THE CIRCULARITY GAP REPORT

2019

Closing the Circularity Gap in a 9% World

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.

The Platform for Accelerating the Circular Economy (PACE)

This report is published as part of the Platform for Accelerating the Circular Economy (PACE). PACE is a public-private collaboration mechanism and project accelerator dedicated to bringing about the circular economy at speed and scale. It brings together a coalition of more than 50 leaders and is co-chaired by the heads of Royal Philips, the Global Environment Facility and UN Environment. It is hosted by the World Economic Forum.

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

Roy Antink

SVP, International Policy Coordination, Sustainability at Stora Enso.

"The report convincingly makes the case for urgent action addressing the massive development challenge in the built environment. Immediate changes in planning, design and construction processes are needed that encourage the use of renewable and low carbon materials, that allow for future disassembly and reuse. In addition - and particularly in Europe - strategies are needed that help renovation and where possible the extension of existing buildings.

Peter Bakker

CEO at WBCSD

"The shift to a circular economy is essential for achieving a world in which nine billion people live well within the means of the planet. At 9.1% circular, we have substantial work to do. The Circularity Gap Report helps business identify circular investment opportunities that drive impactful change. Through Factor10, WBCSD and its more than 30 member companies are committed to driving a circular transition in developing common metrics, advocating for enabling regulations and convening value chains to collective scale circular economy solutions.

Pamela Coke-Hamilton

Director Trade and Commodities at UNCTAD

"In a global economy of 7.5 billion people, a number of markets, jurisdictions and complex value chains coexist. Environmental solutions cannot be engineered top-down or through multilateral negotiations alone. Rebalancing national incentives – and orchestrating those across jurisdictions - is essential for value chains to develop circular patterns of trade. This can help the international community in the pursuit of the SDGs, as well as in the implementation of the Paris Agreement.

Marieke van Doorninck

Deputy Mayor Sustainability and Urban Development at City of Amsterdam

"The City of Amsterdam is keen to make the transition towards a circular economy and aims to be a fully circular and climate neutral city by 2050. Urban leadership will lead the way on delivering the positive effects of a circular economy. A shift in the tax system from labour to raw materials provides the right impetus and is crucial for this process. Solidarity and justice are at its heart to the transition.

James Drinkwater

Director Europe at World Green Building Council

"The Paris Agreement demands that we decarbonise the global building stock, and this timely report highlights the urgency with which we must address the construction sector's total emissions impact. Without radical action towards circular construction, embodied emissions in our sector will continue to rise, eating into our achievements on operational emissions. The Green Building Council movement stands with Circle Economy and those willing to take on this challenge.

Dr. Kirsten Dunlop

CEO at the EIT Climate-KIC

“This report tackles many aspects of the circular economy: capital goods design, practices in the sourcing of building materials, and measurements and metrics. They all share a common feature: the potential to work on a systemic level. Metrics in particular, if they are appropriately crafted, offer a powerful framework to assess where public-private interventions such as the ones EIT Climate-KIC supports, can be systemic and effective. The first lines of the Circularity Gap Report 2019 make it clear: the circularity gap is not yet shrinking. As we go forward, focusing our efforts on more systemic approaches to analysis, measurement, experimentation and, all, design, we expect to see further editions of this report refine our capacity to measure the circularity gap and expand our understanding of the role of product and service design in driving systemic change.

Pascal Eveillard

Director Sustainable Construction at Saint-Gobain

“This second edition of the Circularity Gap Report brings forwards new challenging arguments, ideas and concept to foster the development of a more circular economy: the DISRUPT model and the Mass-Value carbon equation in particular will deserve attention from decision makers. The focus on the construction sector demonstrates again the circularity potential in this sector and very smartly highlights the importance of properly maintaining and renovating our built environment stock.

Dr. Willi Haas

Social Ecologist at University of Natural Resources and Life Sciences (BOKU) Vienna

“If Paris Agreement or Sustainable Development Goals: There is no lack of ambitious goals to achieve a decent living for all. However, what’s lacking are multifaceted but directed actions across scales that are based on a consistent assessment on where we stand. The Circularity Gap report provides such a fundamental view on a specific aspect which nevertheless has the potential both to tackle multiple problems at the same time and to engage actors from different domains and levels. I thank the authors and wish the report to trigger small but decisive changes that pave the way for a change of direction in global developments.

Frans Van Houten

CEO at Royal Philips and Co-chair at the Platform for Accelerating the Circular Economy

“Without a healthy planet, there are no truly healthy people. Yet, the take-make-waste model that the world has pursued for far too long is failing both planet and people, alike. In response, Philips is pioneering innovations to deliver affordable, accessible, outcome-focused healthcare. By embracing Circular Economy models, we can drive forward the sustainable care agenda, both socially and environmentally. Helping align policy and purpose with best practice, the Circularity Gap Report provides clear guidance and actionable solutions to achieve that goal.

Naoko Ishii

CEO and Chairperson at the Global Environment Facility and Co-chair of the Platform for Accelerating the Circular Economy,

“The circular economy is a topic whose time has come, and I see more and more interest in this topic for both governments and businesses around the world. It is nothing less than a blue print for a fundamental transformation of our economic system—a transformation that that is urgently needed, that is entirely possible, and desirable.

Jyrki Katainen

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

“The European Commission and I personally, we have devoted last few years to put in place a conducive legal framework to build CE on. We do believe this work will help transform the European economy towards a more sustainable, low carbon and resource efficient future. But it’s just foundations that have been laid. A lot more is needed. This report is a useful reminder for all of us, public authorities, business, consumers, investors that there is still long way to go. The journey towards the global circular economy has just begun.

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

Martijn Lopes Cardozo

CEO at Black Bear

"The promise of the circular economy is to live in harmony with nature again. It is also essential for resolving our climate crisis and start living within our planetary boundaries. But how do we get started? This report is a wake up call and shows that with 9% circularity we are still scratching the surface. After reading the report ask yourself: What can you do to help save the planet?

Dr. Mari Pantsar

Director carbon-neutral circular economy at Finnish Innovation Fund SITRA

"The global sustainability crisis has four dimensions: the climate crisis, the biodiversity crisis, the crisis of overuse of natural resources and the crisis of social inequality. It is time for us to face the culprit of this crisis: our current consumption pattern. We simply cannot continue our current way of consuming in a world that is only 9.1 % circular.

Janez Potočnik

Co-chair at the UNEP International Resource Panel and Partner at Systemiq

"Circular economy is a concept already accepted by many, but when it comes to the implementation in practice, we are still at the beginning. Circularity Gap Report is trying to asses this gap and it is providing a very valuable insights on the state of the journey. Useful and interesting work with a lot of potential.

Kate Raworth

Author of the book 'Doughnut Economics' and Senior Visiting Research Associate at ECI, University of Oxford

"For insight into the dynamics of the circular economy, read the Circularity Gap report. Full of pioneering concepts, metrics and analysis, it starts to make visible the essential qualities of the 21st century economy that we must now create.

Samir Saran

President at Observer Research Foundation

"The circular economy, an eastern reality is fast becoming a western cause. We see the proliferation of new and established businesses embracing recycling and circularity. Understandings around the distribution of benefits and the long term impacts for big and small economies is yet to be fully deciphered. Who will benefit from this new opportunity? How will value be transferred to those who most require it? And, will the ownership and benefits be once again captured by the incumbents? The "Circularity Gap Report" is an important contribution that seeks to respond to some of these issues that will allow for international collaboration, development and prosperity for all.

Achim Steiner

Administrator at United Nations Development Program (UNDP)

"As climate change experts and practitioners are increasingly searching for new and innovative approaches to increase the climate ambition to enable the achievement of the Paris Agreement, circular economy has the potential to shift our world economy to a 2ºC or even 1.5ºC pathway since 67% of global greenhouse gas emissions are related to material management.

Holger Schmid

Director of the Sustainable Economy Programme at MAVA Foundation

“Innovative solutions and partnerships, which contribute to accelerate the transition towards Circular Economy in Switzerland and beyond are crucial. MAVA believes strongly in investing in innovation by supporting individuals to learn and apply an entrepreneurial approach. Local or global, this important Circularity Gap Report shows how much effort is still needed to make everyone join this exciting journey towards circularity and emphasises the need for a collective dynamic promotion of cross-sector innovation.

Feike Sijbesma

CEO at DSM

“This report demonstrates that circularity is key for achieving the climate goals of the Paris Agreement. However, the measurable progress in developing circular business, since the first Circularity Gap Report, is limited. The continuous development of robust frameworks and metrics is needed to accelerate the transition from a linear world, in which the use of resources and energy is in fact inefficient, to one which is circular, also preserving value better. Business has to lead this trajectory and drive the transition based on clear indicators.

Dominic Waughray

Senior Director and Head of Environmental Initiatives at World Economic Forum

“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.

Ken Webster

Researcher at University of Exeter and Associate at Ellen MacArthur Foundation

“This report takes us much further along the road towards realising a circular economy that is part of a new framework for thinking about the economy based on 21st century not 19th century science

Anders Wijkman

Chairman of the Governing Board of Climate-KIC and Former Co-president at the Club of Rome

“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.

Mark Watts

Executive Director at C40

“A 1.5 degree world will be a circular world. At a time when national governments are not moving at the pace required to avoid climate crisis, cities are leading the way. Circle Economy’s second annual Global Circularity Report gives us concrete examples of where change can be achieved and how.

Gino Van Begin

Secretary General, ICLEI

“Building resilience in the face of climate change, achieving the Sustainable Development Goals and developing a low-carbon future demands that we move beyond an extraction economy. Circular development is one of ICLEI’s five pathways to sustainability, and The Circularity Gap Report shows how local and regional governments - our Members - can and should make high-impact choices to improve the circularity of their economies.

EXECUTIVE SUMMARY

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

A 1.5°C 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 achieving the goals of both 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; it will slow environmental degradation and reduce social inequality.

4 STEPS TO BRIDGE THE CIRCULARITY GAP THROUGH LEADERSHIP AND ACTION:

1. Translate global trends into national, regional and commercial pathways. This will enable nation states, regions, cities, industry and business to formulate practical strategies that are aligned to local context, incentives, markets and mandates.

2. Develop decision metrics and a measurement framework. This will encourage goal-setting, evaluations and peer review, which will in turn serve to benchmark performance and track progress against such longer-term global ambitions as the Paris targets and the SDGs.

3. Facilitate peer-to peer learning and knowledge transfer. This will accelerate the international dissemination of effective circular economy policies and practices, fostering a collaborative ethos that helps to grow understanding and speed uptake.

4. Build a global coalition for action that is both diverse and inclusive. This will bring together front-running businesses, governments, NGOs and academics to collectively boost capacity and capability, so serving societal needs better and more sustainably.

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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 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. 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;

COURSE CORRECTION: MASS-VALUE-CARBON 1900-2050

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 of 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.

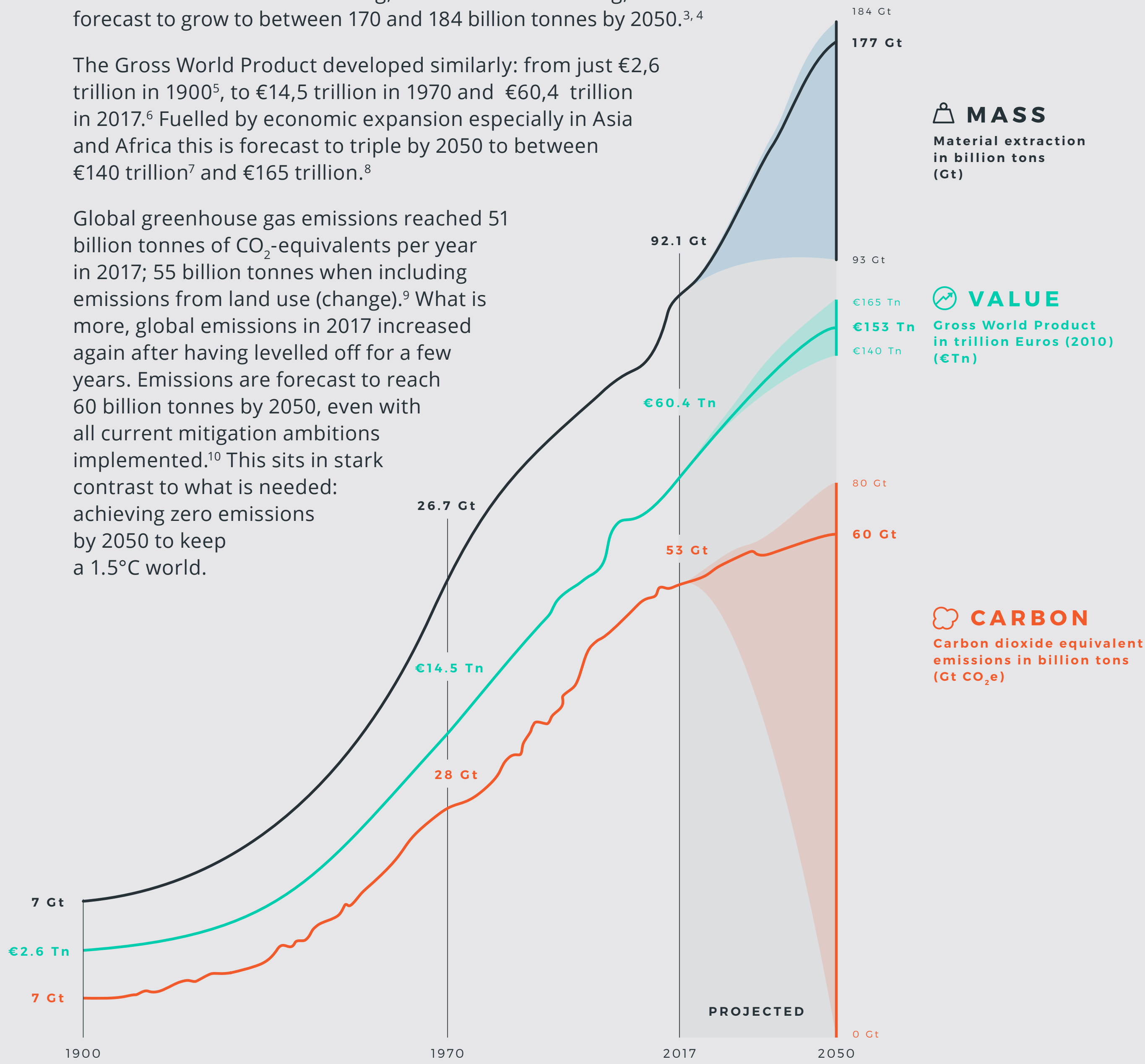


Figure 1 shows the development for material extraction (Mass), financial value creation (Value) and greenhouse gas emissions (Carbon) from 1900 to 2017 and projected to 2050.

DISRUPT: 7 KEY 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. 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.

D — **Design For the Future:** Adopt a systemic perspective during the design process, to employ the right materials for appropriate lifetime and extended future use.

I — **Incorporate Digital Technology:** Track and optimise resource use and strengthen connections between supply-chain actors through digital, online platforms and technologies.

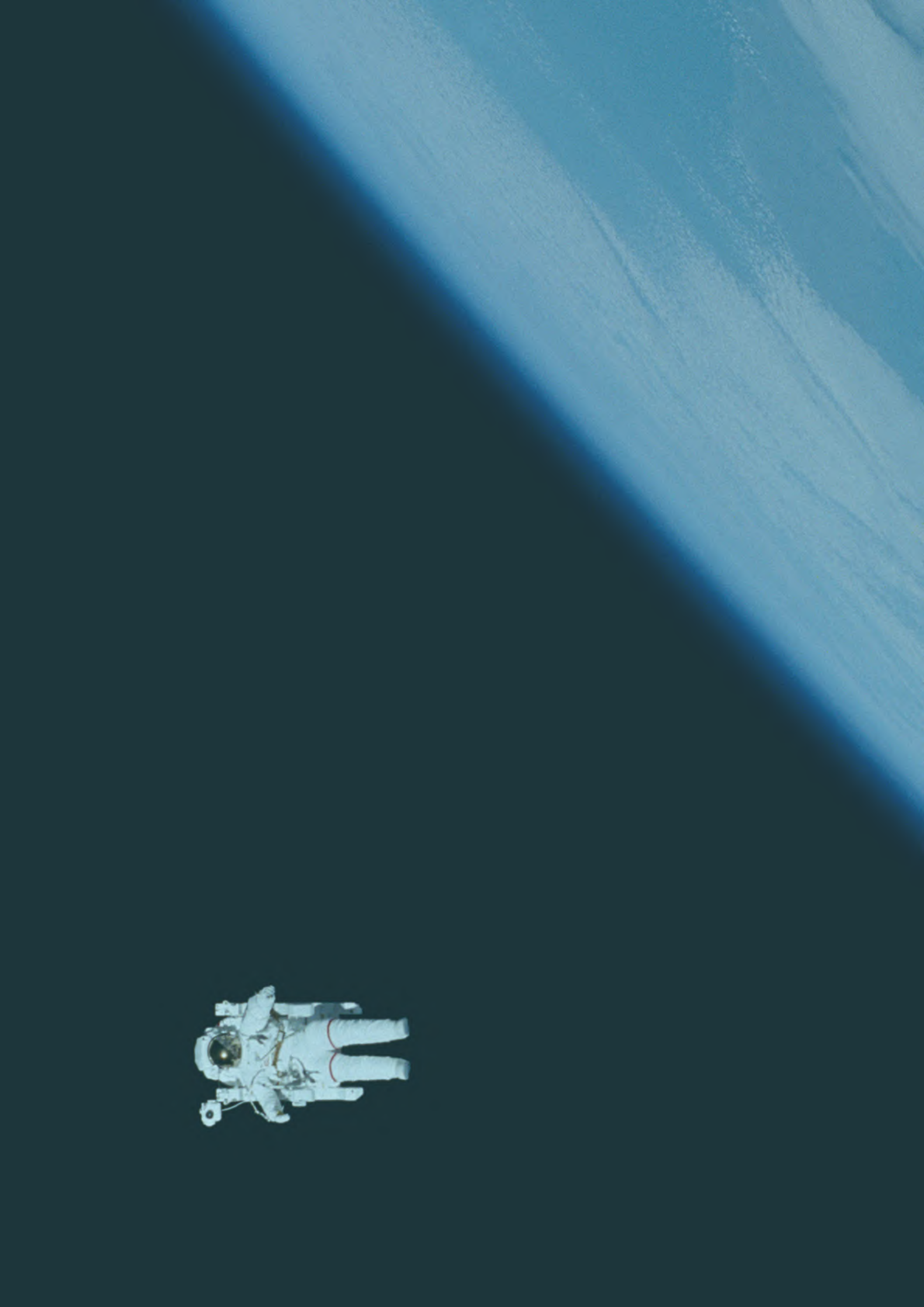
S — **Sustain & Preserve What's Already There:** Maintain, repair and upgrade resources in use to maximise their lifetime and give them a second life through take-back strategies, where applicable.

R — **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.

U — **Use Waste as a Resource:** Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.

P — **Prioritise Regenerative Resources:** Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way.

T — **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.



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 climate 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 materials 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 help to 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.[11]

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 products 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).[12]

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 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 insurance. 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 homecare equipment.

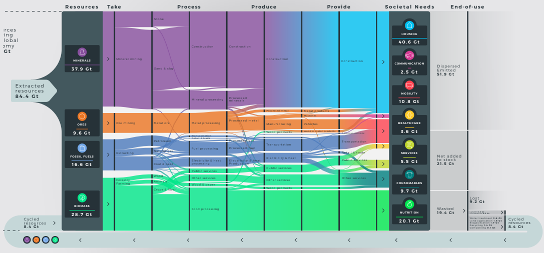
Communication

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.

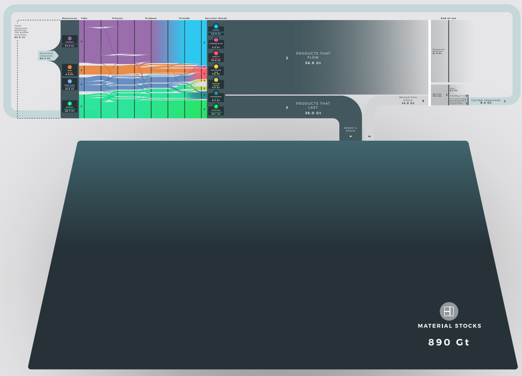
THE GLOBAL MVC FOOTPRINT BEHIND SATISFYING 7 SOCIETAL NEEDS

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 on the following pages 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?

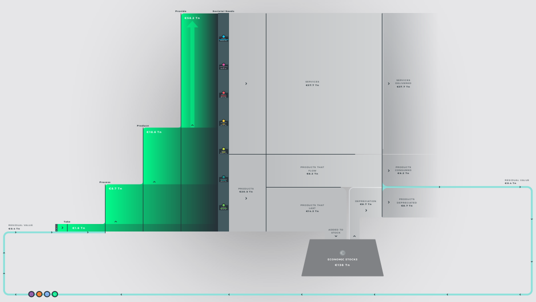
WHAT YOU WILL READ



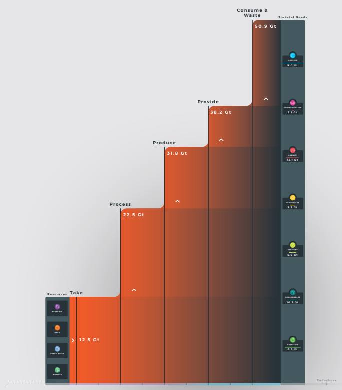
- Our global economy is only 9% circular; 8.4 Gt of materials are cycled input, versus 84.4 Gt coming from extracted resources.
- Of the materials not cycled, the majority is lost beyond recovery - either dispersed in the form of emissions or unrecoverable waste.
- Housing, Nutrition and Mobility together represent more than 82% of the total material footprint.



- Accumulated material stocks are almost 10 times larger in total than annual material throughput - 890 Gt versus 92.8 Gt, respectively.
- Material stocks mostly comprise of minerals and metals in the form of buildings, infrastructure and capital equipment. with a smaller fraction made up of construction wood and plastics.
- The majority (60%) of materials enter the economy in the form of Products that Flow and a smaller fraction as Products that Last.



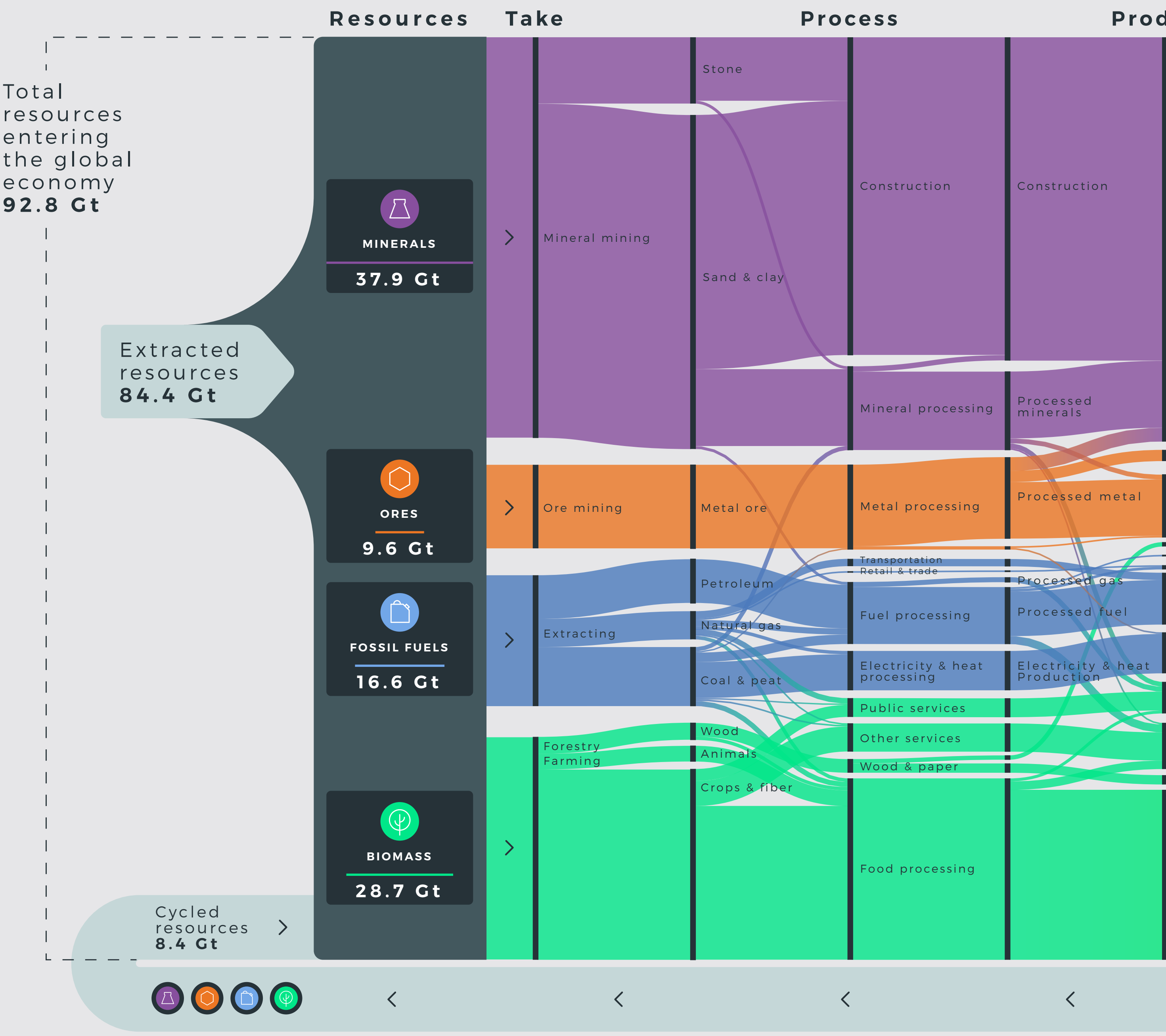
- The delivery of services is responsible for more than 60% of all value-add compared to less than 40% for products manufacturing.
- As all value-add in the production and use of a product depreciates with consumption over time, this shows the importance of slowing the flow by extending the functional lifetime.
- Just 4.6% of all value-add comes in the form of residual material value that re-enters the economy to replace extracted resources.



- Mobility and Consumables are the societal needs whose value chains have the largest carbon footprint, followed by Housing and Nutrition.
- Some 62% of global greenhouse gases are emitted during the Take, Process and Produce stages - circular economy strategies which extend lifetimes and use-intensity cut these emissions.
- When reducing greenhouse gas emissions, there is a fine balance between maintaining existing assets, or accelerating their replacement with more energy-efficient technologies.

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.[4] 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.[13] 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.

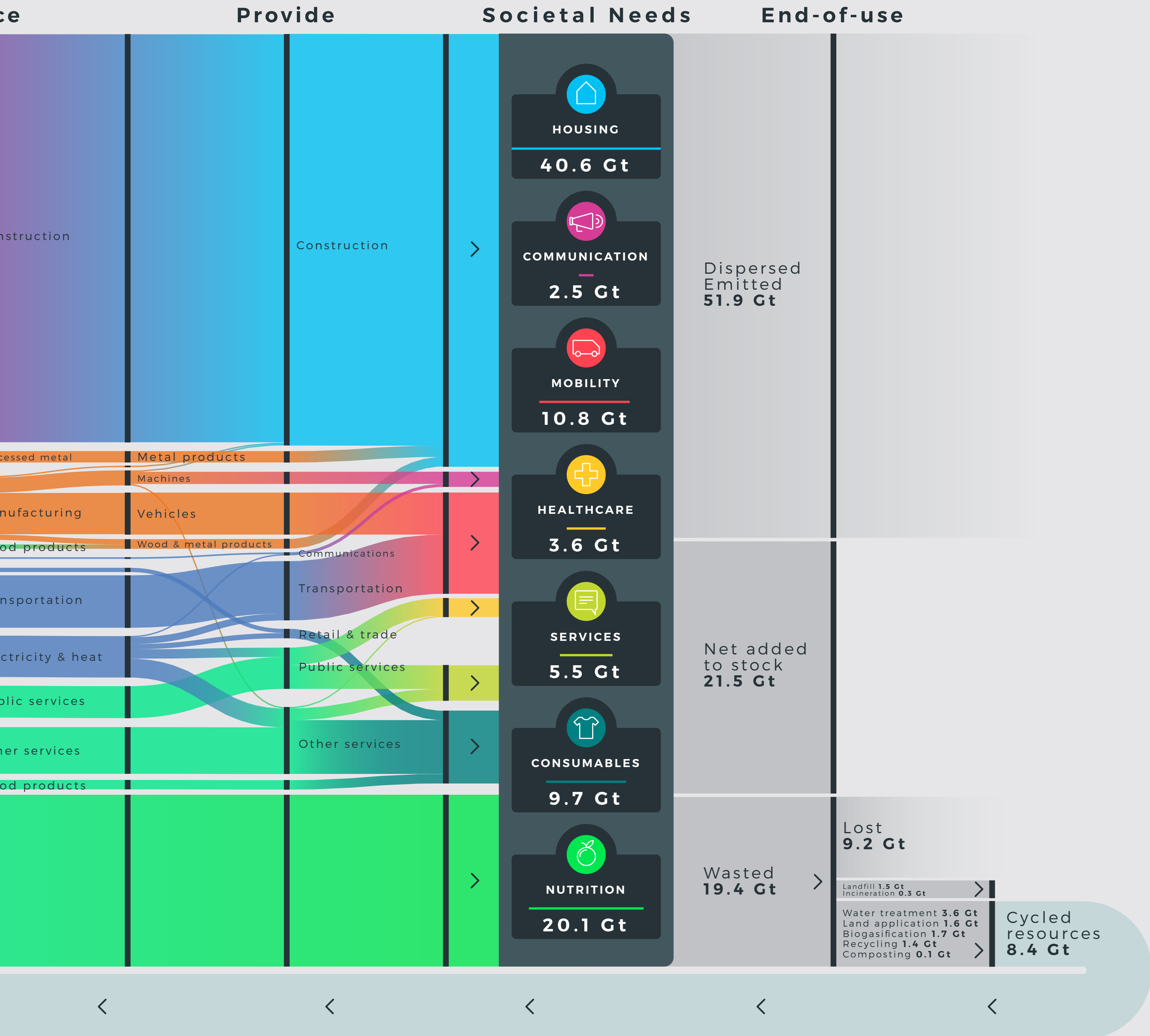
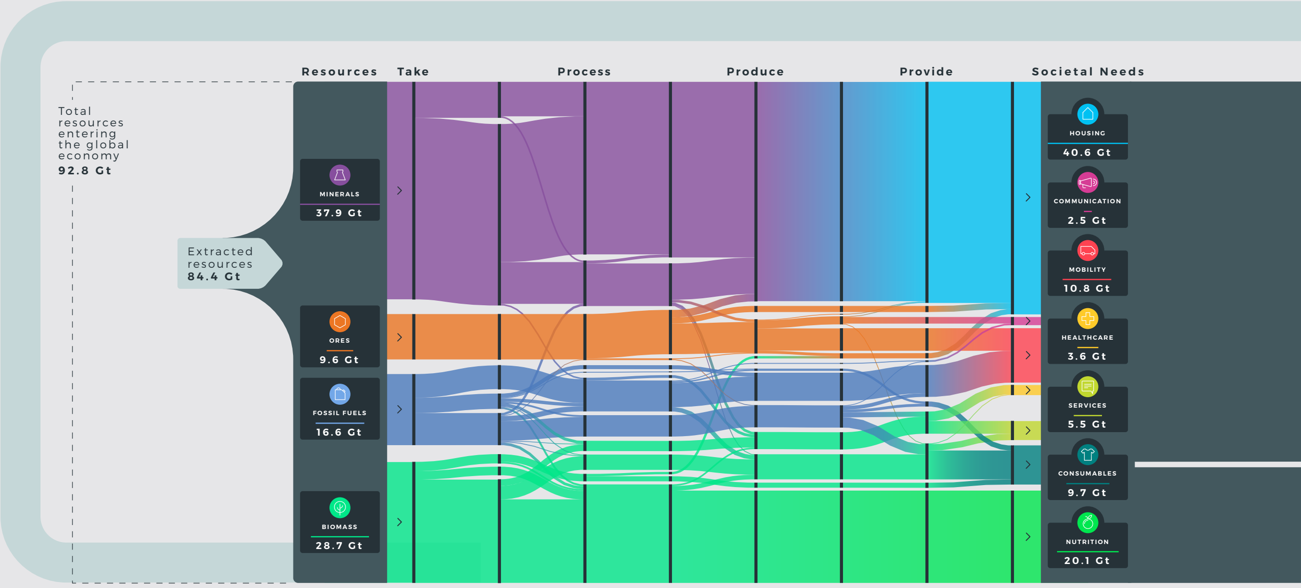


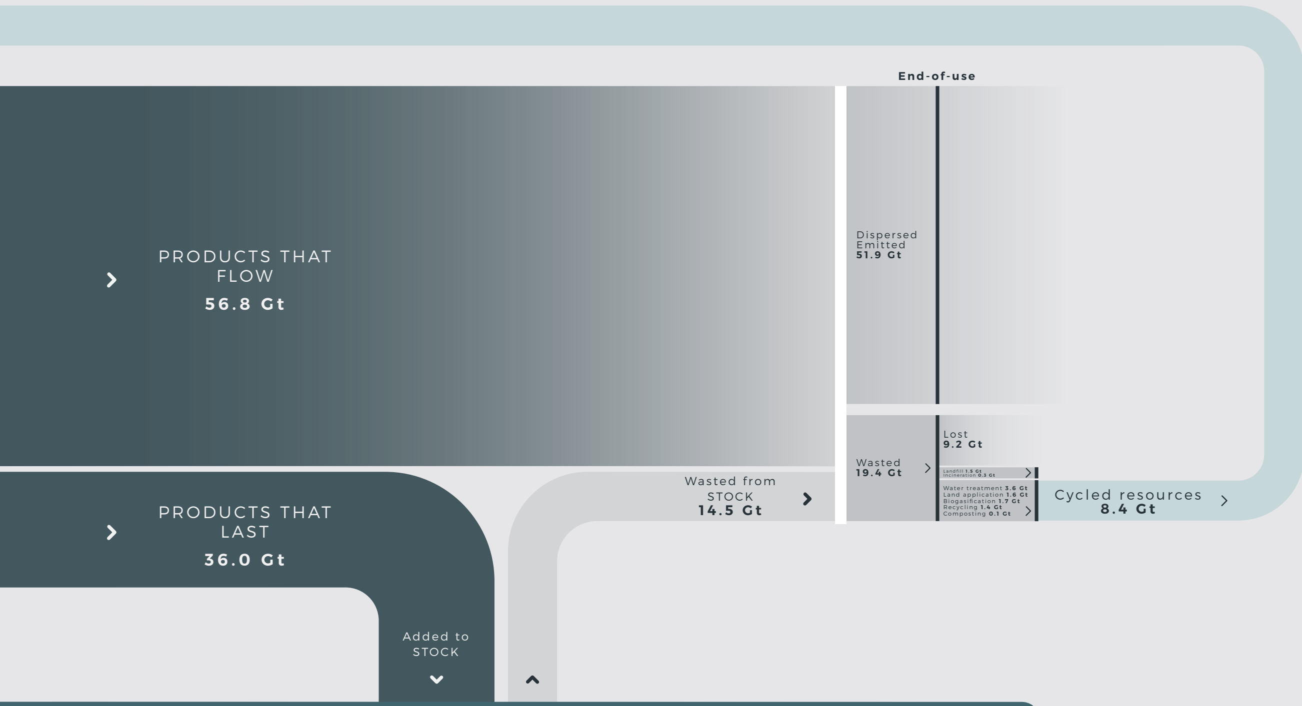
Figure 2. The global resource footprint behind meeting key societal needs



MASS: 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

Figure 3 shows the yearly material flows and accumulated material stocks in our economy.



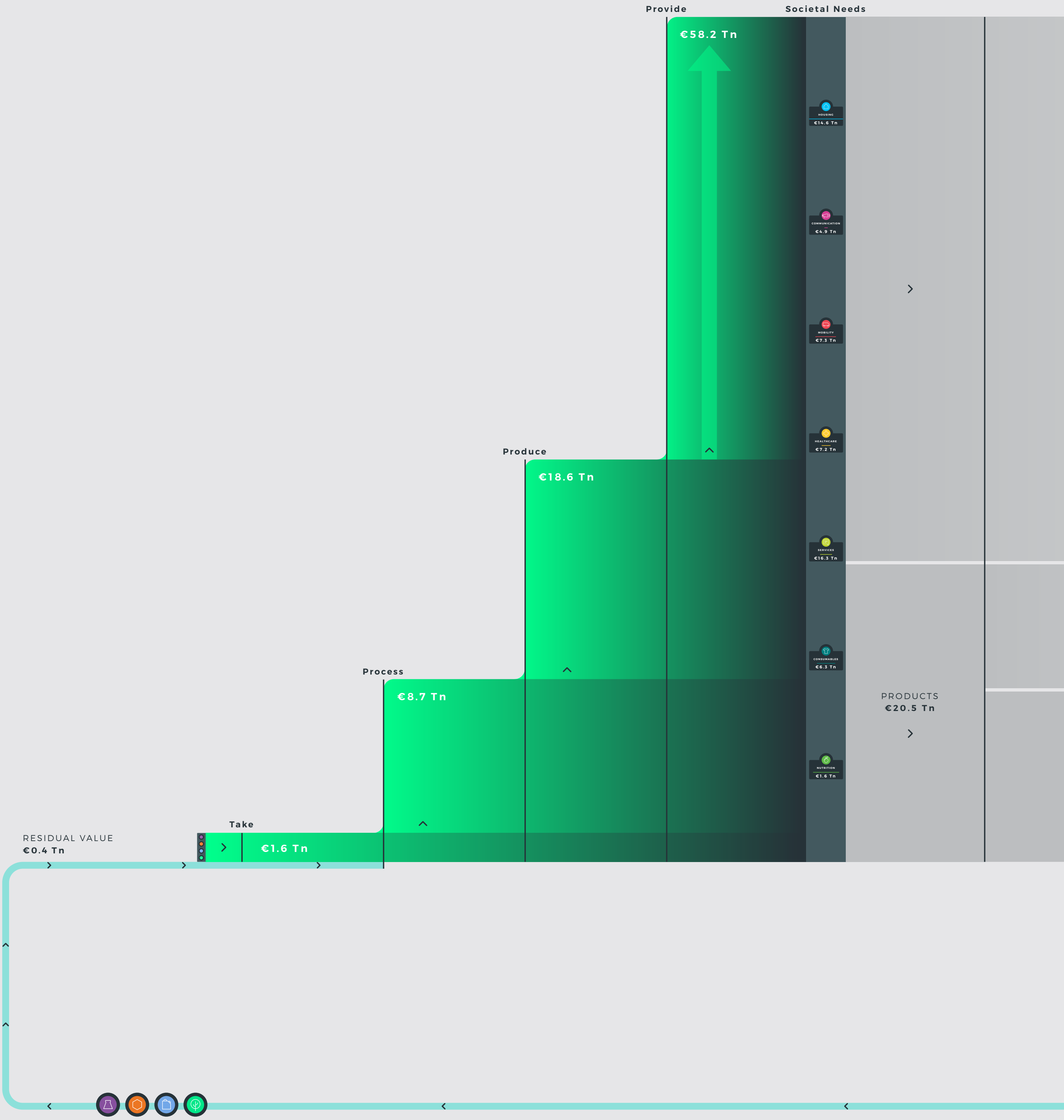
our economy account for almost 10 times more material compared to the annual throughput. The annual throughput was 92.8 Gt while the accumulated material stocks account for 890 Gt. Of these materials entering the global economy every year, the majority (56.8 billion tonnes) are being used by society as short-lived Products that Flow[14], reaching their end-of-use typically within a year. The remaining 36.0 billion tonnes of materials mentioned earlier, enter into long-term stock[15], referred to as Products that Last.[16] 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 (14.5 Gt)[15] (for example as demolition material, or metal from discarded machines and cars). The net result is a significant addition to stock of 21.5 Gt.

MATERIAL STOCKS

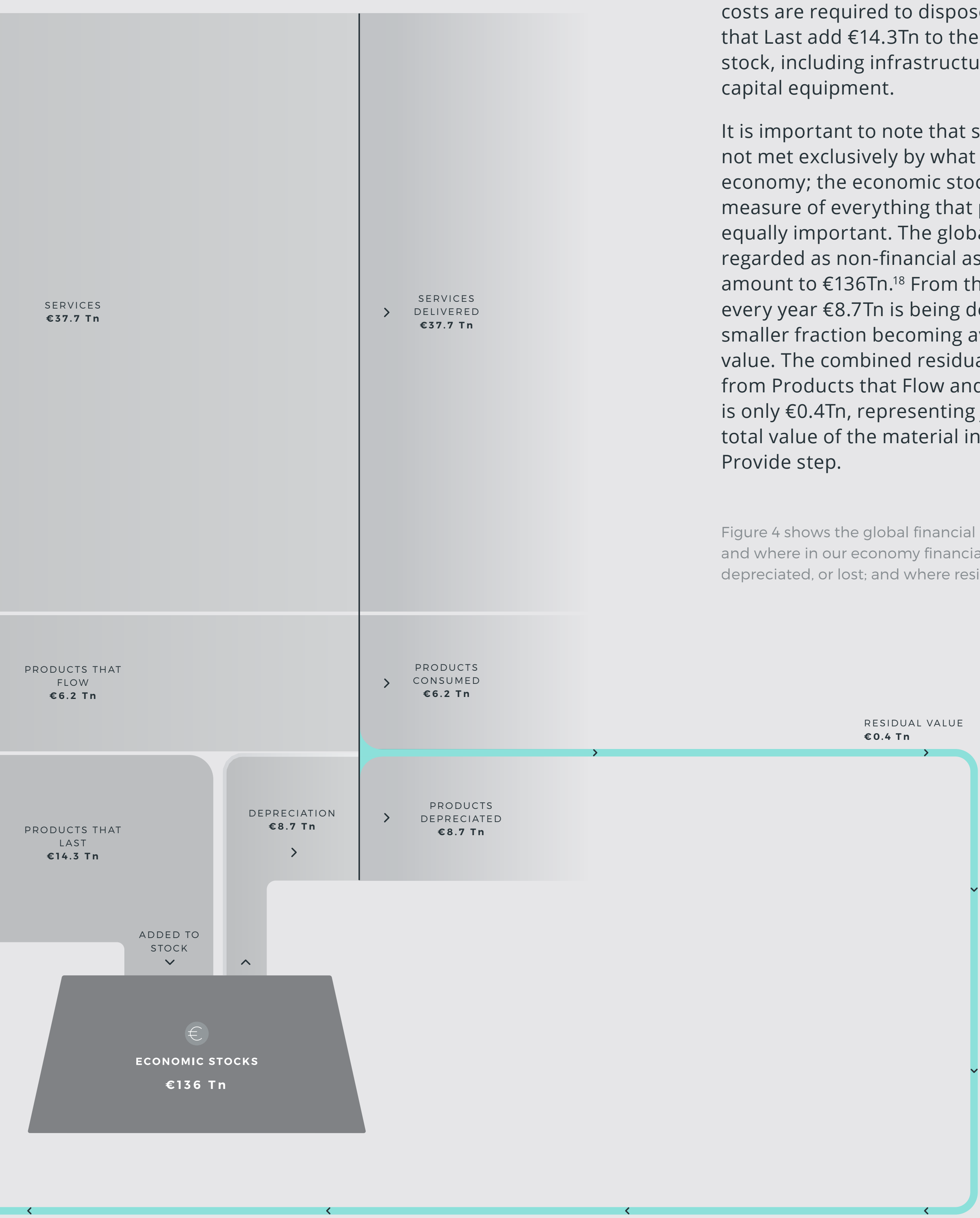
890 Gt

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 58.2 trillion Euros.[17] 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, residual 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.[18] 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.

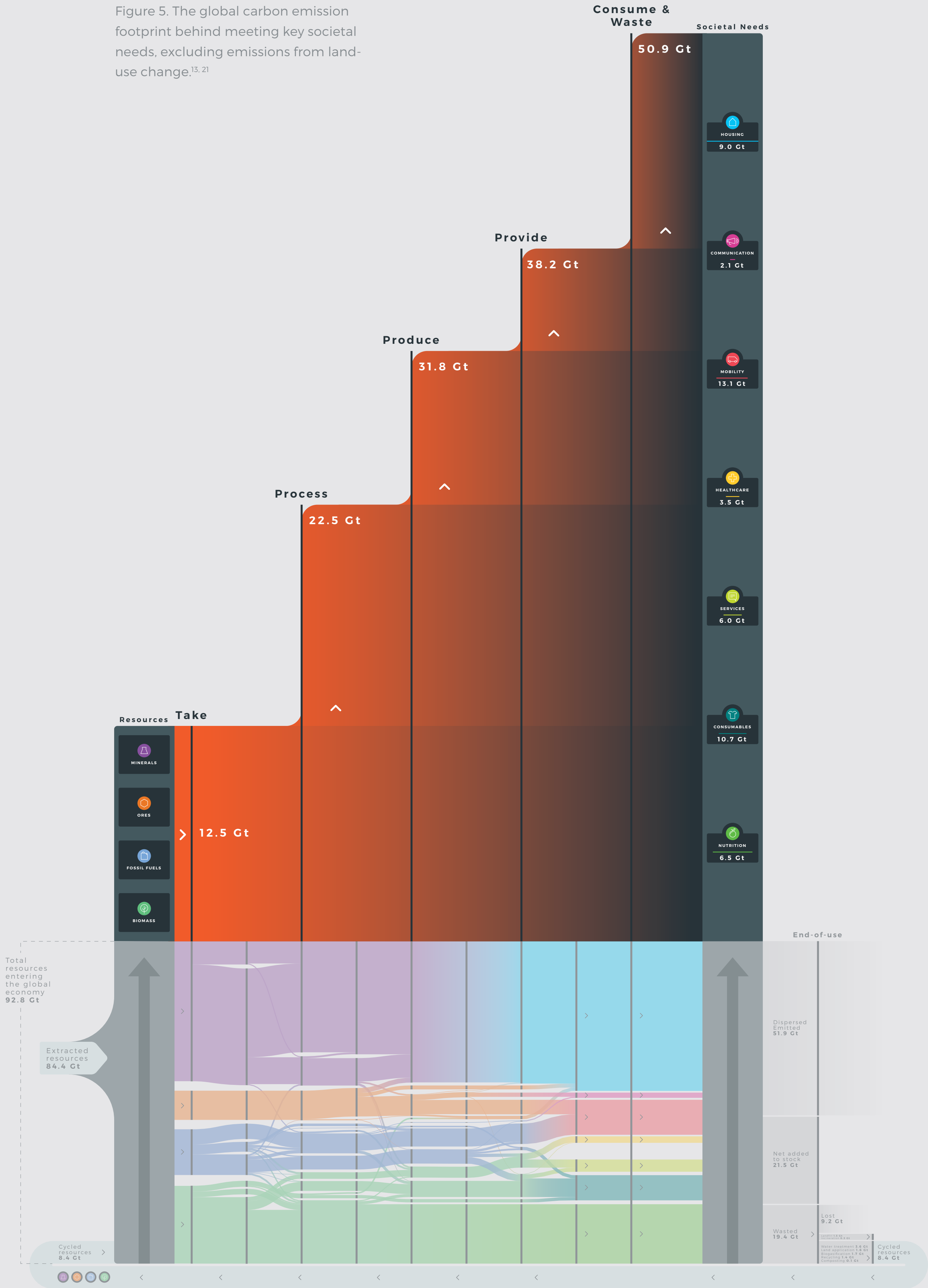
Figure 4 shows the global financial footprint linking how and where in our economy financial value is added, depreciated, or lost; and where residual value is left.

CARBON: THE GLOBAL EMISSIONS BUILDUP 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.[19, 20] 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 Gt CO_2e, 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 5. The global carbon emission footprint behind meeting key societal needs, excluding emissions from land-use change.[13, 21]



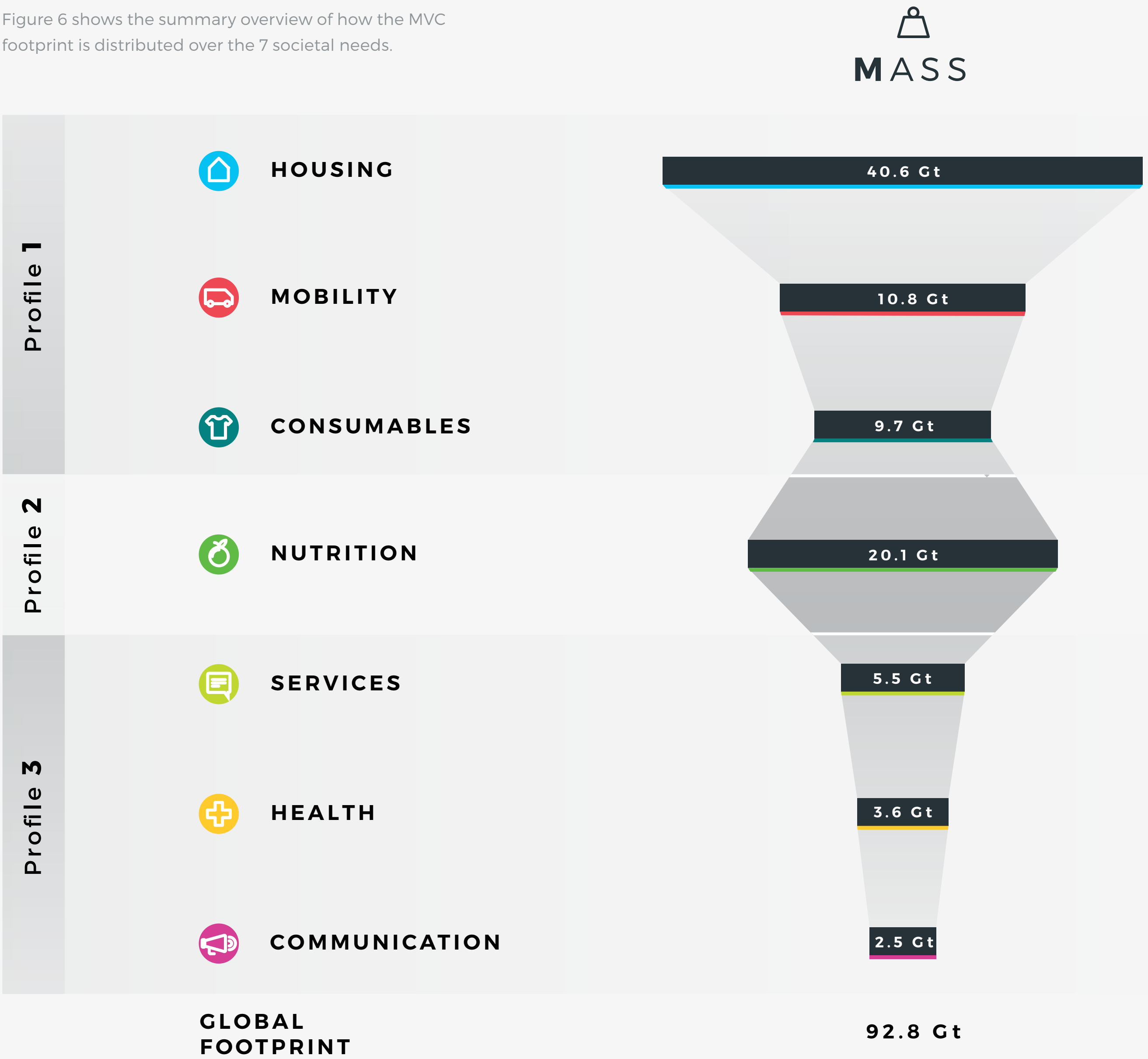
SUMMARISING THE **MASS-VALUE-CARBON NEXUS**

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.

Profile 1: Housing, Mobility and Consumables

Housing, Mobility and Consumables are together responsible for 66% of the total material footprint, 64% of the carbon footprint and 48% 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

Figure 6 shows the summary overview of how the MVC footprint is distributed over the 7 societal needs.



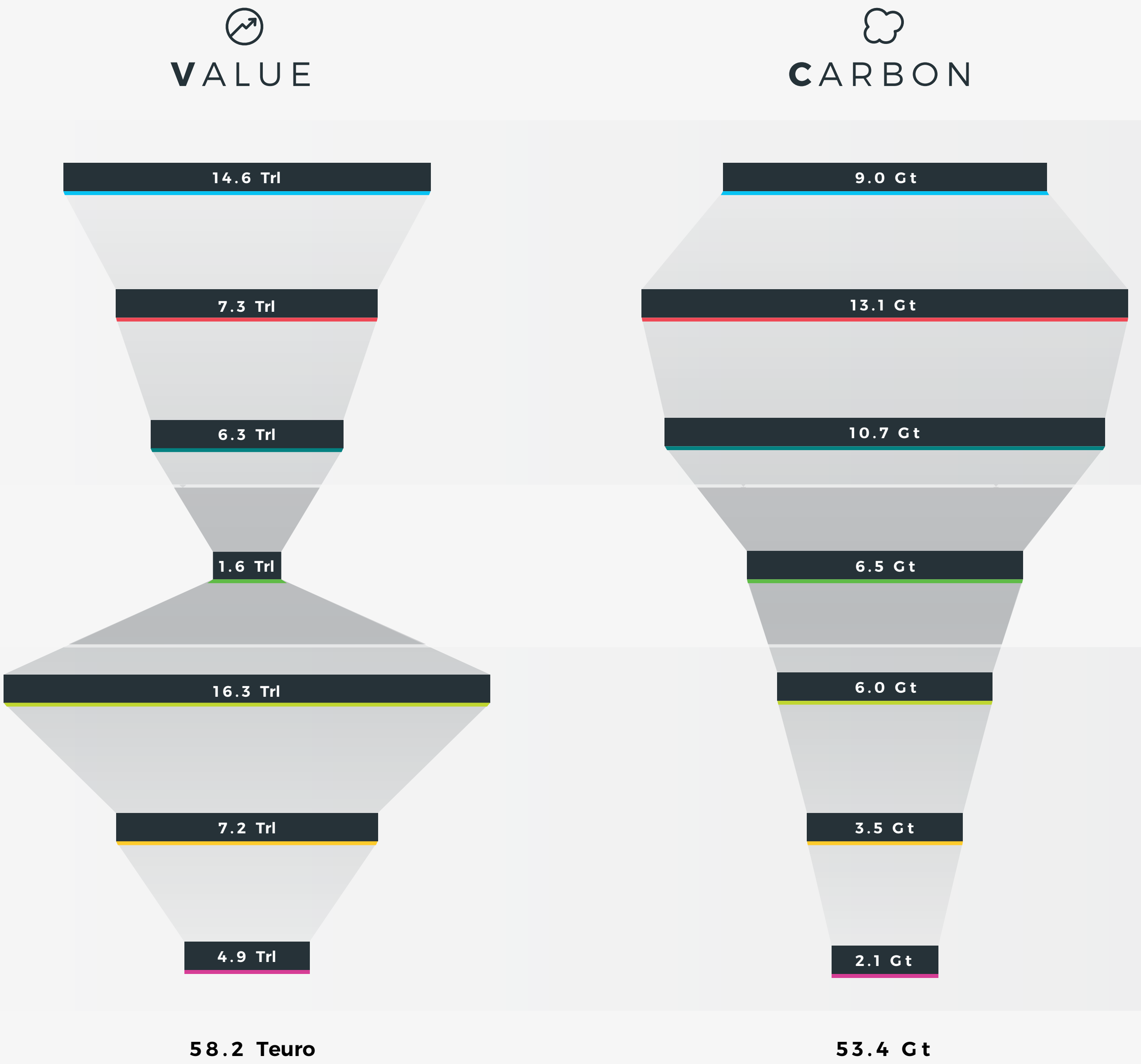
comfort, our desired mobility and material intensive vehicles, plus electronics and appliances explain the high energy use and related greenhouse gas emissions in these value chains. Typical solutions lie in improving the utilisation rate, which can be achieved by prioritising access over ownership.

Profile 2: Nutrition

Nutrition represents the second largest material footprint with 20.1 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 - fourth after mobility, consumables and housing. 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.

Profile 3: Services, Health and Communication

The third 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 3 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.



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 frameworks 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..[22] Then, taking material metabolism as our starting point, we explore and suggest a metric for global circularity.

The Global Circularity Metric applied

When we consider the four fundamentals, 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 29 the total resources entering the economy account for some 92.8 billion tonnes.[4] 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.[13] 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

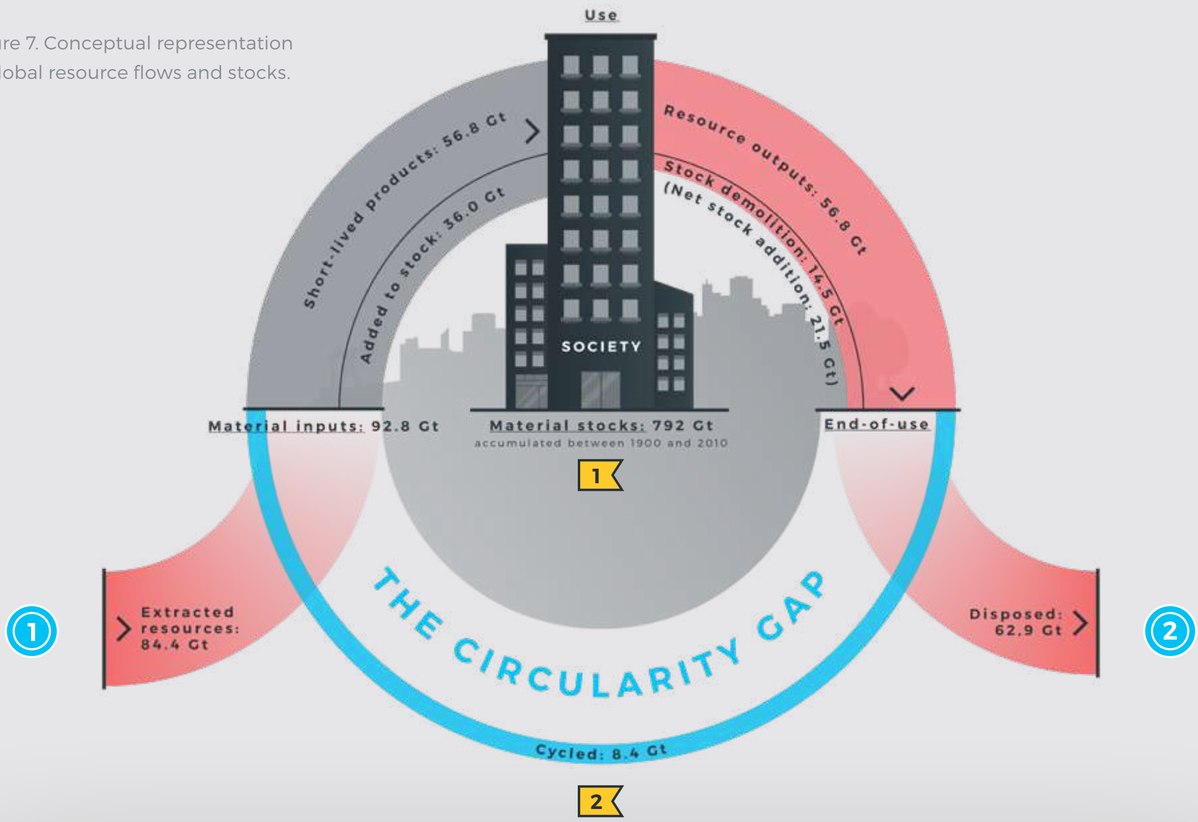
For the product group of Capital Equipment, determination of a definitive Circularity Gap figure did not prove possible, as yet, given current available data. Chiefly, this was because of a lack of sufficiently specific waste statistics for such a varied group of products. What the Capital Equipment 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.

TO FIND OUT MORE VISIT OUR WEBSITE

To find out more about the methodology we encourage you to visit our website:

www.circularity-gap.world

Figure 7. Conceptual representation of global resource flows and stocks.



OBJECTIVES & STRATEGIES

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:

(1) Objective 1:

Resource extraction from the lithosphere is minimised and biomass production and extraction is regenerative;

(2) 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;

1 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

2 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.

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 IMPACTS, 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.[23] In 2015, total material input to satisfy the need for housing was 41 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 sector 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[13], on average, a building material produced and used in China emits double the amount of carbon compared to Europe.

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.[24] 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.[25]

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 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)[45], 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.

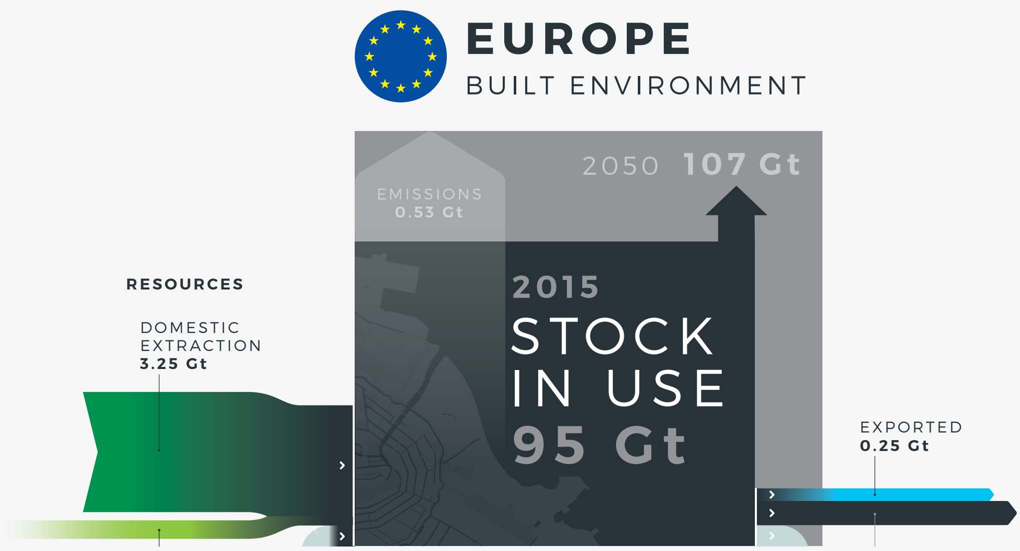
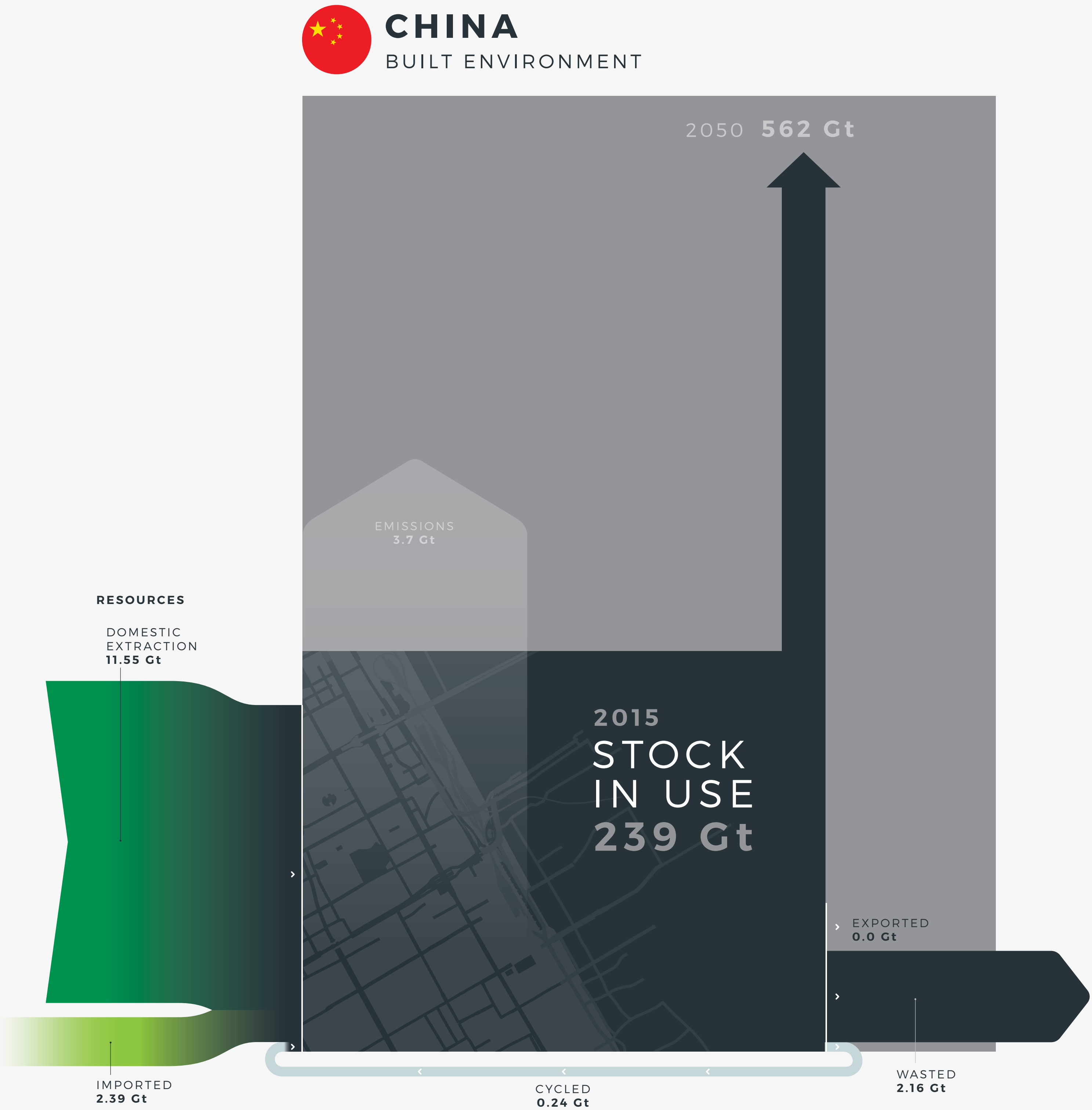


Figure 7 shows material flows and stocks for the built environment in Europe and China for 2015 and projected growth for both regions until 2050.[26-44]



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 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.

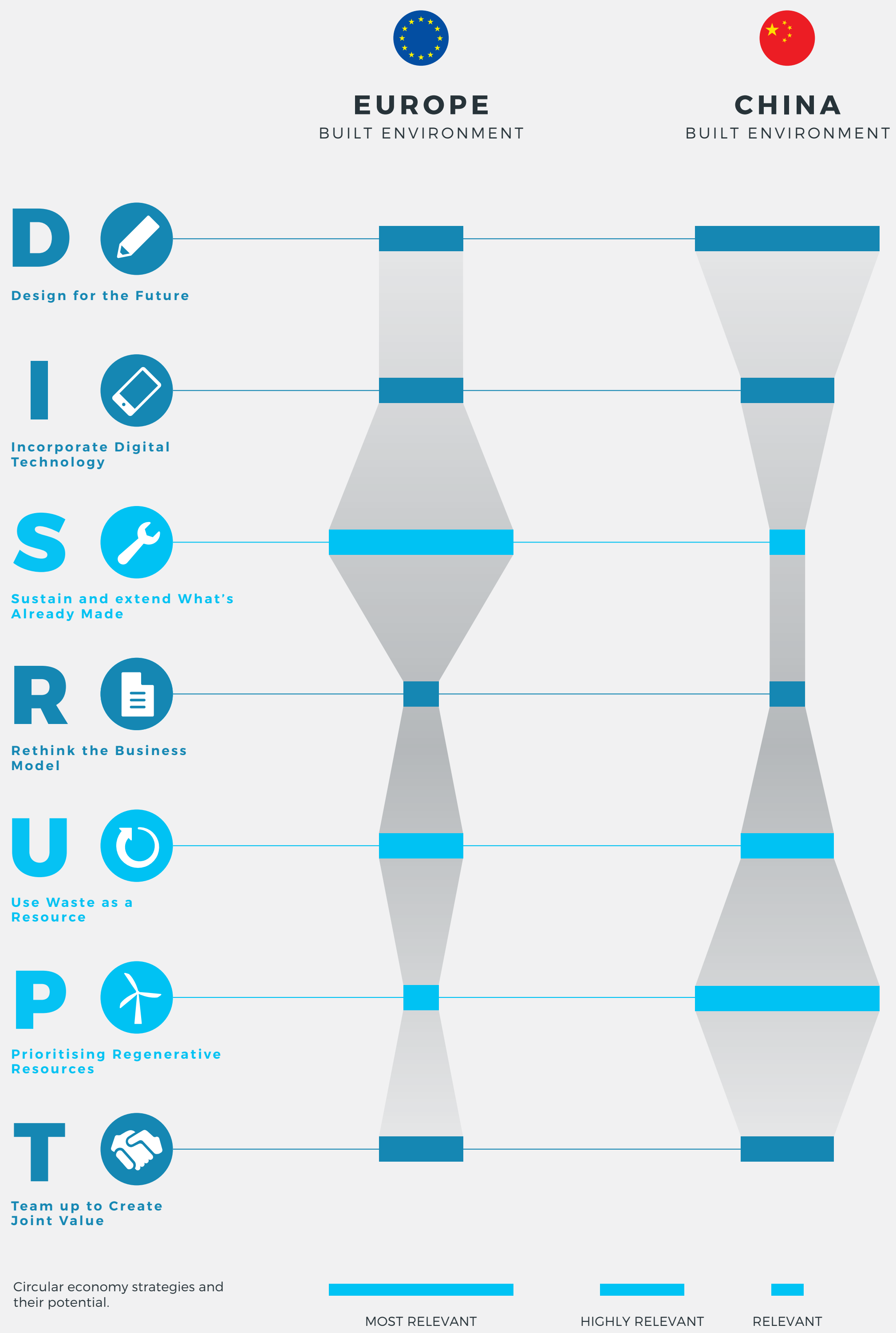
Opportunities to enhance flexibility in use are also valued for facilitating the repurposing of buildings. This ambition is to make and keep Europe's urban areas as sustainable as possible, whilst the inevitable, but gradual, process of stock replacement delivers ever-better building standards. This 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.[46] 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[47], 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.

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.

CIRCULAR ECONOMY STRATEGIES TO MOVE TO CIRCULARITY FOR THE BUILT ENVIRONMENT



Circular economy strategies and their potential.

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. Material impacts for capital equipment are comparatively modest, with only 7.2 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 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.

Critical dependence and increasing scarcity of metals

The metals used in capital equipment include rare and precious metals, used in high-tech applications. Many of these rare earths are forecasted to reach critical scarcity thresholds in the near future.[48] This accelerated demand for the materials is increasingly showing our critical dependence on and increasing the scarcity of our resources more than ever. The continuous extraction of 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. Some of these resources are critical to the continued agricultural production of crops, the acceleration of solar energy, and the scaling-up of electric transport.

CAPITAL EQUIPMENT CONSUMES HALF OF ALL METALS

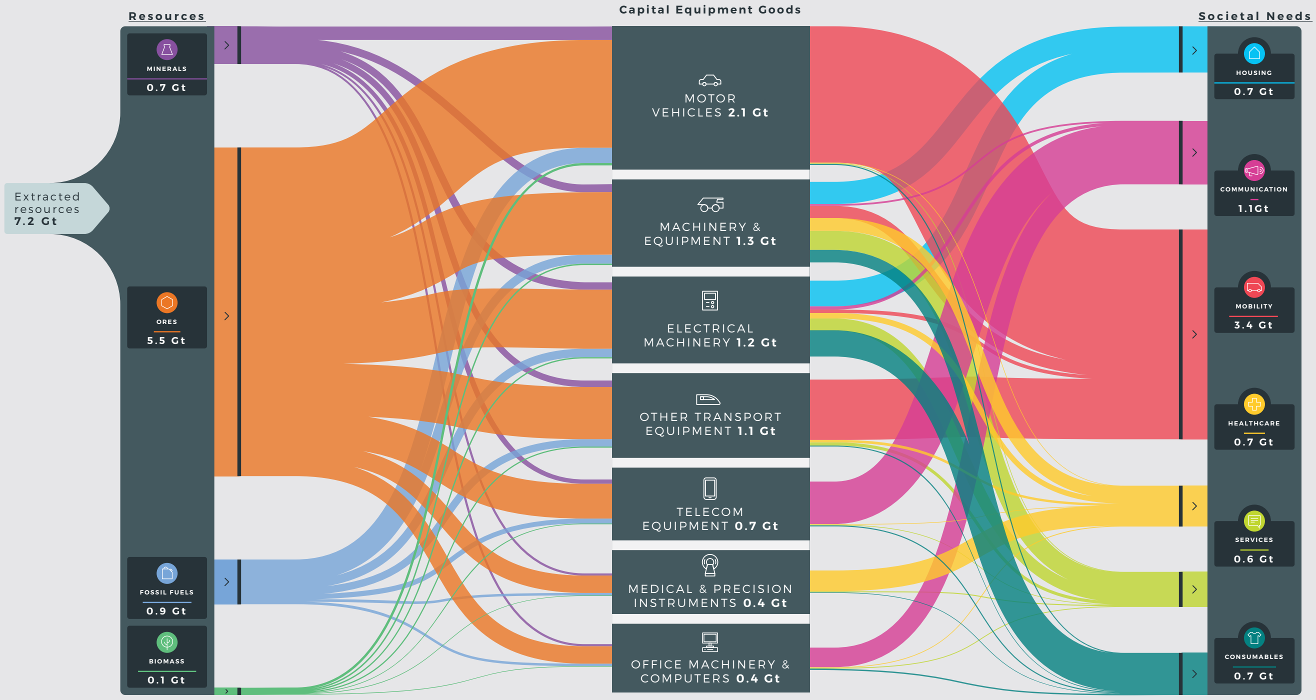


Figure 8 shows how the production and maintenance of capital equipment consumes 7.2 Gt materials per year, out of which 5.5 Gt are metals. This means that capital equipment consumes almost half (57%) of all metals used globally, in providing essential goods to cater to all societal needs. Mobility is the need consuming most materials within capital equipment (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 equipment. Broader categories of machinery, equipment and electrical goods can be attributed mostly to providing housing, healthcare and consumables to society.

THREE CIRCULAR STRATEGIES TO RETAIN VALUE

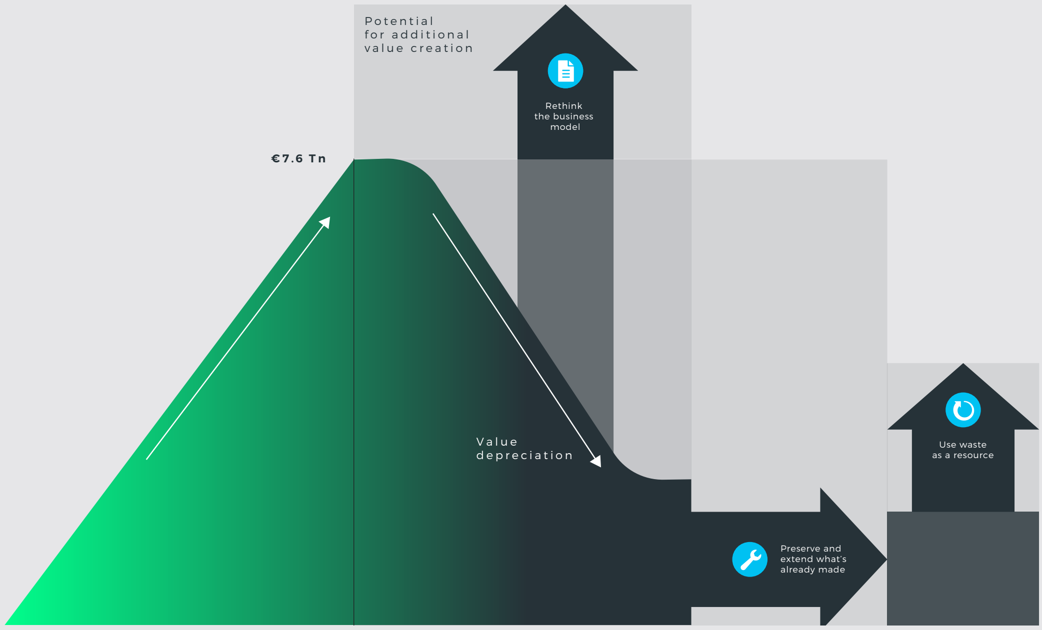


Figure 9 shows the potential of three circular strategies to increase value for specific products that are illustrative for the breadth of Capital Equipment.

The figure shows a 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 (see page 10) are most applicable for capital equipment aimed at value retention during their use and at end- of-life.

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.

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. Figure 10 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.

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.[49] 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.[50] 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.[51] 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 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.

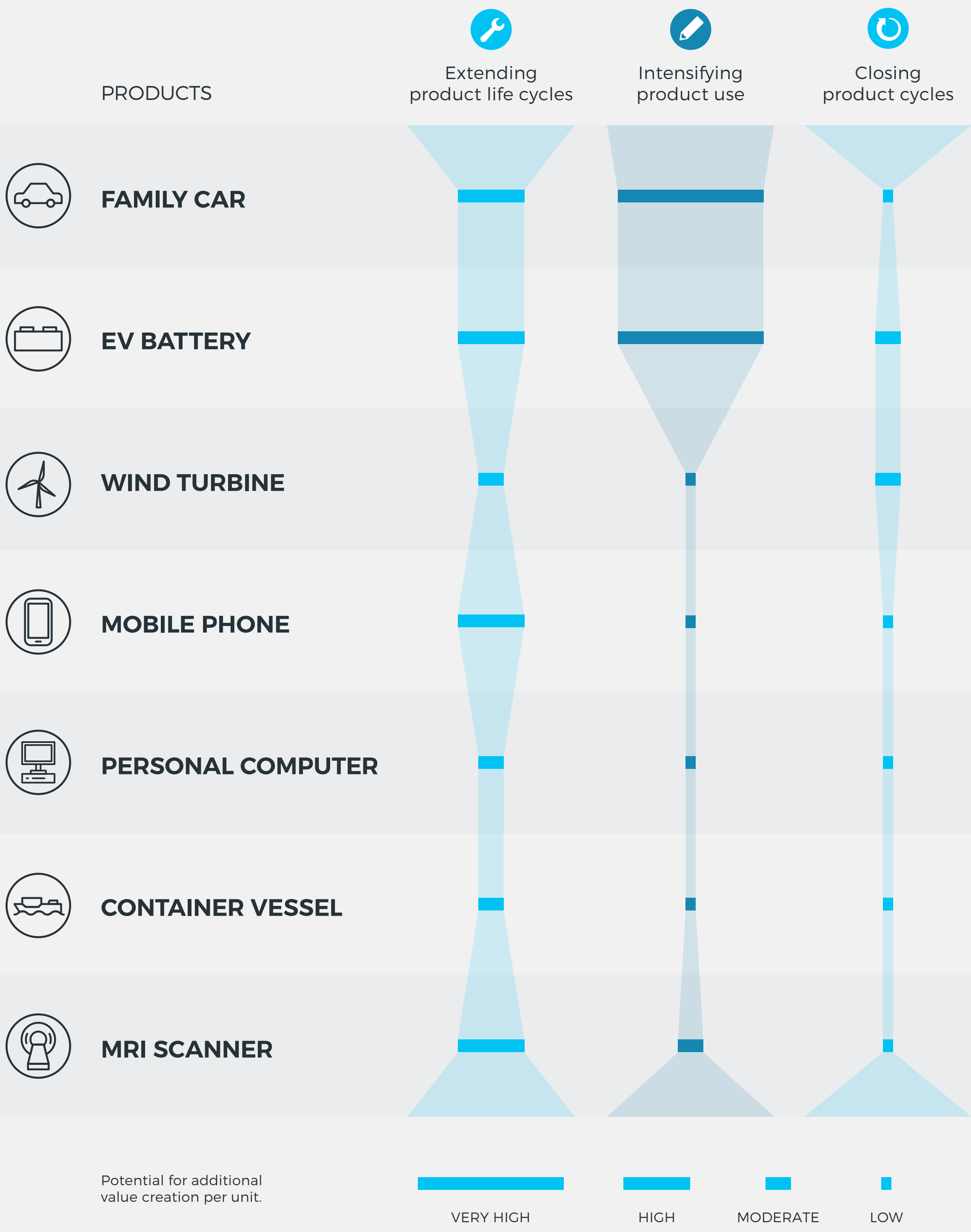


Figure 10 shows the potential of three circular strategies to increase value for specific products that are illustrative for the breadth of Capital Equipment..

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.[52] 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.[53] 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, 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˚C

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.[54]

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 analyses 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.[55] 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 understanding further.[56, 57] 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.[4, 54] 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.

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.

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.[59]

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.[60]

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.[61, 62]

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.

7 CLOSING THE GAP: THE WAY FORWARD

A circular economy represents a deliverable decoupling of economic growth from unsustainable resource extraction and emissions release. Aligned with strategies for both social equity and 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 by the Intergovernmental Panel on Climate Change (IPCC).[58] The pathway to a low-carbon future is therefore necessarily circular; there is no other way. Our world must become more than 9% circular.

4 STEPS TO BRIDGE THE CIRCULARITY GAP THROUGH LEADERSHIP AND ACTION:

1. Translate global trends into national, regional and commercial pathways. This will enable nation states, regions, cities, industry and business to formulate practical strategies that are aligned to local context, incentives, markets and mandates.

2. Develop decision metrics and a measurement framework. This will encourage goal-setting, evaluations and peer review, which will in turn serve to benchmark performance and track progress against such longer-term global ambitions as the Paris targets and the SDGs.

3. Facilitate peer-to peer learning and knowledge transfer. This will accelerate the international dissemination of effective circular economy policies and practices, fostering a collaborative ethos that helps to grow understanding and speed uptake.

4. Build a global coalition for action that is both diverse and inclusive. This will bring together front-running businesses, governments, NGOs and academics to collectively boost capacity and capability, so serving societal needs better and more sustainably.

REFERENCES

1. IPCC, 2018, Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by governments, October 8, 2018
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.
11. Walter Stahel in A new Dynamic - Effective business in a circular economy (2013) by the Ellen MacArthur Foundation
12. Science daily, 2018, Benefits and trade-offs of low-carbon energy, November 30, 2015
13. Exiobase v3 using 2011 data
14. Haffmans et al., 2018, Products that Flow: Circular Business Models and Design Strategies for Fast-Moving Consumer Goods
15. 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
16. Bakker et al., 2014, Products That Last - product design for circular business models
17. The World Bank, Gross Value Added at basic prices (GVA) (current US$)
18. Credit Suisse Global Wealth Databook 2018
19. 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
20. 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
21. 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.

22. 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

23. 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.).

24. European Building Database, data retrieved on 01/01/19

25. Lewis, J.O. et al. (2013) BUILDING ENERGY EFFICIENCY IN EUROPEAN CITIES. Cities of Tomorrow – Action Today. URBACT II Capitalisation. May 2013.

26. 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)

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

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

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

30. 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

31. 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

32. 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

33. 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

34. 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

35. 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

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

37. China Statistical yearbook (2017)

38. 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

39. 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

40. 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

41. 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

42. 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

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

44. 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

45. Hu et al. (2010). Dynamics of urban and rural housing stocks in China. Building Research and Information. 38(3), 301–317 https://doi.org/10.1080/09613211003729988

46. https://www.madaster.com/en

47. https://www.slimbreker.nl/smartcrusher.html

48. European Commission, Report on Critical Raw Materials in the Circular Economy, 2018

49. 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.

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

51. IRENA and IEA-PVPS (2016), "End-of-Life Management: Solar Photovoltaic Panels," International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems

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

53. UNEP (2018). The Emissions Gap Report 2018. United Nations Environment

Programme (UNEP), Nairobi

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

55. UNEP (2017) Resource Efficiency: Potential and Economic Implications. A report of the International Resource Panel. Ekins, P., Hughes, N., et al.

56. 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.

57. UNEP (2017) Resource Efficiency: Potential and Economic Implications. A report of the International Resource Panel. Ekins, P., Hughes, N., et al.

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

59. 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

60. 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

61. 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.2016.09.1070

62. Geng, (2018) carbon storage of harvested wood products, http://dx.doi.org/10.1016/j.forpol.2017.08.007

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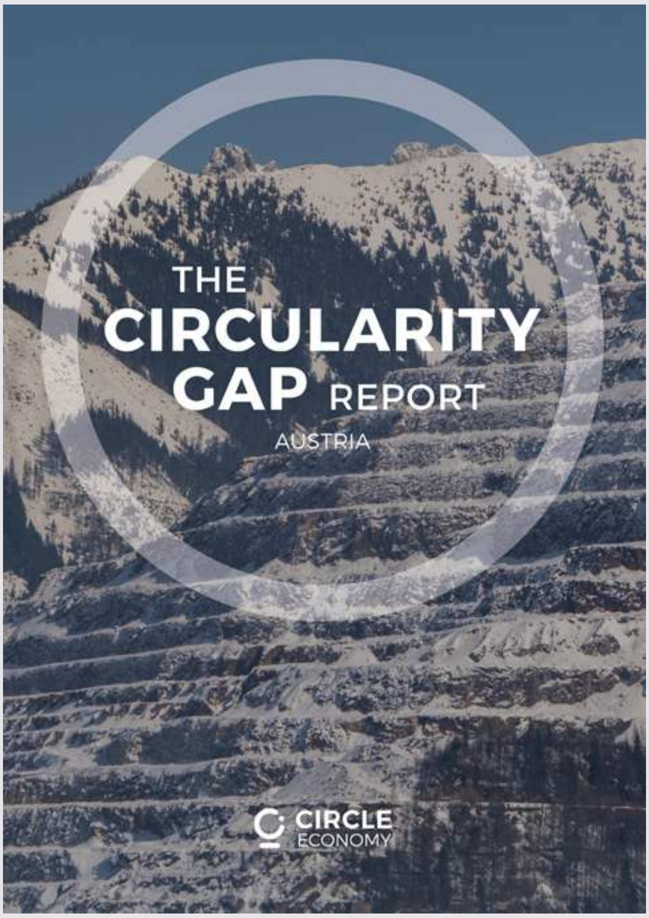

Coming Soon: The Circularity Gap Report Austria

The world economy is 9.1% circular. But what does this mean for my country?

Circle Economy's Circularity Gap Report introduced the first global metric for measurement of the circular economy. Measurement is a key challenge in applying circular principles to government policy and business strategy.

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The 'Building Value' report launched today demonstrates the radical potential in the built environment to accelerate the circular economy. The industry should re-think how to calculate value in buildings and how to finance them.

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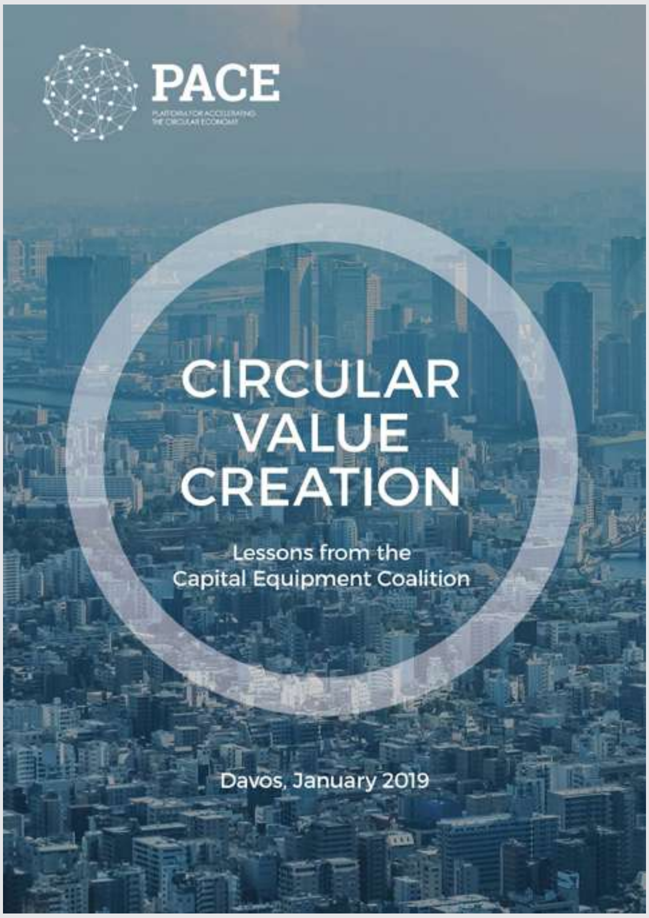

Circular Value Creation

The Capital Equipment Coalition is a group of nine forward-thinking businesses that have committed to applying circular economy principles to preserve and recover value across the lifecycles of their respective products. This document describes learnings of the members of the coalition one year on the way.

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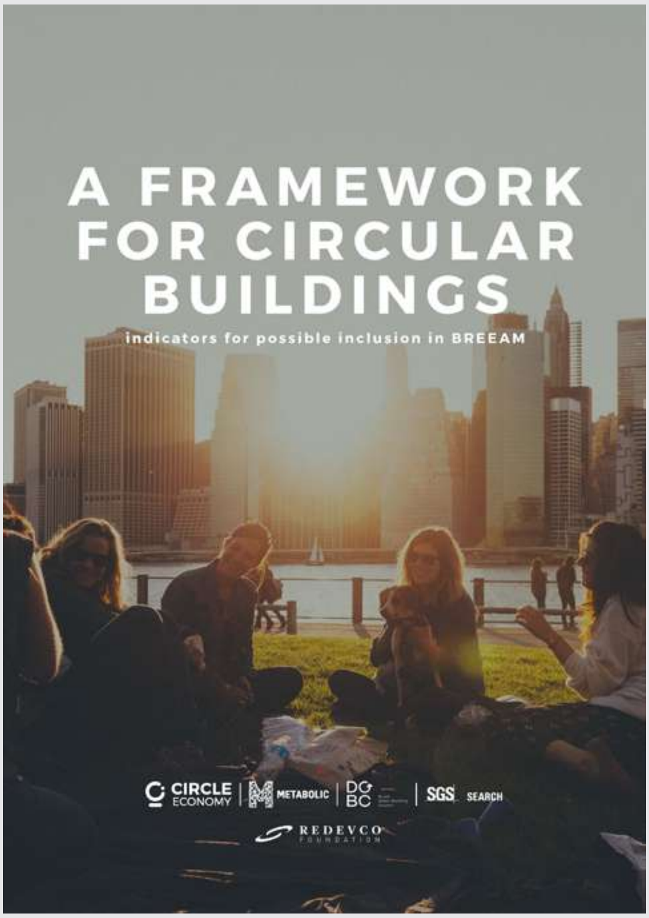

A Framework for Circular Buildings

A new strategic framework has been developed through a collaboration with the Dutch Green Building Society(DGBC), Metabolic, SGS Search and Circle Economy that defines circular buildings. It describes indicators that could be included in the sustainable certificate BREEAM-NL to better evaluate circular buildings.

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Closing the Circularity Gap in a 9% World

How the linear economy is failing people and the planet and why a 1.5°C future must be circular.

The Circularity Gap is widening.
Resource extraction and carbon emissions are still on the rise.
Yet, urgent action is absent;
partly due to a lack of political will and consensus.

Therefore, to avoid climate breakdown and secure social justice calls for a paradigm shift onto a circular pathway.

The time to close the Circularity Gap is now!

CIRCLE ECONOMY