The **CIRCULARITY GAP** Report 2019

Closing the Circularity Gap in a 9% World

January 2019

CIRCLE ECONOMY

CIRCLE ECONOMY | WHO WE ARE

We work to accelerate the transition to a circular economy. As an impact organisation, we identify opportunities to turn circular economy principles into practical reality.

With nature as our mentor, we combine practical insights with scalable responses to humanity's greatest challenges.

Our vision is economic, social and environmental prosperity without compromising the future of our planet.

Our mission is to connect and empower a global community in business, cities and governments to create the conditions for systemic transformation.

ENDORSEMENTS

*** this page will feature support quotes ***

EXECUTIVE SUMMARY

Our world is only 9% circular and the trend is negative. The circularity gap is not closing. In 12 months since the first Circularity Gap Report, the upward trend in resource extraction and greenhouse gas emissions has continued. The circularity gap is not closing and key indicators confirm that the problems of a linear economy are 'baked in' to the global economy. Worse, the engine of our linear global economy is stuck in reverse: we are heading in the wrong direction.

A 1.5℃ world is circular. The goal of the Paris Agreement to limit global warming to 1.5°C above pre-industrial levels can only be achieved by a circular economy. The circular agenda and low-carbon agenda are complementary and mutually supportive: the right fit at the right price. Circular business models and improved resource efficiency are economically attractive means to enhance energy efficiency and renewables, methane abatement and to avoid deforestation. The pathway to a low-carbon future is circular.

The opportunity is real. Making better use of stocks that last is an opportunity for global collaboration, social justice and systemic change. The combined volume of materials in current use (economic stocks) is 10 times larger than the annual consumption of disposable materials. Better use of existing stock is key to achieve the goals of the Paris Climate Agreement and the Sustainable Development Goals (SDGs).

Capital equipment consumes half of all metals. Capital equipment includes a broad spectrum of products, from cars to medical scanners and solar panels. Advances in digital technologies and smart design are creating new circular business opportunities for capital equipment with huge transformative potential.

We know what to do. The long term horizon of the circular economy has implications beyond the material footprint. New decision metrics bring new opportunities for technology-driven prosperity within planetary boundaries. Action to drive the transition from a 'throughput' economy of 'products that flow' to 'products that last' will transform the social contract, slow environmental degradation and reduce social inequality.

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1. THE GLOBAL ENGINE OF CHANGE IS STUCK IN REVERSE

Our world is only 9% circular. This alarming statistic was the main finding of the first Circularity Gap Report. In the 12 months since publication, we have seen no signs the Circularity Gap is closing.

Material use and carbon emissions continue on an upward trend. In terms of sustainability and circularity, the global engine of change is stuck in reverse; we are still heading in the wrong direction.

Both the Circularity Gap and the Emissions Gap remain dangerously high. Signs of climate breakdown are the most visible symptom of environmental damage caused by human actions, revealing the true cost of linear growth. We now live in a world that is 1°C warmer than pre-industrial levels.

In response, the Paris Climate Agreement seeks to limit global warming to 1.5°C. Achieving this ambition will require "rapid, far-reaching and unprecedented changes in all aspects of society".[1]

Systemic failure of the linear economy

What has got us where we are today, in every sense, is the linear economy. Since the boom of the Industrial Revolution, the linear economy has delivered high standards of living and tremendous wealth in some parts of the world. This has, however, been achieved at high cost to the planet and to many of the people on it. In today's resource-constrained world of rapid population growth and urbanisation, therefore, that linear model is no longer fit-for-purpose.

The circular model of Planet Earth

Development as we know it, however, is of course a relatively recent phenomenon. In the 4.5-billion-year history of Earth, humankind arrived late to a planet already functioning in a fully circular manner. The infinite cycles of the natural ecosystem produce no such thing as 'waste'. Waste is essentially a human, social construct. In the last 200 years, though, the transformation of seemingly abundant natural resources into financial capital has brought us to the Anthropocene, the current era when burning of fossil fuels is now measurably and visibly causing climate breakdown.

Paris and the SDGs

In response, though, the last three years have seen our more progressive global leaders, in both civic and corporate arenas, embracing two examples of strategic and ambitious international collaboration: The United Nations Sustainable Development

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[1] IPCC, 2018, Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by governments, October 8, 2018

Goals (SDGs) and the Paris Agreement. Adoption of the SDGs forms the basis of the universal plan for humanity to eradicate hunger, promote good economic development and good health, within global environmental targets. The signing of the Paris Agreement established near-consensus on the need for mitigation of human-made climate change and its impacts, via collective policy and practice. Progress has, however, been painfully slow. Furthermore, with their relatively narrow focus on the energy sector, most national approaches to climate change have also wholly failed so far to leverage the gamechanging mitigation potential of a circular economy.

Development decoupled

A paradigm shift is therefore urgently needed to achieve more equitable prosperity within planetary boundaries. This concept of moving to a 'safe and just operating space'[3][4] for humankind must deliver prosperity in low- and medium-income countries, which are home to five out of every six people on Earth today. To decouple this change from the ecological overload, whilst simultaneously managing the aspirations and expectations of the prosperous minority is the new, core challenge for global development.

The paradigm shift

Transitioning to a world significantly more circular than 9% is the paradigm shift we so desperately need. It offers the prospect of a global economy which is regenerative and abundant. The measure of success, however, will not be throughput-oriented, monetary GDP, alone.

So, the challenge of our day and age is to start reinvesting financial capital, via restorative business practices and policies, into the rehabilitation of natural capital. The goal of a circular economy should be to fundamentally redefine the relationships between the dominant economic realm and other spheres in society and nature. [5] This means closing the Circularity Gap.

Aims of the 2019 Circularity Gap Report

1. Introduce a new measurement framework that extends beyond material use to include financial value creation and extraction, plus greenhouse gas emissions - the Mass-Value-Carbon nexus;
2. Examine and explore the relationship between flows, build-up and maintenance of stocks;
3. Develop a Sectoral Circularity Metric based on the Global Circularity Metric;
4. Provide high-level insights into global, sectoral and product-group-related material metabolism;
5. Identify key levers for transitioning to circularity at all levels by mid-21st century;

WE LIVE IN EXPONENTIAL TIMES

Material extraction has fuelled economic progress since the Industrial Revolution, at the same time causing human-made greenhouse gas emissions. The figure shows the development for material extraction (Mass), Financial value creation (Value) and greenhouse gas emissions (Carbon) from 1900 to 2017 and projected to 2050.

Over the last four decades, the global use of materials almost tripled, from 26.7 billion tonnes in 1970, to 92.1 billion tonnes in 2017[2]. Not only has material use been increasing, it has been accelerating, and is forecast to grow to between 170 and 184 billion tonnes by 2050[3,4].

The Gross World Product developed similarly: from just €2,6 trillion in 1900[5], to €14,5 trillion in 1970 and €60,4 trillion in 2017[6]. Fuelled by economic expansion especially in Asia and Africa this is forecast to triple by 2050 to between €140 trillion[7] and € 165 trillion[8].

Global greenhouse gas emissions reached 51 billion tonnes CO_2-equivalents per year in 2017; 55 billion tonnes when including emissions from land use (change).[9] What is more, global emissions in 2017 increased again after having levelled off for a few years. Emissions are forecast to reach 60 billion tonnes by 2050, even with all current mitigation ambitions implemented.[10] This sits in stark contrast to what is needed: achieving zero emissions by 2050 to keep a 1.5°C world.

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2 IRP, 2019, MaterialFlows.net, Domestic Extraction of World in 1970-2017, by material group
3 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.
4 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
5 Maddison Project Database, version 2018. Bolt, Jutta, Robert Inklaar, Herman de Jong and Jan Luiten van Zanden (2018), "Rebasing 'Maddison': new income comparisons and the shape of long-run economic development", Maddison Project Working paper 10
6 Worldbank (2018), GDP (constant 2010 US$), available from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD
7 PricewaterhouseCoopers. (2015). The World in 2050: Will the Shift in global economic power continue? PwC.
8 OECD (2018), GDP long-term forecast (indicator). doi: 10.1787/d927bc18-en (Accessed on 07 January 2019)
9 Olivier J.G.J. and Peters J.A.H.W. (2018), Trends in global CO2 and total greenhouse gas emissions: 2018 report. PBL Netherlands Environmental Assessment Agency, The Hague.
10 The data for the historic and future greenhouse gas emissions stems from:
1850-1990: Rocha, M., et al. (2015) Historical responsibility for climate change – from countries emissions to contribution to temperature increase.
1990-2017 Olivier J.G.J. and Peters J.A.H.W. (2018), Trends in global CO2 and total greenhouse gas emissions: 2018 report. PBL Netherlands Environmental Assessment Agency, The Hague.
2030: UNEP (2018). The Emissions Gap Report 2018. United Nations Environment Programme (UNEP), Nairobi
2050: Hatfield-Dodds, S., et al., (2017), Assessing global resource use and greenhouse emissions to 2050, with ambitious resource efficiency and climate mitigation policies, Journal of Cleaner Production, Volume 144, , Pages 403-414, Available from: http://dx.doi.org/10.1016/j.jclepro.2016.12.170
IPCC (2018) IPCC Special Report on Global Warming of 1.5°C.
OECD (2011) OECD Environmental outlook to 2050 - Chapter 3: climate change.

Figure xxx shows the development of global annual material extraction (blue), greenhouse gas emissions (red) and global domestic product (yellow) between 1900 and 2050.

DISRUPT: 7 ELEMENTS OF THE CIRCULAR ECONOMY

The circular economy assumes dynamic systems, meaning there is no specific end-point, but it is rather a process of transformation[11]. The DISRUPT model describes 7 key elements that give direction to this transformative process, with the aim of 'slowing the flow' of resources, 'closing the loop' and 'narrowing resources flows', while shifting to regenerative resources and clean energy. The 7 elements describe the full breadth of relevant circular strategies and will be used throughout the report.

- **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.
- **Sustain and extend What's Already Made**. Preserve, maintain, repair and upgrade resources in use to optimise their lifetime and give them a second life through take-back strategies, where applicable.
- **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.
- **Use Waste as a Resource**. Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.
- **Prioritise Regenerative Resources**. Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way.
- **Team up 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.

[11] Raworth, 2017, Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist

2. MASS, VALUE & CARBON: SOLVING THE SUSTAINABILITY EQUATION

This chapter assesses the global economy through three lenses critical to circularity: material throughput, financial value creation and greenhouse gas emissions. This Mass-Value-Carbon (MVC) nexus provides a dynamic conceptual framework for identifying and evaluating key variables. So, whilst the first Circularity Gap Report (2018) concluded that our world economy is only 9% circular – based on an analysis of the global material footprint - this 2nd edition of the Report will expand upon our diagnosis, going beyond material throughput alone. Applying MVC thinking, it will assess both the global financial value and carbon emissions footprint, as well as the mass factors, behind meeting key societal needs, such as housing, mobility and nutrition. Circularity Gap analysis can, therefore, show which needs consume what resources, plus how they create or extract financial value and cause greenhouse gas emissions. Looking at strategic global action plans through a triple-glazed MVC lens provides a balanced perspective that reveals clear relationships, synergies and trade-offs between all three elements of the equation.

Beyond material throughput: introducing the Mass-Value-Carbon Nexus

The concept of the circular economy is closely related to the idea of material metabolism and incorporates strategies for closing material loops. Material transformation offers the prospect of adding financial value at each step of the supply chain - from simple base materials, through to complex products. As part of the same process, however, emissions and waste are generated. Therefore, when considering our economic activity more holistically, we need to adopt three different lenses – Mass, Value and Carbon – to scrutinise the combined inputs and outputs from these steps and understand fully how these activities contribute to meeting our societal needs.

Moving forward, the transition from a linear to a circular economy will increasingly result in the traditional mass-driven business model becoming overhauled and replaced. It is no longer enough to think of financial value as something created simply by turning extracted materials into products. Instead, the circular model sees the financial service value of existing assets being optimised and retained for as long as possible. This will increasingly drive down the rate of extraction of primary materials and deposition of waste. Ultimately, then, this transition to a circular economy in turn implies a transition from value-added to value-maintained.[12]

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[12] Walter Stahel in A new Dynamic - Effective business in a circular economy (2013) by the Ellen MacArthur Foundation,

Therefore, given the interlinked roles of materials, financial value and emissions in the global economy, the Mass-Value-Carbon (MVC) Nexus can provide a framework that connects all these three core dimensions. As such, it is essential to identifying key relationships, synergies and trade-offs, as we move progressively towards a circular economy.

Identifying synergies and trade-offs

The MVC framework can profile how a societal need might score across the nexus. An MVC profile can also be created for a specific intervention - for example, looking at substituting a building material like cement with a biobased alternative. Such a profile may point to synergies, or trade-offs, between Mass, Value and Carbon.

Let us explore in more detail the MVC case for substituting fossil energy carriers like oil and coal with renewable alternatives. On the face of it, utilising renewable energy sources to power an electric car will have a lower impact on the Carbon Profile. However, it may also result in the use of more and different materials to generate that renewable energy. The building of renewable energy installations can increase the need for metals, concrete and rare earth elements. The production of solar cells, for example, uses rare earths, delivering product into a relatively new market, with limited or no recycling systems in place, as yet. What this initial MVC analysis therefore suggests is that whilst the transition to renewable energy may indeed lead to a lower carbon footprint (C), it may also result in a higher material footprint (M).[13]

7 SOCIETAL NEEDS & WANTS

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 per year. 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, 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

[13] Science daily, 2018, Benefits and trade-offs of low-carbon energy, November 30, 2015

kinds of resources such as cotton, synthetic materials like polyester, dye pigments, and chemicals.

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 homecare equipment.

Communication
Communication 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.

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

THE GLOBAL MVC FOOTPRINT BEHIND SATISFYING 7 SOCIETAL NEEDS

A systemic MVC approach can be employed to illustrate how four resource groups (minerals, metal ores, fossil fuels and biomass) satisfy 7 key societal needs. From left to right, the figures show the extraction of resources (*Take*), for example through the mining of minerals, metal ores and coal, the drilling for oil, the production of crops in agriculture or forestry to produce timber for construction. The extracted 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 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 establishing 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?

MASS: THE GLOBAL MATERIAL FOOTPRINT BEHIND SATISFYING KEY SOCIETAL NEEDS

The figure shows the volume of globally extracted resources per year, which amounted to 84.4 billion tonnes in 2015.[14] These extracted resources are complemented by 8.4 billion tonnes of cycled resources bringing total material inputs to 92.8 billion tonnes. Apart from looking at how resource groups satisfy societal needs, the metabolism overview 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. From that same stock, 14.5 billion tonnes of materials were removed, leaving a net addition of 21.5 billion tonnes per year. in terms of the short-lived products that were consumed by the global economy, the majority of material involved, some 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 the short-lived products[15]. 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 xxx the global resource footprint behind meeting key societal needs

[14] 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

[15] Exiobase v3 using 2011 data

MASS (CONTINUED): THE IMPORTANCE OF STOCKS: FROM THROUGHPUT TO BETTER USE OF WHAT WE HAVE

The figure shows the global material footprint presented before in relation (and sized to) the materials stocks in our economy. It shows clearly that the material stocks that have accumulated in our economy account for almost 10 times more material compared to the annual throughput. The annual throughput was 92.8 Gt while the accumulated material stocks account for 890 Gt. Of these materials entering the global economy every year, the majority (56.8 billion tonnes) are being used by society as short-lived *Products that Flow*[16], reaching their end-of-use typically within a year. The remaining 36.0 billion tonnes of materials mentioned earlier, enter into long-term stock[17], referred to as *Products that Last*.[18] These products that last come mainly in the form of capital equipment, buildings and infrastructure. The figure shows that the amount of materials added to stock (36.0 Gt) is significantly higher than the amount wasted from stock (8.7 Gt)[19] (for example as demolition material, or metal from discarded machines and cars). The net result is a significant addition to stock of 27.3 Gt.

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[16] Haffmans et al., 2018, Products that Flow: Circular Business Models and Design Strategies for Fast-Moving Consumer Goods

[17] Krausmann et al. (2017). Global socioeconomic material stocks rise 23-fold over the 20th century and require half of annual resource use. PNAS 2017 114 (8) 1880-1885; doi:10.1073/pnas.161377311

[18] Bakker et al., 2014, Products That Last - product design for circular business models

[19] 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.

VALUE: THE GLOBAL FINANCIAL FOOTPRINT BEHIND SATISFYING KEY SOCIETAL NEEDS

Taking Gross Value Added (GVA) as a measure, the figure shows the global financial footprint linking how and where in our economy financial value is added, depreciated, or lost; and where residual value is left. In 2016, GVA amounted to 52.8 trillion Euros[20]. Totalling just €1.6Tn, the extraction (*Take*) of raw material only represents a small fraction of GVA. The processing of raw materials (*Process*) and the production (*Produce*) of intermediate and final products contribute almost equally to GVA with €7.1Tn and €9.9Tn, respectively. By far the largest contribution to financial value happens in the delivery (*Provide*) step, representing an addition of €39.6Tn annually. The combined added value comes in the form of products and services, with (manufactured) products contributing €20.5Tn and services being responsible for more than 60% of the value-add at €37.7Tn.

For *services delivered* to meet societal needs, the value development is straightforward; when a taxi brings you from A to B at the final stop the value is added. Again, distinguishing between *Products that Flow* and *Products that Last*, we see that the minority, or €6.2Tn of the value-add, is in the form of *Products that Flow* - meaning that these are consumed within a year. For these *products consumed*, the three likely end-of-use scenarios are that either residual value remains, any value is negligible, or costs are required to dispose of them. *Products that Last* add €14.3Tn to the long-term *economic stock*, including infrastructure, housing and capital equipment.

It is important to note that societal needs are not met exclusively by what flows through our economy; the economic stock - the financial measure of everything that provides value - is equally important. The global economic stock, regarded as non-financial assets, is estimated to amount to €136Tn[21]. From this economic stock every year €8.7Tn is being depreciated, with a smaller fraction becoming available as residual value. The combined *residual value* available from *Products that Flow* and *Products that Last* is only €0.4Tn, representing just 4.6% of the total value of the material input needed in the *Provide* step.

Figure xxx show the global build-up of financial value measured in trillion Euros (2016)

[20] The World Bank, Gross Value Added at basic prices (GVA) (current US$)
[21] Credit Suisse Global Wealth Databook 2018

CARBON: THE GLOBAL EMISSIONS FOOTPRINT BEHIND SATISFYING KEY SOCIETAL NEEDS

The figure shows where within the global economy greenhouse gases are emitted in satisfying 7 societal needs. In 2017, total greenhouse gas emissions amounted to 50.9 billion tonnes of carbon dioxide equivalent (Gt CO_2e), excluding emissions from land use, land-use change and forestry.[22] Of this total, approximately 62% of emissions are released during the extraction (*Take*), processing (*Process*) and production (*Produce*) phases, generating 12.5, 10 and 9.3 billion tonnes carbon dioxide equivalent, respectively.

Differentiating between carbon footprints per societal need shows that mobility is an outlier, with 12.7 Gt CO_2e. This is because of the sheer size of fossil-fuel combustion in this sector. The carbon footprint of nutrition is relatively low since the analysis excludes land use and forestry-related emissions and sinks.

Figure xxx the global carbon emission footprint behind meeting key societal needs, excluding emissions from land-use change.[23]

[22] UNEP (2018). The Emissions Gap Report 2018. United Nations Environment Programme, Nairobi, available from: http://wedocs.unep.org/bitstream/handle/20.500.11822/26895/EGR2018_FullReport_EN.pdf?sequence=1&isAllowed=y
PBL (2017), Trends in global CO2 and total greenhouse gas emissions: 2017 report, available from: https://www.pbl.nl/en/publications/trends-in-global-co2-and-total-greenhouse-gas-emissions-2017-report

[23] Sources: Exiobase and Olivier J.G.J. and Peters J.A.H.W. (2018), Trends in global CO2 and total greenhouse gas emissions: 2018 report. PBL Netherlands Environmental Assessment Agency, The Hague.

SUMMARISING THE MASS-VALUE-CARBON NEXUS

After presentation of the MVC footprints separately, the below diagram provides a summary overview, showing how the MVC footprint is distributed over the 7 societal needs. What stands out is that the MVC profiles per societal need are very different. We can distinguish three main profiles. The first profile applies to societal needs for which mass, value and carbon are all sizeable and in the same order of magnitude - this is true, for housing, mobility and consumables. A second profile is that of societal needs that are significantly responsible for value creation, but without causing proportionately significant emissions and with less dependence on material use. This profile is associated with services, healthcare and communication. A third very distinct profile is that of nutrition, which displays a significant material production and carbon emissions profile, but with considerably less value-add, actually ranking lowest on value addition across all societal needs.

Figure xxx shows the respective weight of the mass, value and carbon footprint per each of the seven societal needs.

Profile 1: Housing, Mobility and Consumables

Housing, Mobility and Consumables are together responsible for 68% of the total material footprint, 64% of the carbon footprint and 45% of the financial value footprint. These are sectors dominated by product ownership by the consumer, resulting in a relatively low use rate for individual products. In addition, the production of material in houses, the need for thermal comfort, our desired mobility and material intensive vehicles, plus electronics and appliances explain the high energy use and related greenhouse gas emissions in these value chains. Typical solutions lie in improving the utility rate, which can be achieved by prioritising access over ownership.

Profile 2: Services, Health and Communication

The second profile considers high-value activities that require significantly less material and have a lower carbon footprint per unit of value-added than the societal needs in Profile 1. Profile 2 is also where societal needs are to a higher extent met with service models. They rely more upon human capital than material stock, which is particularly the case for Services. Healthcare helps maintain the 'quality' of a stock of human capital, for instance by servicing patients who seldom own an MRI scanner. Communication is where large and capital-intensive infrastructure is provided as a service, connecting the mobile devices of large numbers of customers.

Profile 3: Nutrition

Nutrition represents the second largest material footprint with 21.8 billion tonnes. In contrast to the other sectors, Nutrition relies predominantly on organic materials. It incorporates agriculture and food processing to satisfy our dietary needs and has a considerable carbon footprint of 6.5 billion tonnes of CO_2 equivalent - third after mobility and consumables. What stands out, is the very low value addition along the nutrition supply chain, representing only €1.6 trillion. This seems to contradict the essential nature of this sector, but actually serves to illustrate how through photosynthesis it taps into potentially completely renewable sources.

3. METRICS: GLOBAL CIRCULARITY & THE CIRCULARITY GAP

This section presents a measurement framework and metrics for circularity. In the first edition of the Circularity Gap Report we launched the Global Circularity Metric. In this 2nd edition we build on this work by applying the Circularity Metric to specific sectors such as the Built Environment and product groups like Capital Equipment. To date, the lack of a consistent measurement framework has posed a major challenge for implementing circular economy into government policy and business strategy. The real value of the Circularity Metric 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 just a closed-loop system. This report introduces a strongly simplified conceptual representation of the global metabolism - materials flowing through and in (long-term) use by the economy. The approach adopted here builds on and is inspired by, amongst others, the work of Haas et al.[24] Then, taking material metabolism as our starting point, we explore and suggest a metric for global circularity.

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 suggest 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 - this approach also entails limiting the stocks temporarily not in use (hibernating), or mobilising materials to re-enter the economy (urban mining); plus

[24] Haas et al., How Circular is the Global Economy?: An Assessment of Material Flows, Waste Production, and Recycling in the European Union and the World in 2005. Journal of Industrial Ecology Volume 19, Number 5, p. 765-777 DOI: https://doi.org/10.1111/jiec.12244

- 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.

The Global Circularity Metric applied

When we consider the four fundamentals above it becomes apparent that the last one, the cycling of materials is a key factor. To capture this essential dynamic, we, therefore, suggest that the circularity metric should measure the share of cycled materials as a proportion of the total material inputs into the global economy every year.

As presented on page X the total resources entering the economy account for some 92.8 billion tonnes.[25] These annual material inputs into our economy are composed of extracted resources, complemented by cycled resources. In 2015, 8.4 billion tonnes of cycled resources were reused by the global economy which brought the total for extracted material inputs up to 84.4 billion tonnes.[26] Applying the definition to these numbers results in a GLOBAL CIRCULARITY METRIC of 9.1% for 2015.

Scanning a sector: Circularity of the Built Environment

An analysis of the circularity of the built environment in low-, medium- and high-income countries was performed by applying the Circularity Metric to markets in both Europe and China. For each region, three essential data points were needed: (1) the input of materials; (2) the output of materials; and (3) the accumulated material stocks. The input of the materials comprises of three categories: the materials that are domestically extracted; materials that are imported; and materials that are cycled back into the economy of the sector and region. Material imports are considered as 'direct imports'. The material outputs category considers three categories: all materials for the construction sector that are exported; those that are wasted (beyond recovery); and those that are cycled. Similar to the Global Circularity Metric, the Sectoral Circularity Metric for a specific sector (Built Environment) and specific region (China or Europe) is calculated by measuring the cycled materials as part of the total material inputs into the sector in that region in one year. Applying this definition, the numbers per region are presented in the following Chapter 5. An elaborate methodological description is available online.

Scanning a product group: Capital Equipment

For the product group of Capital Equipment, determination of a definitive Circularity Gap figure did not prove possible, as yet, given current available data. Chiefly, this was

[25] 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
[26] Exiobase v3 using 2011 data

because of a lack of sufficiently specific waste statistics for such a varied group of products. What the Capital Equipment analysis in Chapter 6 does though provide is a useful metabolism overview, specifying which resources are consumed in what quantities and for which societal needs they are put to work.

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To find out more about the methodology we encourage you to visit our website: https://www.circularity-gap.world/

PRACTICAL CHALLENGES CALCULATING AND INTERPRETING THE CIRCULARITY METRIC

The value of 9.1% for the Circularity Metric suggests a significant Global Circularity Gap of more than 90%. Whilst it is undeniably true that our current economy is dominantly linear, it is helpful 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 three practical challenges (2-4):

1. **Setting a benchmark.** The real advantage with the GCM 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 fallout. The GCM does not, however, explicitly consider individual strategies that are core to building a circular economy - such as asset sharing, lifetime extension or remanufacturing. These strategies extend the functional lifetime of products, whereby waste creation is prevented, thus ‘slowing down’ flows and lowering waste volumes. At the same time, they also 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 is variable. 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. Unavailability of good quality waste statistics is the reason why calculating an annual update of the Circularity Metric for the global economy is not yet possible.

4. **Quality loss and degradation.** The proposed metric focuses on the end-of-use cycling of materials that re-enter the economic system. The GCM 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.

4. SPOTLIGHT #1 THE BUILT ENVIRONMENT: BIG IMPACT, GETTING BIGGER

The built environment provides essential basic needs in the form of housing and infrastructure. This tangible value to society means its rate of development and renewal is often used as shorthand for economic prosperity. In terms of the MVC equation, however, its impacts regarding mass and carbon are also very significant. Its construction and maintenance consumes almost half of all materials going into the global economy annually, plus generates about one fifth of emissions. The speed at which new infrastructure and houses are built, though, varies hugely between global regions. China for example is faced with rapid expansion of its built environment, lifting millions of people out of situations of poverty towards middle class lifestyles. This sits in stark contrast with Europe where the last century had already seen the build-up of housing stock and the dominant activity now is maintenance and refurbishment. This chapter explores the differences between regions as regards development pace and priorities, plus how MVC and Circularity Gap analysis can be applied sector-wide.

Built Environment: poised for spectacular expansion

To continue meeting the world's societal needs, the urban built environment will grow by a massive 60% by 2050.[27] In 2015, total material input to satisfy the need for housing was 42 billion tonnes. To put this in perspective, the accumulated building stock in the last two centuries until 2015 totals 832 Gt. This means that the accumulated stock is almost 20 times the size of the materials going into the economy yearly. Materials going into the built environment - past and present - are dominated by minerals in the form of concrete, asphalt, bricks, sand and gravel. Other significant materials are metals and wood, with plastics and glass representing a smaller fraction.

The forecasted global growth is especially seen in world regions where population growth rates and levels of urbanisation are high. In other parts of the world, like Europe, the expansion of the urban built environment follows a more incremental pace. In particular, the building stock in China will grow more than 10 times faster than Europe. As a result, by 2050, an additional 373 billion tonnes, or 135%, will be added in China, compared to just 12 billion tonnes or 13% in Europe. Furthermore, not only is there a difference in the speed of growth, but the materials typically used in China are also more carbon intensive than those in Europe. Based on our analysis[28], on average, a building material produced and used in China emits double the amount of carbon compared to Europe.

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[27] UNEP. (2013). *City-Level Decoupling - Urban resource flows and the governance of infrastructure transitions, A Report of the Working Group on Cities of the International Resource Panel*. (M. Swilling, B. Robinson, S. Marvin, & M. Hodson, Eds.).

[28] Analysis based on Exiobase data

Comparing one region with another, therefore, historical differences in rates of industrialisation and urbanisation have clearly resulted in varying degrees of built environment development and density. This, in turn, leads to disparities in supply and demand. In addition, discrepancies in relative availability and usage of particular building materials have seen these contrasting regional profiles diverge still further. Like climate change, however, circularity is a global issue. So, whilst the solutions and strategic responses might vary region-to-region, the global problems remain common to all geographies and the responsibilities are shared worldwide. Europe and China are simply two parts of the same equation, with both their economies invested in closing the Global Circularity Gap.

Europe: 12% circular, with significant existing stock and incremental growth
Europe as a region is representative of the developed world. It exhibits significant past stock build-up, with the primary focus now being on maintenance and refurbishment. It is also characterised by incremental rates of growth in new housing and infrastructure development.

The figure below shows these dynamics in context, highlighting the relationship between the current stocks and flows. Europe has seen significant build-up of stocks in the form of houses, offices and infrastructure, particularly over the last century, with approximately 95 Gt of stocks now in use. This material stock, aside from infrastructure, represents an estimated 30 billion square metres of floor space - equal to the land area of Belgium - for residential and non-residential buildings[29]. This figure is increasing at an average rate of around 1% per year.

Every year, approximately 4.3 Gt of materials flood into Europe's built environment, with more than half of the resources used for maintenance and renovation. The use of re-used or recycled construction materials is high in Europe compared to other world regions. Almost 12% of all materials used in construction come from a secondary source. Hence, the circularity of Europe's built environment is estimated at 12%, which is higher than the global figure of 9% across all sectors and societal needs. It should be pointed out, though, that much of this waste is being downcycled to a lower application.

Between 2015 and 2050, built environment stock in Europe is expected to grow by a mere 12Gt (13%). The reality is that about 75% of the buildings that will make up the housing stock in 2050 are already in existence today[30].

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[29] European Building Database, data retrieved on 01/01/19
[30] Lewis, J.O. et al. (2013) BUILDING ENERGY EFFICIENCY IN EUROPEAN CITIES. Cities of Tomorrow – Action Today. URBACT II Capitalisation. May 2013.

Figure X shows material flows and stocks for the built environment in Europe and China for 2015 and projected growth for both regions until 2050.[31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49]

China: 2% circular, with 10% recycling of construction and demolition waste

China as a country is representative of low- to middle-income regions. While it already exhibits significant past stock build-up, the primary focus now and for the future lies in creating new housing and infrastructure, particularly in urban areas and megacities.

The materials that have accumulated in the Chinese built environment between 1995 and 2015 amount to approximately 239 Gt. In 2015 alone, 14.2 Gt of materials were

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[31] EXIOBASE 3.3.8 HSUTs (Merciai et al. (2018). Methodology for the construction of global multi-regional hybrid supply and use tables for the EXIOBASE v3 database. Journal of Industrial Ecology, 22(3), 516-531)

[32] EU Buildings Database. Available at: https://goo.gl/UAbYWo (last consulted on: 15 November 2018)

[33] Deilmann et al. (2014). Ressourcenschonung im Hochbau. Sensitivitätsstudien zur Bautätigkeit bis 2050 spiegeln Einsparpotenziale durch höhere Recyclatanteile wider. ReSource 27(4), 20-26

[34] Deilmann, C., Krauß, N., Gruhler, K., & Reichenbach, J. (2014). Sensitivitätsstudie zum Kreislaufwirtschaftspotenzial im Hochbau. *Endbericht Stand*, *17*. Available at: https://goo.gl/7JXEP1

[35] Schiller et al. (2015). Kartierung des anthropogenen Lagers in Deutschland zur Optimierung der Sekundärrohstoffwirtschaft. Dessau-Roßlau: Umweltbundesamt, 2015, S. LIV, 261 (Texte / UBA; 83/15), http://www.umweltbundesamt.de/publikationen/kartierung-des-anthropogenen-lagers-in-deutschland

[36] Schiller, G., Müller, F., & Ortlepp, R. (2017). Mapping the anthropogenic stock in germany: Metabolic evidence for a circular economy. *Resources, Conservation & Recycling, 123*, 93-107. https://doi.org/10.1016/j.resconrec.2016.08.007

[37] Ortlepp et al. (2016) Material stocks in Germany's non-domestic buildings: a new quantification method. Building Research & Information, 44(8), 840-862 https://doi.org/10.1080/09613218.2016.1112096

[38] Schiller, Müller, Ortlepp (2016). Material stocks in Germany's non-domestic buildings: a new quantification method. Building Research & Information, 44(8), 840-862 https://doi.org/10.1080/09613218.2016.1112096

[39] Ortlepp et al. (2017). Grundlagen für materialeffizientes Planen und Bauen: Baustoffzusammensetzung des deutschen Nichtwohngebäudebestandes. In: Bautechnik 94 (2017) 1, https://doi.org/10.1002/bate.20160002

[40] Schiller, Gruhler, Ortlepp (2017). Continuous MFA approach for bulk non-metallic mineral building materials taking the example of the German building sector. Journal of Industrial Ecology, 21(3), 673-688
Wiedenhofer et al. (2015). Maintenance and expansion: Modeling material stocks and flows for residential buildings and transportation networks in the EU25. Journal of Industrial Ecology, 19(4), 538-551 https://doi.org/10.1111/jiec.12216

[41] IOER information portal for Structural Data. Available at http://ioer-bdat.de/en/ (last consulted on: 21 November 2018)

[42] China Statistical yearbook (2017)

[43] Shi et al. (2012). Toward a Low Carbon–Dematerialization Society Measuring the Materials Demand and CO2 Emissions of Building and Transport Infrastructure Construction in China. Journal of Industrial Ecology. 16 (4), 493-505. https://doi.org/10.1111/j.1530-9290.2012.00523.x

[44] Hou, W., Tian, X., & Tanikawa, H. (2015). Greening China's wastewater treatment infrastructure in the face of rapid development: analysis based on material stock and flow through 2050. Journal of Industrial Ecology, 19(1), 129-140. https://doi-org.tudelft.idm.oclc.org/10.1111/jiec.12186

[45] Huo, T., Cai, W., Ren, H., Feng, W., Zhu, M., Lang, N., & Gao, J. (2019). China's building stock estimation and energy intensity analysis. Journal of Cleaner Production, 207, 801-813. https://doi.org/10.1016/j.jclepro.2018.10.060

[46] Han, J., & Xiang, W. N. (2013). Analysis of material stock accumulation in China's infrastructure and its regional disparity. Sustainability science, 8(4), 553-564. Available at: https://goo.gl/AEvt5i

[47] Huang et al. (2013). Materials demand and environmental impact of buildings construction and demolition in China based on dynamic material flow analysis. Resources, Conservation and Recycling, 72, 91-101 https://doi.org/10.1016/j.resconrec.2012.12.013

[48] Eurostat Database, available at: https://ec.europa.eu/eurostat/data/database (last consulted on: 2 December 2018)

[49] Deloitte (2017.) Study on Resource Efficient Use of Mixed Wastes, Improving management of construction and demolition waste – Final Report. Prepared for the European Commission, DG ENV. Available at: http://ec.europa.eu/environment/waste/studies/pdf/CDW_Final_Report.pdf

added to the stock representing a carbon footprint of 3.7 Gt. China's carbon footprint per tonne of materials is double that of Europe's, as for each tonne of material, 0.26 tonnes of carbon is emitted in China versus 0.125 in Europe. By 2050, an additional 323 Gt of building stock will have been built.

The use of secondary materials is also relatively low: less than 2% of the built environment can be considered circular. Given the short lifetime of an average building in China (30-40 years[50]), this situation shows how big the challenge is to reduce material and carbon footprints.

However, a positive trend can be found in the recycling of construction and demolition waste. In 2015 this was at least 10% recycling – and even 13% according to local researchers - despite a rapid expansion in new building in the previous five years, and this number is still rising.

Figure x Circular Economy strategies and their potential contribution to move to circularity for the built environment in China and Europe

Implementing circular strategies in China

The majority of the houses that people in China will inhabit and the roads they will travel in the next 10 to 50 years are yet to be built. This means that the opportunity is now to build in a circular way. Design for the future makes sure we avoid locking-in linearity and the toxins of tomorrow, today. Future-proofing the design requires adopting state-of-the-art building principles instead of the current traditional methods, which remain the norm even in most parts of high-income countries, including Europe. The need for an integrated design approach goes beyond the requirements of individual buildings alone and is equally relevant for urban and city planning. Design strategies include construction methods that allow for disassembly, with modular building proving particularly attractive.

An integral part of the design process should be an emphasis on prioritising regenerative resources that are renewable and non-toxic. Particularly needed are alternatives to carbon-intensive materials such as (steel-reinforced) cement. Other important areas of interest include the introduction of advanced sorting and re-use to foster better waste as a resource rates, plus the opportunity to leverage digital technology. Adoption of state-of-the-art building practices in China provides a platform for scaling innovation and benchmarking best-in-class performance.

Implementing circular strategies in Europe

Many high-income countries and regions like Europe are faced with an ageing demographic, plus a mature and in cases outdated housing stock. Around 4 out of

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[50] https://www.tandfonline.com/doi/full/10.1080/09613211003729988

every 10 houses in Europe were built before 1960, a time when building practices were poor by today's standards. As a consequence, the construction sector is predominantly concerned with maintenance of the existing housing stock, having only incremental expansion prospects for new build. The priority is to sustain and preserve what is already made in this case the current building stock and boost its performance from the perspective of material reuse and energy efficiency.

Opportunities to enhance flexibility in use are also valued for facilitating the repurposing of buildings. This ambition is to make and keep Europe's urban areas as sustainable as possible, whilst the inevitable, but gradual, process of stock replacement delivers ever-better building standards. This approach places an important focus on the design and planning phase, including spatial planning, plus the securing of adequate financial means. Leveraging the possibilities of digital technology has merit, too, for example by creating building material passports following the Madaster example[51]. Better insights into material composition and processing options at end-of-use could also help optimise waste as a resource. Examples include innovations like the Smart Crusher[52], a technology for recovering sand, gravel and cement from concrete. Particularly relevant for the construction sector is the need for more collaboration across the supply chain to create shared value and resolve split incentives.

[51] https://www.madaster.com/en
[52] https://www.slimbreker.nl/smartcrusher.html

5. SPOTLIGHT #2: CAPITAL EQUIPMENT: HIGH-VALUE CIRCULAR DISRUPTORS

Capital equipment comprises a broad group of products, ranging from medical scanners, via solar panels and cars, to industrial printers and elevators. Across many rapidly-evolving and tech-driven sectors, this varied product group is central to advances in digital connectivity, clean technology and smart design. Characterised by a large amount of capital involved over relatively long product lifespans, this category plays an integral role in meeting and improving on societal needs such as mobility, healthcare and housing. Not surprisingly, therefore, capital equipment features most heavily in the financial value dimension of the MVC nexus, contributing almost 13% of global gross value added[53]. Material impacts for capital equipment are comparatively modest, with only 6 billion tonnes (6.5% of total global mass). Even so, capital equipment consumes more than half of all metal ores consumed globally. The emissions impact is comparable in share to the material footprint with 3.2 billion tonnes of emissions (6.5%). With such an exceptional MVC profile, capital equipment carries the promise of huge transformative potential - if, circularity can be designed-in, manufactured and valued over time, bringing disruptive innovation beneficially to market.

Capital Equipment drives innovation across sectors

Whether it is an Magnetic Resonance Imaging (MRI) scanner in a hospital generating medical images that help to cure patients better and faster, or precision-farming robots that optimise agricultural production processes, capital equipment is at the centre of innovation in today's technology-driven economy. Many of the major technology trends shaping the future economy, such as the renewable energy transition, digital connectivity in industrial systems via the internet of things (IoT) and machine autonomy through artificial intelligence (AI) technologies, revolve around capital equipment products. Reconsidering the design and use of these goods can therefore be the source of circular disruption, sparked by new technologies and business models that are less material- and carbon-intensive.

Capital Equipment consumes half of all metals

Figure X shows how the production and maintenance of capital equipment consumes 6.0 Gt materials per year, out of which 5.5 Gt are metals. This means that capital equipment consumes more than half (57%) of all metals used globally, in providing essential goods to cater to all societal needs. Mobility is the need consuming most materials (47%), followed by Communication (15%). Both needs provide particular examples of rapid technology disruption taking place – including such gamechangers as the scaling-up of electric vehicles and innovations in digital connectivity. These are serviced chiefly by equipment from the automotive industry- and other transport-related sectors, as well as communication and computing

[53] EXIOBASE v3 using 2011 data

equipment. Broader categories of machinery, equipment and electrical goods can be attributed mostly to providing housing, healthcare and consumables to society.

Figure X Shows the material footprint behind the production and maintenance of capital equipment and how this equipment is put to work to satisfy societal needs.

Critical dependence and increasing scarcity of metals

The metals used in capital equipment include rare and precious elements, employed in high-tech applications. Many of these rare earths are forecast to reach critical scarcity thresholds in the near future[54]. Accelerated demand for these materials is revealing our growing critical dependence on increasingly scarce resources. The continuous extraction of such resources to produce the goods and services we demand, coupled with dramatic shifts in the way we use and dispose of these resources, is threatening both their availability and affordability. These resources are critical to activities involved in satisfying key societal needs, including such priority operations as the continued agricultural production of crops, the acceleration of solar energy, and the scaling-up of electric transport.

THREE CIRCULAR ECONOMY STRATEGIES TO RETAIN VALUE

The figure shows the typical value distribution across the product lifecycle for capital equipment. In the linear model, value builds up in the production and sales of a product. Then, during use, its value gradually depreciates; after which, disposal follows with marginal value recovered. In contrast, circular economy strategies are aimed at preserving the complexity and value in products, both during their use phase and at end-of-use. Due to the diversity of capital equipment products, however, there is no one-size-fits-all approach to transitioning to a circular model. Three circular strategies from the DISRUPT model are most applicable for capital equipment aimed at value retention during their use and at end- of-life.

FIGURE X shows a conceptual model of value creation with the three circular strategies

1. Sustain and preserve what’s already made

As befits a sector concerned with ‘products that last’, the first circular product strategy is to create products that last longer and thereby generate additional functional value within their lifecycle. By making design choices aimed at reducing product degradation, improving durability and upgradability as well as by optimising maintenance, the lifespan of many machines can be extended significantly, resulting in both a decreased need for new products and increased value creation per individual unit.

[54] European Commission, Report on Critical Raw Materials in the Circular Economy, 2018

The potential for additional value creation of this strategy is particularly high for products that are capital intensive and have low operating expenses. Extending the useful life of such products has the dual benefit of additional functionality due to more years of utilisation, coupled with the ability to spread upfront investments over a longer time period.

2. Rethink the business model

Alongside extending the lifespan of capital equipment, intensifying its use within its lifecycle offers potential for additional value creation by both filling up unused capacity and reducing idle time. This can be achieved by providing product access to a greater number of users and enabling shared utilisation. Frequently, this strategy entails offering use of a product as a service, whilst retaining ownership. Producer incentives are therefore aligned with providing maximum functional, rather than material value. Ideally, this strategy should be applied to capital equipment that spends substantial time sitting idle, or could provide functionality to more users, more of the time, concurrently.

3. Use waste as a resource

The third circular product strategy is concerned with the end of the useful life of capital equipment. By improving recycling infrastructure and designing products with different end-of-life scenarios in mind, this strategy offers particular potential for products, which, even though they are no longer suitable for their original purpose, still retain intrinsic value. This residual value may pertain to a different, subordinate function, one that the item can still perform, as well as to the value of component parts and individual materials on secondary markets.

CIRCULAR ECONOMY STRATEGIES THAT ENABLE VALUE RETENTION

Due to the diversity of products involved, there is no one-size-fits-all approach to transitioning from a linear to a circular model in the capital equipment sector. It therefore requires integrating these strategies within the individual product context to form a tailored approach. The figure shows the potential to retain and increase value by implementing the 3 circular strategies for 7 products that are illustrative for the breadth of Capital Equipment. The scores are based on own research and interviews with industry experts from the Capital Equipment Coalition.

Figure X shows the potential of three circular strategies to increase value for specific products that are illustrative for the breadth of Capital Equipment.

Case 1: Building comprehensive use concepts around passenger vehicles

Carsharing, ridesharing, autonomous vehicles, e-mobility and connected mobility: All of these trends in the automotive sector share the common denominator of bringing disruptive transformation to the way, and specifically, the extent to which we use cars. On average, the typical passenger car sits idle for 96% of the time[55]. Different access models like ridesharing and carsharing - especially, when enhanced by autonomous driving - will multiply current utilisation rates by a factor of at least eight[56]. To counter the accelerated degradation of cars under intensified utilisation, electric powertrains, intelligent maintenance programmes and software integration increase durability and upgradability of vehicles. Adding these trends together leads us to estimate that the functional value created per individual car in the future will more than double.

Case 2: Mastering end-of-life in the energy transition

Realising the benefits of future mobility scenarios depends on a foundation of abundant, clean and renewable energy. The required energy transition also entails that solar panels, wind turbines and batteries are accounted for at the end of their useful life. By 2050, 78 million tonnes of decommissioned equipment is estimated to arise from solar panels alone[57]. Simultaneously, increasing demand for scarce metals improves the business case for reuse and recovery of resources, as well as cascading use throughout other applications at end-of-life. So, with prices for virgin materials increasing in the future, further innovation in sorting and recycling technologies will be triggered. The economic opportunity at end-of-life is amplified further if the design

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[55] Pasaoglu, G., Fiorello, D., Martino, A., Scarcella, G., Alemanno, A., Zubaryeva, A. and Thiel, C., 2012. Driving and parking patterns of European car drivers-a mobility survey. Luxembourg: European Commission Joint Research Centre.

[56] Ark Invest, 2014. How Many Cars can One Zipcar Replace: Zipcar and the Impact of Car Sharing on Auto sales

[57] IRENA and IEA-PVPS (2016), “End-of-Life Management: Solar Photovoltaic Panels,” International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems

of new equipment already has circularity built-in, facilitating disassembly and cycling of materials in secondary markets.

Case 3: Preserving value by optimising the software-hardware interface for medical scanners

As is the case for much capital equipment, technological innovation in magnetic resonance imaging (MRI) technology increasingly focuses on the software-hardware interface, with the image-processing software becoming more advanced. So, with rising scanner complexity, additional services and maintenance are required, which has led the Dutch life-science company Philips to pioneer new revenue models with partners. For instance, by entering into full-service partnerships with several hospitals in the UK, Philips provides equipment and services for a period of 10 years at a monthly fee. This business model incentivises Philips to design for upgradability and software compatibility, ensure advanced maintenance and postpone technical obsolescence. Using such a strategy allows for the number of machines required to be minimised and lifespans to be extended, which can increase functional value per unit by at least half the original value.

6. CIRCULAR ECONOMY: ESSENTIAL TO DEEP DECARBONISATION PATHWAYS

A 1.5°C world can only be circular; and there is growing evidence to support this claim. This final section therefore discusses in detail the extent to which a circular economy can cut greenhouse gas emissions. It explains how the circular and low-carbon agendas are both compatible and mutually cost-beneficial - making them the right fit at the right price. To start with, however, we have a problem; and it is a problem with our current climate solution. The much-lauded measures proposed by countries in their pledges under the Paris Agreement simply fall short of keeping the globe on a 1.5°C pathway. Complementary mitigation strategies are needed. Despite urgent demand for new and different climate solutions, though, the mitigation impact of a circular economy is barely even being considered. The focus is typically on renewable energy, energy efficiency, methane abatement and avoiding deforestation. However, the untapped mitigation potential of recycling, followed by circular business models and product resource efficiency is vast and could also effectively complement existing abatement strategies. Furthermore, the road to a circular, low-carbon future is economically attractive.

Time is running out to close the Emissions Gap

The IPCC has demonstrated that a 1.5°C pathway requires that CO_2 emissions decline 45% between 2010 and 2030, reaching net zero by 2050.[58] The national pledges under the Paris Agreement, including the part conditional upon international support, simply cannot deliver this.

Even if all countries were to realise their mitigation ambitions, global emissions would still increase, rather than decrease, and reach 53 billion tonnes CO_2e by 2030. This would leave a gap of 29 billion tonnes CO_2e in an emissions scenario consistent with a 1.5°C world.[59] Therefore, in addition to accelerating and expanding the implementation of strategies which underpin the current pledges, we urgently need new and different strategies which can complement this package.

On the plus side, though, the private sector is stepping up its mitigation efforts, even despite the lukewarm level of commitment demonstrated by certain national governments. The circular economy is seen as a good news story by the business community – especially corporates, global brands and large commercial organisations – providing them with a positive narrative for transformational change,

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[58] IPCC Special Report: Global Warming of 1.5 °C - Summary for policymakers, available from: https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers

[59] UNEP (2018). The Emissions Gap Report 2018. United Nations Environment Programme (UNEP), Nairobi

rather than the punitive discourse which all too often characterises the climate debate.

We need both circular and low-carbon strategies to keep the globe to 1.5℃
Since the launch of the first Global Circularity Gap report, Swedish sustainability consultancy Material Economics has conducted the most comprehensive analysis to date of circular mitigation potential across a range of sectors in Europe. Their conclusion is that circular economy measures could reduce greenhouse gas emissions from the four key value chains of the steel, plastics, aluminium and cement industries by a staggering 56%. This transformative shift could be achieved by deploying materials recirculation and improving materials efficiency, plus using circular business models, measured against a baseline of continued improvement in energy efficiency.

Such large-scale mitigation potential goes far deeper than anything low-carbon energy could provide in isolation, but it is the combination of the two approaches together that holds the true transformative power. Between 2015 and 2100, circular economy strategies could reduce global cumulative emissions from these four value chains by about 36%. Deploying existing low-carbon technologies could cut a further 20%, leaving only 44% of the baseline emission level remaining. Deeper reductions are possible when adding even more circularity, production process breakthroughs and material substitutions into the mix.[60]

The text box identifies the principal mitigation strategies. As yet, material substitution is not being quantified in the European study by Material Economics, nor are future process breakthroughs or more disruptive innovations. When used well, though, these approaches could tip the balance to an emissions level which is fully in line with a 1.5 °C pathway.

Scenario analysis for all sectors at the global level yields perhaps even more convincing results. Estimates suggest that the combination of low-carbon and resource-efficiency strategies could reduce global greenhouse gas emissions by 63% by 2050. In isolation, each strategy could deliver only 56%, or 19% respectively. There is also overlap in the mitigation potential. So, aiming for full development of both strategies simultaneously, could substantially increase the likelihood that these emission reductions actually mature, representing a clear win-win opportunity.

It must be noted, however, that we are only just beginning to understand the interaction between global natural resource use, resource efficiency, energy efficiency, economic growth and greenhouse gas emissions; and we need to improve our

[60] Material economics (2018), The circular economy - a powerful force for climate mitigation.

understanding further.[61] Nevertheless, the combination of ambitious climate mitigation and resource efficiency is already being recognised as an economically attractive route to take. In fact, about half the circular mitigation potential would be economically feasible even at a carbon price of zero.[62] It is also encouraging that 2019 will see the launch of a global assessment of the mitigation potential of resource efficiency by the International Resource Panel.

A circular economy therefore represents a deliverable decoupling approach to climate mitigation. Its aim is to grow prosperity, whilst intelligently managing resources within the boundaries of our planet. Moving society away from the 'take-make-waste' tradition of the linear economy, a circular model serves 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.

If we are to bridge the Emissions Gap and get back on track towards a target limit of 1.5°C, then closing the Circularity Gap is essential, not merely desirable. Transitioning to a circular economy is the paradigm shift that can help us achieve the "rapid, far-reaching and unprecedented changes in all aspects of society", called for in the Paris Climate Agreement.[63] The pathway to a low-carbon future is therefore necessarily circular; there is no other way. Our world must become more than 9% circular.

Circular carbon mitigation strategies

1. Extend product lifetime and improve use-intensity
This is about making better use of existing products. When extending the lifetime of a product, reusing or sharing it, less product is needed to respond to a given demand. As a result, value-chain emissions from the *Take*, *Process*, *Produce* and perhaps even *Provide* steps are reduced. Taken together, these strategies make up about a quarter of the circular mitigation potential in European industries.[64]

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[61] 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.
UNEP (2017) Resource Efficiency: Potential and Economic Implications. A report of the International Resource Panel. Ekins, P., Hughes, N., et al.
[62] Hatfield-Dodds, S., et al., (2017), Assessing global resource use and greenhouse emissions to 2050, with ambitious resource efficiency and climate mitigation policies, Journal of Cleaner Production, Volume 144, , Pages 403-414, http://dx.doi.org/10.1016/j.jclepro.2016.12.170
Material economics (2018), The circular economy - a powerful force for climate mitigation.
[63] IPCC, 2018, Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by governments, October 8, 2018
[64] Based on extrapolation to global industries of the results in: Material economics, 2018, The circular economy - a powerful force for climate mitigation.

2. Enhance recycling to use waste as a resource
Approximately half the potential for circular mitigation in European industries lies in using waste as a resource. By feeding waste materials back into the processing phase of a value chain, emissions from the *Take* and *Process* phases can be reduced. For the vast majority of products and materials we use, producing them from primary materials yields far greater greenhouse gas emissions, than producing them from recycled materials.[65]

3. Circular design: reduce material use
Lightweighting products adds another quarter to the circular mitigation potential in European industry. This requires changing product design.

4. Circular design: prioritise low-carbon materials
The first three strategies are aimed at reducing the demand for materials and rely on the extensive work done by the International Resource Panel and Material Economics. Substituting carbon-intensive materials with low-carbon and potentially bio-based alternatives is another promising strategy which has barely been explored, as yet. When it comes to biomass however, using it for its material properties is a more effective mitigation strategy than using it as a renewable energy source.[66]

An example is the utilisation of bamboo, wood and organic-fibre materials in the built environment or other applications with a very long lifetime. These materials can sustain their embodied carbon for the many decades of life-expectancy typical for a building, or durable consumer product. These materials can even replace highly carbon-intensive bulk products, such as metals and processed mineral elements, which so dominate material use in the construction sector.[67]

However, the production of wood, bamboo or other organic-fibre materials requires land and, consequently, competes with other services also dependent on that resource - such as food production, or residential real estate. Furthermore, global forest cover and aboveground biomass stock is still declining. This limits the potential for responsible sources of woody biomass to countries which have stringent and well-enforced environmental legislation in place to ensure sustainable forest management.

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[65] 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
[66] Geng, G., et al., (2017) Review of carbon storage function of harvested wood products and the potential of wood substitution in greenhouse gas mitigation, Forest Policy and Economics, Volume 85, pages 192-200, http://dx.doi.org/10.1016/j.forpol.2017.08.007
[67]Ramage, M.H.., et al., (2017), The wood from the trees: The use of timber in construction, Renewable and Sustainable Energy Reviews, Volume 68, , Pages 333-359, Available from: http://dx.doi.org/10.1016/j.rser.2016.09.107
0 Oliver,C.D, Nassar, T.N., Lippke, B.R. McCarter, J.B. (2014) Carbon, Fossil Fuel, and Biodiversity Mitigation With Wood and Forests, Journal of Sustainable Forestry, 33:3, 248-275, https://doi.org/10.1080/10549811.2013.839386
Geng, (2018) carbon storage of harvested wood products, http://dx.doi.org/10.1016/j.forpol.2017.08.007

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