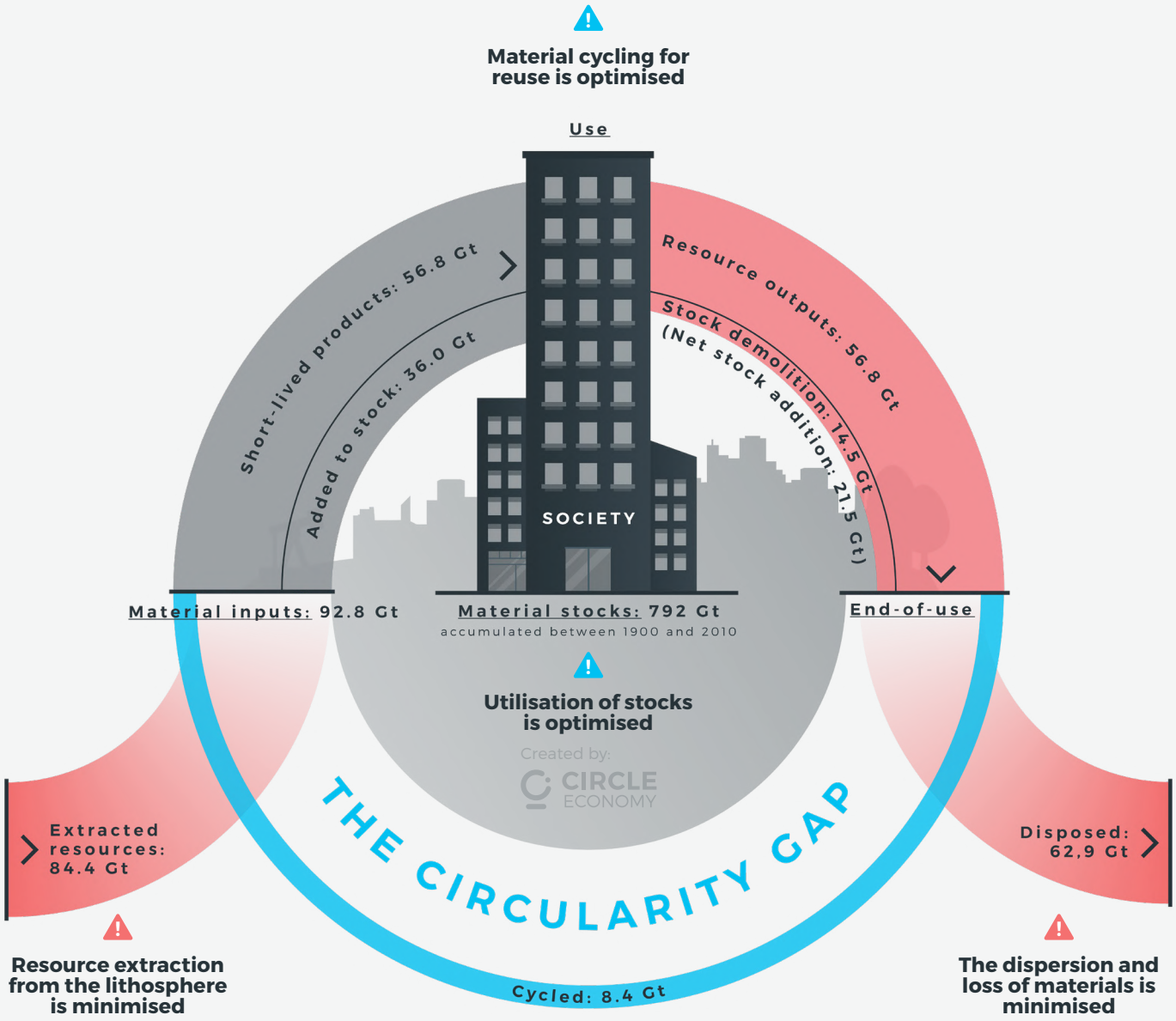


Figure 6 presents a strongly simplified conceptual representation of the global metabolism: material flows and stocks. Flow numbers are for 2015 , the material stocks figure of 792 billion tonnes (Gt) describes accumulated material stocks between 1900 and 2011 (PNAS, 2015).

PRACTICAL CHALLENGES CALCULATING AND INTERPRETING THE CIRCULARITY METRIC

The value of 9.1% for the circularity metric suggests a significant circularity gap of more than 90%. While it is undeniably true that our current economy is dominantly linear, it is good to provide context for how the circularity metric can be interpreted and used in guiding action.

The Global Circularity Metric (GCM) is a strongly simplified measurement for a very complex system. Calculating and interpreting the GCM has one core strength (1) and at least four practical challenges (2-5):

1. **Setting a benchmark.** The real value of the global circularity metric is its ability to set a zero measurement for the globe and track progress over time. The ambition should be to report on its value and underlying fundamentals periodically, for example every year, as happens with the UN Emissions Gap Report.
2. **Ignorance of core traits.** A circular economy is not the same as a system that optimises the recycling of materials. On the contrary, it is about retaining value and complexity as highly as possible, for as long as possible - ideally without any degradation or fall-out. The Global Circularity Metric does not explicitly consider strategies that are core to building a circular economy such as asset sharing, lifetime extension or remanufacturing. These strategies extend the functional life time of products whereby waste creation is prevented thus lowering waste volumes and, at the same time, reduce the requirement for new inputs to produce new products for replacement.
3. **Data quality.** For the quantification of global material flows and stocks, data quality varies. Data on material extraction and use are relatively robust. What happens to materials after they are discarded is generally less certain, because waste is heterogeneous in nature, geographically spread-out and its categorisations differ between statistical sources.
4. **Quality loss and degradation.** The proposed metric focuses on the end-of-use cycling of materials that re-enter the economic system. The metric measures how much (in mass) materials are cycled, but does not consider in what composition, or to what quality level. As such, any quality loss and degradation in processing is not considered.

IS A FULLY CIRCULAR ECONOMY POSSIBLE?

Under current global economic trends, and available technology, a fully circular economy is possible only in the long run. There are four primary reasons for this.

1. We are still building up our stock of rare materials, mostly rare earth metals, required for the more innovative and sophisticated products we use;
2. Emerging and developing economies are still accumulating their stock of built-environment assets and infrastructure, and should be enabled to continue doing so;
3. Our technical capabilities are insufficient to fully close the loop and in many recycling processes there are still losses in material quality and quantity;
4. Finally, some materials, including certain minerals like the Feldspar group, may be available in such abundance, especially in particular geographies, that we can continue exchanging them with the lithosphere without major implications for the immediate ecosystems which they support.

5 BRIDGING THE CIRCULARITY GAP

So far, we have presented insights into the global metabolism and the resource footprint behind meeting the most important societal needs. To get the global economy on a pathway towards circularity, though, major trend corrections are needed. This section identifies key levers on a global level and points to 'inconvenient truths' that provide systemic challenges for moving to circularity by mid 21st-century. The broader ambition is that these directions facilitate and trigger concerted action and the formation of global and local coalitions to advance ideas across sectors, supply chains, cities and regions.

Bridging the circularity gap per societal need, applying circular strategies

Bridging the circularity gap, essentially by significantly reducing resource extraction, requires very different interventions for different societal needs. To address this call for diversity of action, we can use the 7 elements for circularity as a framework to align relevant strategies with their respective needs. This generic set of circular strategies is made explicit per need and illustrated with examples of current practices either in use, under development, or required to move to a circular state. Figure 7 shows the relevance of these 7 strategies to bridge the gap per societal need.

ESSENTIAL TO BRIDGE THE CIRCULARITY GAP IS TO LIMIT EXTRACTION AND BOOST THE CYCLING OF RESOURCES AGAINST A FORECASTED TREND OF STEEP INCREASED EXTRACTION

The figure shows how extraction of resources increased from 7 billion tonnes in 1900 to 84.4 billion tonnes in 2015. A steep further increase is forecasted for 2050, reaching approximately 177 billion tonnes yearly. The needed direction ahead is clear: limit extraction and boost the cycling of resources. To translate this direction into one clear aggregated target for limiting extraction is difficult, if not even undesired. The extracted resource groups fossil fuels, ores and minerals are all very different in how they contribute to positive (satisfying needs) and negative (affecting planetary boundaries) impacts. The figure aims to contribute to explore how target-setting is done taking into account the many complexities.

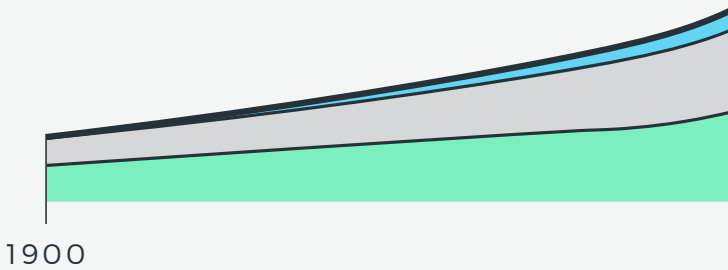
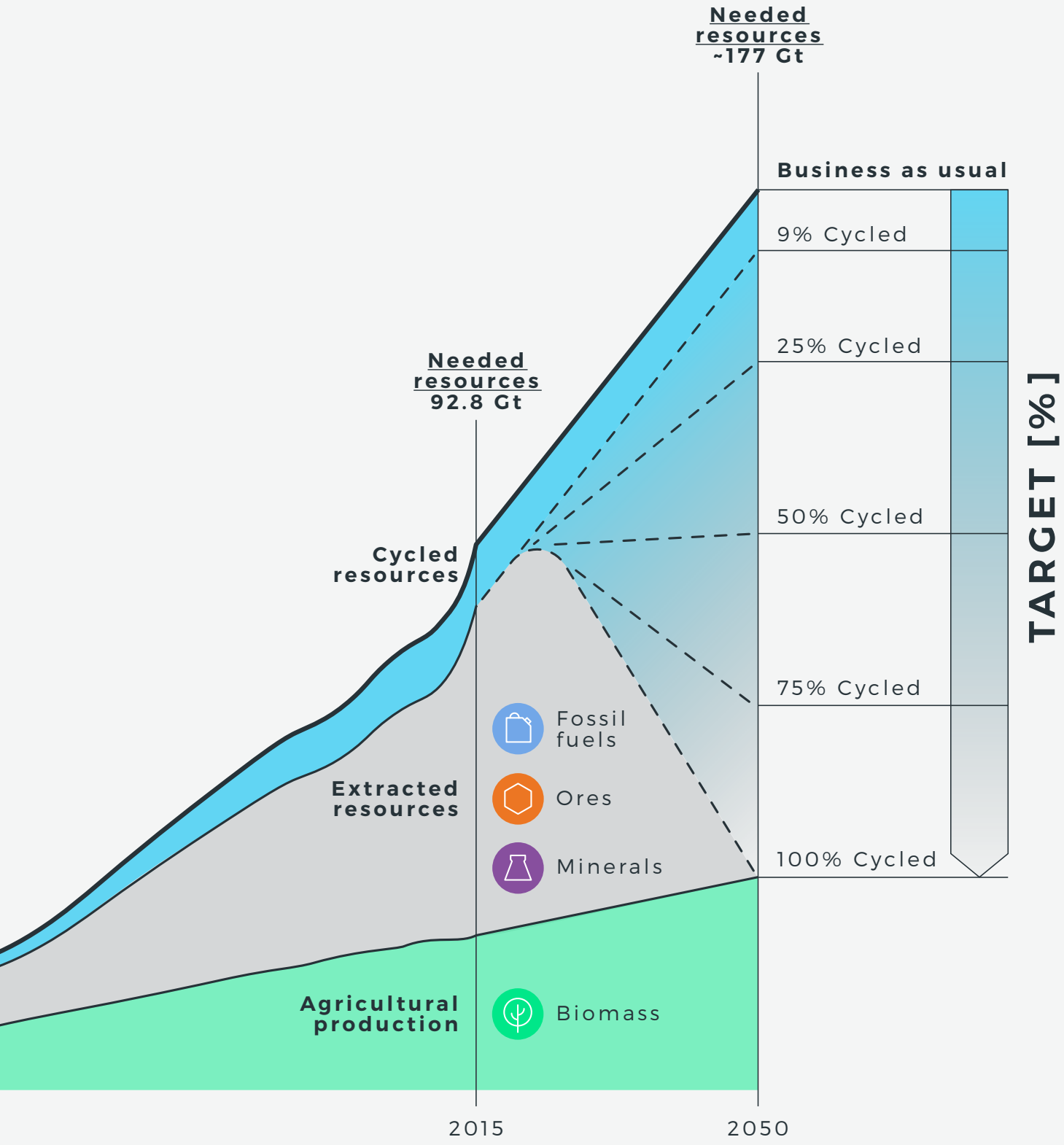


Figure 7. A forecasted trend of steep increased extraction.


Needed resources ~177 Gt
Business as usual
9% Cycled
25% Cycled
50% Cycled
75% Cycled
100% Cycled
TARGET [%]
Needed resources 92.8 Gt
Cycled resources
Extracted resources
Fossil fuels
Ores
Minerals
Agricultural production
Biomass
2015
2050

Housing and infrastructure

In order to build our homes, offices, roads, and other infrastructure used on a daily basis, we consume 42.4 billion tonnes of resources annually, including processed metals and minerals such as sand, gravel, and limestone.[38] This equates to 40% of our total annual resource use. The majority of these resources are fixed in buildings and roads for decades to come (added to long-term stock). This therefore means that even if we started reusing all construction materials coming out of demolished buildings today, we would still require vast additional amounts to satisfy current growth plans, for example in the construction of megacities for Asia's middle class.

Given these projections, **design for the future** makes sure we are not locking-in the toxins of tomorrow, today. So, for instance, (offsite) construction methods that allow for disassembly by building modularly are particularly attractive. Use of low-carbon materials to substitute for cement can also be effective. Leveraging the possibilities of **digital technology** has merit, too, for example by creating building material passports following the recent Madaster example. Better insights into material composition and processing options end-of-use could also help optimise **waste as a resource.** Examples include innovations like the Smart Crusher, a technology for recovering sand, gravel and cement from concrete.[39] Particularly relevant for the construction sector is the need for more **collaboration** across the supply chain to create shared value and resolve split incentives.

Nutrition

Of all the resources extracted, about half of them cannot be recovered, including the fossil fuels that we burn and the food products that we eat. The majority of the 28.7 billion tonnes of biomass is consumed as food.[36] At first sight, food products - and the bio-cycle in general - appear hard targets for application of circularity thinking. Three circular strategies in particular, though, are highly relevant to developing the agricultural production system sustainably, while feeding an increasing population demanding more protein-rich diets.

The resource footprint for agriculture relies on good quality lands and nutrients which include fossil phosphorus. A key challenge is to optimise a cascading approach using **waste as a resource.** Interesting strategies can involve, for example, 'nutrient recovery technologies' like anaerobic digestion, breaking down manure, organic waste and wastewater to produce nutrient-rich products that can be used to replace synthetic fertilisers, which have increased significantly in cost over the past decade and contribute heavily to CO_2 and N_2O emissions. In addition, **design for the future** can advance modernisation of agriculture by moving to precision farming, for example, including measures for irrigation, fertilisation and real-time crop-tracking to optimise harvest cycles. Closing agricultural product and nutrient cycles locally also helps maintain local soil quality and prevent land-use change elsewhere.

Mobility

The material footprint to satisfy our mobility needs roughly comprises the fuels we burn in our engines and the materials required for the production and maintenance of automobiles, trains, trucks and airplanes. The former, the dominant use of fossil fuels for our mobility is a linear practice that will need to be replaced entirely by the **prioritisation of regenerative resources** like electric transport run on renewable resources. For airplanes, fuels needed in the short- to middle-term scenario can at least in part be supplied by bio-kerosene produced from organic residues. Strategies aimed at existing motor vehicles call for us to **rethink the business model**, for example by moving to car-sharing in urban settings to boost utilisation rates and minimise road-space demand. Also, strategies to **preserve what's already made** by refurbishment and maintenance can reduce overall material use.

Consumables

A broad mix of consumables is involved in servicing our many daily needs, ranging from clothing and personal care products, to paints for our walls and home appliances such as a toaster. This diverse and complex group of products generally has short to medium lifespans and opportunities for reuse vary considerably. Some products, such as paints and cleaning agents, are virtually unrecoverable. With many others that have not been used to their full potential, the collection infrastructure and the recycling processes necessary to make reuse possible are lacking.

Given this diverse nature, the strategies to move to circularity on consumables and close the gap differ. In the case of textiles - a large proportion of the consumables group - currently more than half of all post-consumer waste is landfilled or incinerated. Using **waste as a resource** by closing the loop for textiles is clearly a lever, but requires more sophisticated collection, return logistics and sorting infrastructure. Again, leveraging the opportunities of **digital technologies** like online exchange platforms to give products a second or third life are a way to **extend what's already made.** In the case of many products with low recoverability potential, proper **design for future** should be considered, for example by substituting biodegradable alternatives for non-degradable fossil-based plastics, in such as cleaning agents or food packaging.

CIRCULAR ECONOMY STRATEGIES AND THEIR POTENTIAL CONTRIBUTION TO MOVE TO CIRCULARITY PER SOCIETAL NEED

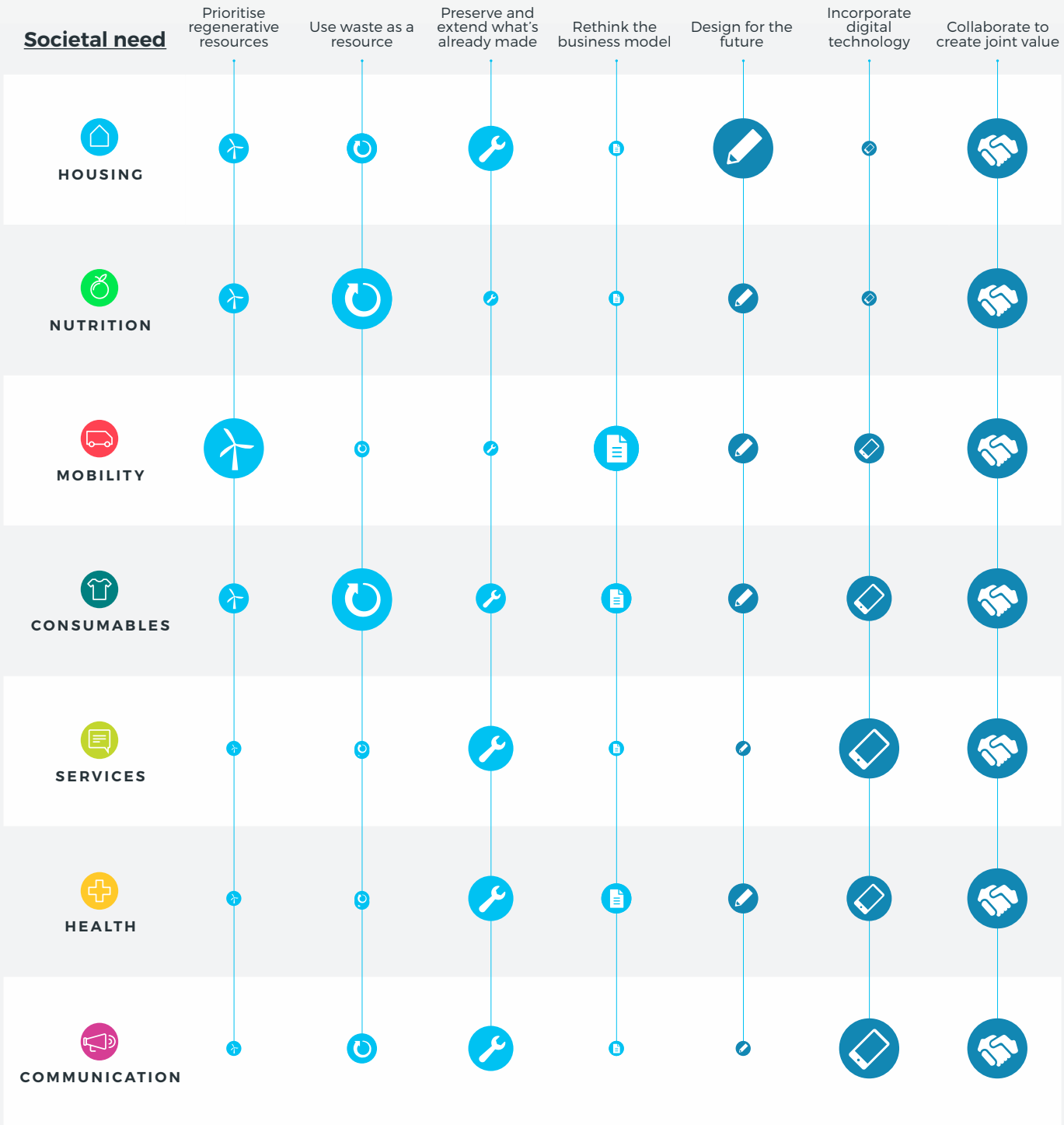


Figure 8. Circular economy strategies and their potential.

Legend: Most relevant · Highly relevant · Relevant · Less relevant

Services

As described above in the discussion of societal needs in Chapter 3, the overall resource footprint of services is relatively modest. The most fundamental ongoing shift affecting the sector concerns the deployment of **digital technologies**, used to offer services such as banking without the need for a network of local branches. In addition, new services are arising that replace ones previously requiring vast resources, thereby leading to dematerialisation - as with online music streaming. Propositions that **rethink the business model** are also being developed and offered, as seen in the move from product sales to service delivery for printing, personal computers, carpet tiles and coffee machines. These business-model changes put the financial incentive for production and maintenance on the producers, leading to refurbishment programmes aimed at **preserving and extending what is already made.**

Health

The delivery of healthcare services is a basic need for any modern society and has a significant resource footprint. Strategies focus on the setting-up of return programmes to facilitate the upgrade and refurbishment of medical equipment to **preserve and extend what's already made.** This approach is increasingly helped by development of propositions that **rethink the business model,** moving to leasing arrangements for capital-intensive equipment. Another key product group comprises the disposables used in clinics, ranging from gloves to multi-layer sterile packaging. Here, strategies focus on getting larger proportions of these materials back into the loop to use waste as a resource again. Complementary opportunities also exist to alter the design, for example by producing biodegradable alternatives.

Communication

A rapidly expanding communication network with an increasing number of connected personal devices, plus infrastructure ranging from wireless cloud capabilities and data centres, to (subsea) transmission cables can be a vital enabler of change. Not surprisingly, implementation of **digital technology** is playing a key role, able to virtualise services that can for instance replace home-based modem stations. It is good to bear in mind that although virtualisation can replace materiality these virtual services also require capital equipment and energy. For these assets, refurbishment programmes to **preserve and extend what's already made** can boost the longevity of such key elements as transmission equipment or server stations. The same goes for personal devices that can benefit from solid **design for the future** moving to easy do-it-yourself repairability. Small devices and larger assets are all heavy consumers of metals including rare earths and precious metals often in small quantities and complex designed devices. Strategies aimed at **using waste as a resource** are essential to prevent fall-out and avoid landfill or incineration upon end-of-use.

A KEY ROLE FOR CITIES IN THE TRANSITION TO A CIRCULAR ECONOMY

All over the world, urban areas are undergoing rapid growth and it is projected that 60% of the world's population will be living in urban deltas by 2030. Cities are tightly connected to economic growth, producing over 75% of the world's GDP, contributing to 75% of carbon emissions, while consuming 75% of global resources. It is clear that cities hold a leadership opportunity to pioneer ways of living that strengthen ecosystems and promote high social and economic welfare. In 2016, following on from the UN SDGs, 170 countries agreed to a New Urban Agenda which sets a global standard for sustainable urban development, and will help us rethink how we plan, manage and live in cities. It provides guidance on achieving both the SDGs and climate goals, with city mayors and leaders increasingly taking centre stage in the drive towards mitigating climate change.

The systemic approach of the circular economy can advance the role of cities even further in addressing key social, environmental, and economic challenges holistically. Circular economy strategies implemented through cities are already having a significant impact, with large untapped potential for more. Car-sharing, modular building, the sustainable management of organic waste streams, and exploring new models of consumption can enable cities to take practical steps to help reduce emissions, create new jobs[41] and strengthen industries and competitiveness, plus enhance the health and wellbeing of its citizens. Making more efficient use of energy, materials and assets puts cities in the driver's seat in reducing greenhouse gas emissions. Development of a forward-thinking circular economy action agenda is therefore essential for cities to lead the way to ensuring prosperity for all within our planetary boundaries.

6 THE CIRCULAR ECONOMY: A KEY LEVER IN MITIGATING CLIMATE IMPACT

Bridging the circularity gap is not a goal in itself, but should deliver higher, societal and ecological objectives, prevent overshoot of the planetary boundaries and provide minimum levels of access to basic societal needs. In this section we elaborate in particular on how bridging the circularity gap can mitigate climate impact.

Prevent planetary boundary overshoot: the case of climate impact

The circular economy is a transition mechanism that serves to keep the globe on a trajectory to reach humanity's core sustainability goals. Two frameworks in particular are relevant to consider as a benchmark to guide actions at a global level: the United Nations Sustainable Development Goals and the Stockholm Resilience Centre nine planetary boundaries.[42] A clear ambition featured in both frameworks is the necessity to keep global warming below 2 ˚C - or a 1.5 ˚C scenario.

The course correction needed

Global greenhouse gas emissions amounted to 51,9 billion tonnes CO_2e in 2015 and in a 'business as usual' pathway would reach approximately 65 billion tonnes CO_2e by 2030.[43] In that scenario, we are facing dangerous climate change, with an increase of the global temperature over 4 ˚C by the year 2100. To limit climate change by the end of the century to the 1.5 ˚C ambition expressed in Paris, annual emissions should stay below 39 billion tonnes CO_2e per year by 2030. Compared to the 'business as usual' scenario there is a gap of 26 billion tonnes CO_2e. Climate policies already in place and committed to under the Paris Agreement fall short in delivering the needed reduction. Circular economy strategies can contribute to further mitigating the emissions gap.

How the circular economy contributes

In total, an estimated 67% of global greenhouse gas emissions are related to material management.[44] This statistic includes all global greenhouse gas emissions, with the following categories excepted: passenger transport by cars, trains and planes; heating and cooling of houses; and any energy used for personal care like washing machines or razors. What is included is the impact of all emissions to extract resources, to refine them, to move them around (logistics) by ocean vessels, planes or trucks and to process them at end-of-use. The majority of these emissions stem from the extraction, processing and production stages.

Circular economy strategies target emission reductions in two ways (see Chapter 3): by cycling more through the minimising of wasting and extracting; and by preserving and extending the lifetime of what we already have.

Whilst further research is needed to assess the relationships and effective interventions in depth, five priorities have been identified:

- **Using waste as a resource** can significantly reduce greenhouse gas emissions. On average, products that are produced from recycled instead of primary resources have an almost 1.4 tonne CO_2e lower carbon footprint per tonne product,[45] meaning that the energy that goes into the reprocessing of these recycled materials far outweighs the use of virgin.
- **Phasing out fossil fuels** for energy and transportation sources, as they are inherently linear and a significant source of human-made greenhouse gas emissions.
- **Cycling of carbon-intensive materials** as a small group of products represents a huge part of global emissions. A prime example is cement production, representing roughly 5% of global emissions, with alternatives under development for cycling, reuse and substitution.
- **Pursuing dematerialisation** and prioritising low-carbon materials, so replacing carbon-intensive products in the first place with sustainable alternatives.
- **Closing nutrient cycles in agriculture,** for example by deploying nutrient recovery technologies that can deliver nutrient-rich components to replace high-impact fossil and synthetic fertilisers.

CIRCULAR ECONOMY'S CLIMATE MITIGATION ESTIMATED FOR DIFFERENT GLOBAL REGIONS

The mitigation opportunity of a circular economy has been estimated for several geographies, including:

1. **India** The Ellen MacArthur Foundation estimated a circular development pathway would reduce greenhouse gas emissions 40%, compared to Business as Usual.[46]
2. **Europe** The Dutch NGO Ex'Tax and Cambridge Economics estimated that shifting 13% of labour tax to resource use and disposal would reduce greenhouse gas emissions 8.2% and boost employment 2.9%.[47]
3. **Five EU member states** The Club of Rome compared development scenarios for five EU member states and found that renewable energy and energy efficiency alone can reduce greenhouse gas emissions 50%. When adding circular economy strategies that number would increase to 70%.[48]

7 CONCLUSIONS AND WAY FORWARD

Our world economy is only 9.1% circular, leaving a massive circularity gap. This alarming statistic is the main outcome of this first Circularity Gap Report to measure how the world is progressing on the pathway towards its ambition of becoming more circular.

The Report also outlines the complexity of the task and reveals the tremendously broad support in evidence amongst a multitude of stakeholders from the business community, the UN and international organisations, non-profits, plus cities and governments.

The Circularity Gap report therefore suggests this support and energy should be channelled into an action agenda and concrete deliverables, responding to the call of the challenges we are all facing today.

4 **STEPS** TO TAKE ACTION IN BRIDGING THE CIRCULARITY GAP THROUGH LEADERSHIP AND ACTION

1. **Build a global coalition for action,** comprised of front-running businesses, governments, NGOs and academics, that will input and convene an authoritative annual report on the circular state of the global economy and measure progress towards its implementation.
2. **Develop a global target and action agenda** by working with all relevant stakeholders to agree clear goal-setting and alignment with the SDGs and emission-reduction targets.
3. **Translate global targets into local pathways** for circular change, taking big-picture directions and interpreting these for nation states, individual sectors, supply chains, regions and cities to embed strategies in their specific context and align with incentives and mandates.
4. **Improve our understanding** of how different levers for circular change affect aspects such as material saving, value retention and climate mitigation. Also consider fully the dynamics of international trade and employment, plus implications for education, training and future skills, both for young people today and the next generations of tomorrow.

JOIN THE CONVERSATION

#CircularityGapReport

www.circularity-gap.world

REFERENCES

1. UNEP (2017). The Emissions Gap Report 2017. United Nations Environment Programme (UNEP), Nairobi, available from: http://www.unep.org/emissionsgap/
2. "An alert for the world" - UN Secretary-General António Guterres, 2018 New Year Video Message, available from: https://www.youtube.com/watch?v=FNfSEI-kFEk
3. "Transforming our world: the 2030 Agenda for Sustainable Development". United Nations – Sustainable Development knowledge platform. 2015, available from: https://sustainabledevelopment.un.org/post2015/transformingourworld
4. Steffen et al., 2015, Planetary boundaries: Guiding human development on a changing planet, Science 15 January 2015 DOI: 10.1126/science.1259855
5. See: https://sustainabledevelopment.un.org/sdgs
6. UNDP, "Circular economy strategies for Lao PDR – A metabolic approach to redefine resource efficient and low-carbon development" 2017.
7. UNEP (2017) Resource Efficiency: Potential and Economic Implications. A report of the International Resource Panel. Ekins, P., Hughes, N., et al
8. See: http://unfccc.int/paris_agreement/items/9485.php
9. UNEP (2017). The Emissions Gap Report 2017. United Nations Environment Programme (UNEP), Nairobi, available from: http://www.unep.org/emissionsgap/
10. IRP (2017). Assessing global resource use: A systems approach to resource efficiency and pollution reduction. Bringezu, S., et al., a Report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya.
11. Hatfield-Dodds, S., et al., Assessing global resource use and greenhouse emissions to 2050, with ambitious resource efficiency and climate mitigation policies, Journal of Cleaner Production (2017), http://dx.doi.org/10.1016/j.jclepro.2016.12.170
12. Allwood, J.M., et al, Industry 1.61803: the transition to an industry with reduced material demand fit for a low carbon future. Available from: http://rsta.royalsocietypublishing.org/content/375/2095/20160361
13. A. Schaffartzik and others, "The global metabolic transition: Regional patterns and trends of global material flows, 1950–2010, Global Environmental Change, Vol. 26, May 2014. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25844026.
14. See: https://www.ellenmacarthurfoundation.org/circular-economy
15. See: https://www.ellenmacarthurfoundation.org/circular-economy/schools-of-thought/performance-economy
16. M. Braungart and W. McDonough, Cradle to Cradle: Remaking the Way We Make Things. New York, North Point Press, 2002.
17. G. Pauli, The Blue Economy/Version 2, USA, Academic Foundation, 2017.
18. W.R. Stahel and G. Reday-Mulvey, Jobs for Tomorrow: The Potential for Substituting Manpower for Energy. New York, Vantage Press 1981.
19. See: http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1530-9290
20. Kalundborg Symbiosis, "Kalundborg Symbiosis is the world's first working industrial symbiosis". Available from: http://www.symbiosis.dk/en.
21. See: https://biomimicry.org/
22. den Hollander, M. C., Bakker, C. A. and Hultink, E. J. (2017), Product Design in a Circular Economy: Development of a Typology of Key Concepts and Terms. Journal of Industrial Ecology, 21: 517–525. doi:10.1111/jiec.12610
23. Cullen, J. M. (2017), Circular Economy: Theoretical Benchmark or Perpetual Motion Machine?. Journal of Industrial Ecology, 21: 483–486. doi:10.1111/jiec.12599
24. See: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0398R(01)&from=EN
25. Ex'Tax, 2016, New Era, New Plan, The Ex'tax Project in cooperation with Deloitte, EY, KPMG Meijburg, PwC, Cambridge Econometrics and Trucost
26. Pikkety, 2014, Capital in the Twenty-First Century, The Belknap Press of Harvard University Press

27. Stuchtey, M. et al, A Good Disruption - Redefining Growth in the Twenty-First Century, 2016, available from: http://gooddisruption.com/

28. Allwood, J.M., et al, Industry 1.61803: the transition to an industry with reduced material demand fit for a low carbon future. Available from: http://rsta.royalsocietypublishing.org/content/375/2095/20160361

29. See: https://www.circle-economy.com/the-7-key-elements-of-the-circular-economy

30. References to use for Exiobase - also mention that we got the latest version of the Hybrid Supply Use Table Database from one of the consortium partners, 2.0 LCA Consultants

31. It is good to consider that the environmental impact of these needs requires more aspects than the material footprint alone. Exiobase v3 using 2011 data

32. Data from 2010: Krausman, et al. (2017), Global socioeconomic material stocks rise 23-fold over the 20th century and require half of annual resource use, PNAS, vol. 114, no. 8, available from: http://www.pnas.org/content/114/8/1880.full

33. Exiobase v3 using 2011 data

34. Krausman, et al. (2017), Global socioeconomic material stocks rise 23-fold over the 20th century and require half of annual resource use, PNAS, vol. 114, no. 8, available from: http://www.pnas.org/content/114/8/1880.full

35. Hatfield-Dodds, S., et al., Assessing global resource use and greenhouse emissions to 2050, with ambitious resource efficiency and climate mitigation policies, Journal of Cleaner Production (2017), http://dx.doi.org/10.1016/j.jclepro.2016.12.170

36. Exiobase v3 using 2011 data

37. Krausman, et al. (2017), Global socioeconomic material stocks rise 23-fold over the 20th century and require half of annual resource use, PNAS, vol. 114, no. 8, available from: http://www.pnas.org/content/114/8/1880.full

38. Exiobase v3 using 2011 data

39. See: https://www.circle-economy.com/the-7-key-elements-of-the-circular-economy

40. Amsterdam Smart City, https://amsterdamsmartcity.com/products/smartcrushercircular-concrete-saving-co2

41. R. Gower and P. Schröder, "Virtuous Cycle: How the circular economy can create jobs and save lives in low and middle-income countries", Tearfund 2016. Available from: http://tilz.tearfund.org/en/resources/policy_and_research/sustainable_economics/the_circular_economy/.

42. See: http://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/the-nine-planetary-boundaries.html

43. UNEP (2017). The Emissions Gap Report 2017. United Nations Environment Programme (UNEP), Nairobi, available from: http://www.unep.org/emissionsgap/

44. Own analysis based on: Bajželj, B., et al., (2013) Designing Climate Change Mitigation Plans That Add Up, Environmental Science and Technology, 47 (14), pp 8062–8069, and related data annexes.

45. Analysis based on D.A. Turner et al. / Resources, Conservation and Recycling 105 (2015) 186–197, table 6. Available from: https://www.sciencedirect.com/science/article/pii/S0921344915301245

46. EMF (2016), Circular economy in India: rethinking growth for long-term prosperity.

47. Ex'tax (2016), New era. New plan. Europe. A fiscal strategy for an inclusive, circular economy, available from: http://www.ex-tax.com/new-era-new-plan/

48. Club of Rome (2016), The Circular Economy and Benefits for Society -Jobs and Climate Clear Winners in an Economy Based on Renewable Energy and Resource Efficiency

Pictures

p1: DigitalGlobe, Getty Images, Escondida copper mine

p8: Shutterstock, Earth view

p13: Shutterstock, Hiker heading towards distant

p21: Mandy barker, SOUP: Refused, www.mandy-barker.com

p25: Shutterstock, Smart indoor farm and Photoperiodism concept

p31: Shutterstock, People crowd streets around Guomao area during rush hour, Beijing

www.circularity-gap.world