

The Circularity Gap Report 2025

C:G:R

2025

A circular economy
to live within the safe
limits of the planet

 CIRCLE
ECONOMY

Behind the cover

This year's cover captures a stark contrast: desert encroaching on lush forest. It's a powerful visual metaphor for our current trajectory—where resource overuse and environmental degradation threaten to erase what remains green and vital. The circular economy offers a path to push back the desert, both literally and figuratively, by restoring balance between people, planet, and prosperity.



Circle Economy is driving the transition to a new economy. In this economy we help businesses, cities and nations leverage business opportunities, reduce costs, create jobs and inspire behavioural change. As a global impact organisation, our international team equips business leaders and policymakers with the insights, strategies, and tools to turn circular ambition into action.

Circle Economy has been at the forefront of the circular economy transition since 2012. Our annual *Circularity Gap Report* sets the standard for measuring progress and we manage the world's largest circularity database, encompassing data from over 90 nations, 350 cities, and 1,000 businesses.

In collaboration with:

Deloitte.

Deloitte provides leading professional services to nearly 90% of the Fortune Global 500® and thousands of private companies. Our people deliver measurable and lasting results that help reinforce public trust in capital markets and enable clients to transform and thrive.

Building on its 180-year history, Deloitte spans more than 150 countries and territories. Learn how Deloitte's approximately 460,000 people worldwide make an impact that matters at

www.deloitte.com



Table *of contents*

Executive summary 10

1 Introduction 16

2 How circular is the global economy? 22

A comprehensive look into the state of global circularity

3 The way forward 57

Calls to action for stakeholders in government and business

Endnotes 66

Acknowledgements 72

In support of the *Circularity Gap Report*

HRH Princess Sumaya bint El Hassan

President, The Royal
Scientific Society of Jordan



‘To unleash the full potential of circularity and help raise the global Circularity Metric beyond its current 6.9%, we hope that the *Circularity Gap Report 2025* will serve as a catalyst for informed, data-driven action. Such action is essential for accelerating the global transition towards a circular economy. This will help address the triple planetary crisis of climate change, biodiversity loss, and pollution, while advancing human well-being within the limits of our planet. In Jordan, where resource scarcity and environmental pressures are keenly felt, the case for circularity is both urgent and compelling. At the Royal Scientific Society, we remain steadfast in our commitment to advancing circular economy principles through innovation, collaboration, and regional leadership. We believe that Jordan can serve as a model for practical, scalable solutions that respect both people and planet.’

Dr Jack Barrie

Senior Research Fellow,
Royal Institute of
International Affairs



‘The *Circularity Gap Report* has become a key measure of progress in the global transition to a circular economy. The 2025 report reveals how far the world is from achieving a truly regenerative circular system—and, as a result, how vulnerable economies are to increasing resource volatility and competition. It also provides a global benchmark—a critical reference point from which to accelerate progress—alongside a compelling case showing why urgent global action is needed today.’

Atte Jääskeläinen

President, The Finnish
Innovation Fund Sitra



‘Amid rising geopolitical tensions, resource competition, and economic volatility, the circular economy is more important than ever. It plays a key role in driving new investments, shaping free-trade agreements, and strengthening development cooperation—such as the support provided by the new Sitra-led EU Circular Economy Resource Centre. The world’s resource flows are changing, and this report manages to both stress the urgency of transitioning while capturing the opportunities a circular economy offers.’

In support of the *Circularity Gap Report*

Hege Sæbjørnsen

Global Circular Strategy
Leader, Ingka Group, IKEA



'Businesses play a crucial role in scaling circular solutions, and brands, in particular, have the power to mobilise consumers across the globe and drive behavioural change. By rethinking product design, investing in new business models, and developing new capabilities, the private sector can accelerate the transition towards a circular economy. The *Circularity Gap Report* is a valuable tool that provides insights, informs better actions, and suggests impactful indicators for progress.'

Dr Mohab Ali Al-Hinai

Vice President Sustainability
& Circular Economy, be'ah



'At be'ah, we believe that circularity is the foundation for a sustainable future. The *Circularity Gap Report 2025* highlights the urgent need for systemic change, reinforcing the role of collaboration, innovation, and responsible resource use in shaping a resilient global economy. We are proud to support this initiative and remain committed to driving impactful change for Oman and beyond.'

Helena McLeod

Deputy Director-General
and Head of Green Growth
Planning & Implementation
Division, Global Green
Growth Institute



'Despite widespread discussions on the circular economy, the world is becoming less circular. I commend the *Circularity Gap Reports* for bringing this urgent issue to light. Its call is clear: nations must urgently shift to a circular economy to build resilience and sustainability. We look forward to more region- and country-specific assessments and the formal adoption of circularity metrics in national and regional policy frameworks.'

In support of the *Circularity Gap Report*

Janez Potočnik

Co-Chair, International
Resource Panel



'The *Circularity Gap Report 2025* highlights that, more than ever, urgent action to boost circularity is required from policymakers and industry leaders. The transition needs to be guided by science-based targets for material consumption, particularly in high-income countries, which are overshooting the safe and just boundaries of our planet.'

Elisabeth Türk

Director of Economic
Cooperation and Trade Division,
United Nations Economic
Commission for Europe



'The *Circularity Gap Report 2025* highlights the crucial role of governments in driving the circular transition through smart policies and multilateral collaboration. UNECE supports this goal by providing policy tools that leverage trade, innovation, and infrastructure financing, while fostering cooperation through Circular STEP—a network of government experts working to bridge the Circularity Gap in line with the UN's Sustainable Development Goal 12 on sustainable consumption and production.'

Quentin Drewell

Senior Director, Circular
Products and Materials,
World Business Council for
Sustainable Development



'Circular solutions are the only way for businesses to meet both their growth ambitions and global sustainability targets. The *Circularity Gap Report 2025* provides critical insights that help bridge the gap between circular potential and action. Aligning with initiatives like the Global Circularity Protocol, this report plays a crucial role in guiding business leaders toward measurable and transformative actions to ensure businesses can generate long-term value and build up resilience.'

Seema Arora

Deputy Director General,
Confederation of Indian
Industry



'Globally, there is an urgent need for bold, innovative solutions that drive a systemic shift towards a circular economy. Incorporating circular principles will play a critical role in building competitiveness and addressing socioeconomic development challenges. The Confederation of Indian Industry recognises the importance of transparent, robust data—as provided and championed by the *Circularity Gap Report 2025*—to inform decision-makers and create an enabling policy environment within which industry can act.'

In support of the *Circularity Gap Report*

Heike Vesper

Chief Executive, Transformation
& Policies, WWF Germany



‘Circularity requires resource-light consumption, circular business models and ambitious policy targets. This year’s *Circularity Gap Report* highlights the missing link in circularity: we must reduce our overall material footprint and waste generation. Reuse and lifetime extension are crucial. Policymakers must implement economic conditions for circularity to thrive, and businesses must scale impactful strategies and drive systemic change.’

Johanna Pakarinen

Senior Advisor, Statistics Finland



‘The data-driven approach taken by the *Circularity Gap Report 2025* emphasises the critical role of metrics in advancing the circular economy. By measuring and analysing how resources are used, the report provides essential insights for informed decision-making on sustainability, highlighting the importance of tracking material flows in achieving a resilient future.’

Smail Al Hilali

Chief, Division of Circular
Economy & Green Industry,
United Nations Industrial
Development Organization



‘The *Circularity Gap Report 2025* is a decisive wake-up call. By revealing our declining circularity and emphasising the urgent need for systemic change, it provides a roadmap for clean industrial transformation that can address climate, nature and economic risks. UNIDO supports these efforts through a broad range of technical cooperation services on the circular economy.’

Dr Zsuzsanna Király

Deputy Secretary General,
Central European Initiative



‘I fully endorse the *Circularity Gap Report 2025* and its Circularity Metric for the insightful overview of the transition to a circular economy it provides. While this shift presents a substantial challenge for the Central European Initiative region, it also offers significant opportunities to strengthen local economies, empower communities, and foster sustainable development and resilience.’

In support of the *Circularity Gap Report*

Fabian Farkas

Chief Markets Officer,
Forest Stewardship Council
International



'The *Circularity Gap Report 2025* rightly highlights the urgency of transitioning to a circular economy. The Forest Stewardship Council supports its call for regenerative systems that prioritise renewable, responsibly sourced, and reused materials. This keeps value in the loop and ensures that ecosystems—such as forests—can thrive—sustaining people, climate and biodiversity for generations to come.'

Jennifer Steinmann

Deloitte Global Sustainability
Business Leader, Deloitte



'The *Circularity Gap Report 2025* is a broad scorecard on the state of global circularity and offers a clear roadmap for how to incorporate circular practices into business strategies. It provides leaders with actionable insights on how to invest in diverse material streams and circular pathways in order to enhance supply chain resilience and mitigate risks. By doing so, business leaders can unlock growth and new opportunities for innovation and efficiency across their enterprises.'

Rasmus Abildgaard Kristensen

Ambassador of Denmark to
India, Ministry of Foreign
Affairs of Denmark



'India is central to the global circular economy transition, with its dynamic industries, innovation ecosystem, and vast potential for circular solutions. The *Circularity Gap Report 2025* provides vital insights to guide this shift, highlighting both the urgency and opportunities of reducing material use while supporting resilience.'

Chris Jansen

Minister for the Environment
and Public Transport,
Government of the Netherlands



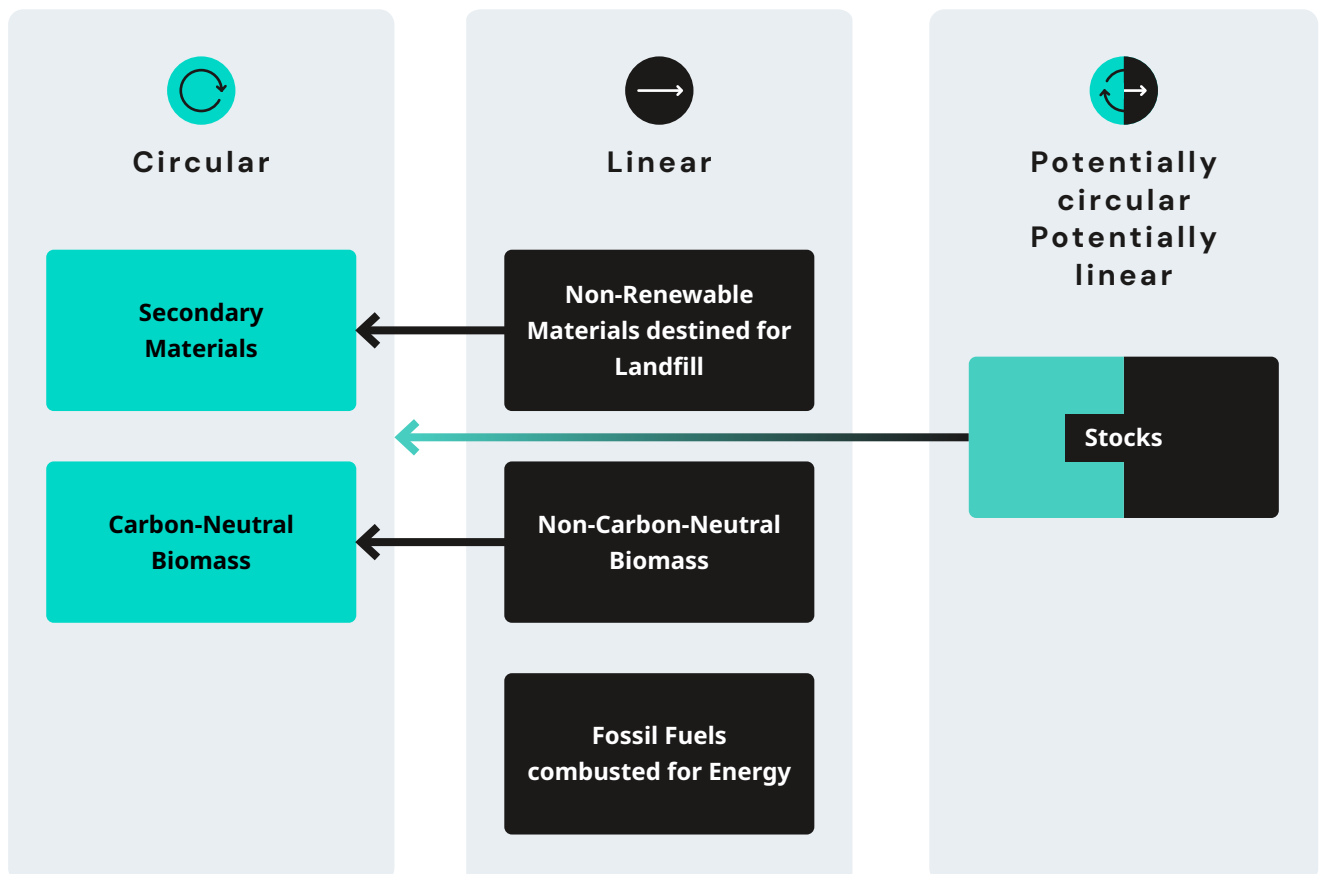
'The annual *Circularity Gap Report* gives an important insight into the relative amounts of recycled materials in our economy. It is therefore a source of inspiration for the Netherlands in shaping effective and realistic circular policies. We can unlock an acceleration towards the circular economy to enhance our competitiveness, reduce strategic vulnerabilities, and create future-proof jobs.'

Executive summary

The economic system should deliver maximum possible wellbeing within the safe limits of our planet. After seven years of reporting, our message remains much the same: in the face of escalating global challenges, the circular economy offers a means to rewire the entrenched linear practices that no longer serve most people or the planet. Since the launch of the first *Circularity Gap Report* in 2018, we've analysed the Circularity Metric to offer insight into the global state of the circular economy transition.¹ This single figure quantifies the share of secondary materials out of total material consumption, serving as a North Star for tracking progress towards the circular transition. But the Metric is one piece of a larger puzzle. That's why, for the first time, this report analyses the Circularity Gap to examine how the rest of the materials flowing into and out of the global economy are contributing to a circular economy—or not. Global material flows can be broken down into three interconnected categories:

- **Circular:** Secondary Materials (the Circularity Metric) and Carbon-Neutral Biomass;
- **Linear:** Non-Carbon-Neutral Biomass, Fossil Fuels combusted for energy, and other Virgin, Non-Renewable Materials destined for landfill;
- **Potentially circular, potentially linear:** Net additions of virgin materials to Stocks—such as buildings, infrastructure, and machinery—that can either be recycled or wasted at their end-of-life many years down the road.

This report examines how materials enter the economy, whether they re-enter it and, if not, how they leave it—either as waste or emissions. Various sub-indicators support each of the headline indicators above to give a sense of where we are, where we're heading, and where targets are needed to drive action in the right direction. This year's report serves as a data-rich, comprehensive report card for the global state of circularity, opening up the Circularity Gap to support practical decision-making.





The Circularity Metric continues to decline: the vast majority of materials entering the economy are virgin, with the share of secondary materials falling from 7.2% to 6.9% as of the latest analysis.

Ongoing declines in circularity can largely be tied to sustained growth in material use. Although the absolute *scale* of secondary material consumption is slowly trending upwards, this is being outpaced by growth in virgin material use. Global extraction has more than tripled in the last fifty years, recently reaching a landmark 100 billion tonnes—and without ‘bending the trend’, this is set to rise by a further 60% by 2060.²

A truly circular economy should be resource-light: without profoundly rewiring systems of production and consumption and applying structural changes across key systems—from housing and food to mobility and manufacturing—we will not be able to close the loop on material consumption. At the same

time, there is a significant opportunity to bolster the Circularity Metric by recycling all the materials that potentially *could*³ be cycled but currently aren’t. Virgin, Non-Renewable Materials destined for landfill—including heavy industrial wastes, short-lived consumer products, and end-of-life vehicles or construction materials—account for nearly one-fifth (18.1%) of global material inputs. This represents huge untapped potential: if we were to recycle all waste currently not being recycled *without* reducing overall material use, for example, the Circularity Metric would grow to approximately 25%.

There is potential to boost circularity by better-managing construction and demolition waste, as well as smaller waste streams, like municipal solid waste. However, a good portion of Virgin, Non-Renewable Materials are hard-to-recycle, lower-value waste types, from waste rock to soils, underscoring the importance of rolling out circular strategies that minimise waste from the outset while prioritising high-value reuse and recycling where possible.

The verdict

Without strong global targets to hold us to the right path, we’re veering off course for several key indicators. Natural resource management and global material use trends are moving in the wrong direction: material extraction and waste generation are trending upwards, while recycling and controlled disposal rates are both trending downwards over a five-year period. What’s more, official, science-based global material use targets are lacking, making it difficult to drive progress.

In an ideal world,

we use as many secondary materials as possible while minimising extraction and consumption. Industries have embraced principles of material efficiency and sufficiency, prioritising the use of recycled inputs alongside circular design principles. Material recovery from long-lived stocks—such as buildings and infrastructure, which can act as ‘banks’ of materials for reuse—has been optimised. At the same time, countries have vastly improved waste collection, processing and recycling and have minimised waste from extraction processes.



A sustainable bioeconomy is important to the global circular economy transition, but measuring its impact remains a blind spot.

Of all the materials flowing into the global economy, **21.5%** are Carbon-Neutral Biomass, and **2.2%** are Non-Carbon-Neutral Biomass.* Carbon-Neutral Biomass refers to biomass that absorbs as much carbon as it emits over its lifecycle, maintaining a balance through natural processes like regrowth and carbon sequestration.

Non-Carbon-Neutral Biomass represents the portion that exceeds this balance: it doesn't imply a difference in how the biomass is extracted but rather reflects that a certain proportion is 'in the red'. However, all biomass extraction comes with numerous uncaptured environmental impacts. Although renewable, biomass isn't sustainable by default, and carbon neutrality is only a partial criterion for quantifying its circularity. By only considering this aspect, we can't account for the loss of ecological complexity and biodiversity that biomass extraction may cause—for example, large-scale monoculture plantations can deplete soil

nutrients, reduce habitat diversity, and contribute to deforestation, threatening ecosystems and species. It is not currently possible to measure other important criteria for circular biomass, such as whether nutrients are safely returned to the biosphere in the right place and at the right rate. For this reason, even Carbon-Neutral Biomass should be considered carefully and with nuance. Though Non-Carbon-Neutral Biomass accounts for just 2.2% of material inputs, it represents approximately one-tenth of total biomass use—still a crucial share to minimise.

Despite its declining share in global material extraction, the scale of biomass extraction has more than doubled in the last half-century, driving land-use change and biodiversity loss and accounting for a significant portion of global emissions. Developing a more circular economy will require a rebalancing of global land use: currently, a disproportionate share of the planet's land is used for agriculture—particularly for pasture and feed crops. Transforming our food systems towards circular, regenerative practices and plant-based, unprocessed diets will be critical to reducing these pressures and restoring ecosystems.

The verdict

We're making some progress, but more must be done to help meet global targets.

Global biomass extraction and other key indicators—water stress, for example—are trending upwards, while the share of forested land is decreasing. While we are making progress at safely treating wastewater and bolstering land protection, progress isn't happening at the speed and scope needed to meet global climate and biodiversity targets. Without accelerated action, ecosystems may struggle to sustain the industries and communities that depend on them.

In an ideal world,

we've reduced the land footprint intensity of biomass production and use biomass in a way that respects natural cycles—such as the carbon, nitrogen, phosphorus, and water cycles—prevents the harmful transformation of land, nurtures biodiversity and soil health, and maximises value through cascading where possible.

* A much smaller share of biomass is captured by other indicators, making its way into the technical cycle and contributing to the Circularity Metric, Virgin, Non-Renewable Materials destined for disposal, or Net Additions to Stock.



Fossil fuel use remains high and continues growing, with few strong incentives to change course.

Although the rate of fossil fuel extraction relative to other materials has declined, absolute extraction has increased—from 6.1 billion tonnes in 1970 to 15.8 billion tonnes in 2021.⁴ **13.3%** of materials flowing into the economy are Fossil Fuels combusted for energy, the main driver of climate breakdown. In 2021, energy use accounted for 73%⁵ of global greenhouse gas emissions—excluding those from land use, land-use change and forestry—with fossil fuels remaining the dominant energy source today, representing 82% of total primary energy supply.⁶

Historically, fossil fuel demand and global economic growth have been closely coupled—and even now, their use continues to be incentivised through artificially low prices, with explicit subsidies amounting to an estimated US\$1.4 trillion in 2021.⁷

The transition to a net-zero energy system presents a major opportunity to reduce reliance on fossil fuels while mitigating environmental harm. To do this, we should systematically restructure how we power transport, generate electricity and process materials. This requires scaling down these activities and reorienting financial flows from subsidies towards decarbonised systems based on electricity and powered by renewable sources. Although the energy transition will initially be material-intensive—particularly in terms of metals—smart system design can reduce reliance on present and future material inputs. This contrasts with the current energy system, which requires a constant flow of fossil fuels to sustain.

Adopting circular design principles—such as durability, reuse, and recycling—at both the product and the system level will be crucial to minimise environmental burden shifting, such as halting fossil fuel extraction but ramping up mining.

The verdict

While there's been some progress towards decarbonisation, it isn't enough to limit warming to 1.5-degrees. Total energy supply and global greenhouse gas emissions are still trending upwards—and while we're seeing positive increases in electrification and renewable energy consumption, we're not yet on track to meet global targets. Electrification, for example, is growing more slowly than energy demand, and the carbon intensity of electricity generation is growing. What's more, half of the waste generated by the global economy is released in the form of emissions: because we can't 'close the loop' on emissions, this represents a significant barrier to bolstering circularity.

In an ideal world,

we've prioritised systemic efficiency to keep growing energy demand in check, enabling renewable energy to replace—rather than simply add to—fossil-based sources in the energy mix. Because electricity is the most efficient and easiest form of energy to decarbonise, we've electrified as many activities and end uses as possible and powered them with clean renewables.



Rapid stock accumulation is a primary driver of rising resource extraction—particularly non-metallic minerals, which account for half of total extraction.

Of all materials entering the global economy, **38%** are virgin Net Additions to Stock. This includes non-metallic minerals, metals, and small amounts of fossil-fuel-based materials and biomass used primarily for buildings, infrastructure, vehicles and machinery.

Stocks aren't inherently positive or negative and even have serious potential to boost circularity down the road if circular design principles are integrated now. By 'mining' existing stocks, we can expand the pool of recyclable materials available

to increase the Circularity Metric. However, stocks are highly material-intensive, with their total weight increasing 23-fold over the 20th century,⁸ a trend set to continue alongside rapid urbanisation and economic growth.

By 2050, urban populations will grow by 2.5 billion, requiring significant stock build-up,⁹ particularly in lower- and middle-income countries. These nations have the opportunity to embed circular principles at scale, avoiding the unsustainable development patterns of higher-income countries by prioritising dense urban environments supported by public and shared mobility options. Meanwhile, higher-income countries with vast existing stocks should minimise new stock growth and focus on extending the lifetime of existing stock through renovation, repurposing, reuse and repair.

The verdict

We're using more materials than ever to build up stocks—but targets to guide how and at what rate this is done are lacking across the board. Total floor space, the weight of material stocks and growth in built-up areas are all trending upwards. With a complete lack of global and sub-global targets, we're neither on nor off track—technically speaking. Limiting stock growth—in both incremental and cumulative terms—where it's not necessary and sustainably optimising it through circular design where it is will be essential going forward.

In an ideal world,

circular practices like repair, retrofitting and refurbishing are commonplace ways to keep physical assets in use for as long as possible. Stocks are designed for longevity, and are easy to repair, dismantle and recycle at their end of life—thus providing a flow of valuable secondary materials. Renewable materials, such as sustainably-sourced timber, biocement and biocomposites, contribute to stock composition, and are managed in a circular way. Operations are localised as much as possible to reduce energy consumption for unnecessary transport.

Governments have a key opportunity to lead the circular transition through smart policies and transparent multilateral collaboration. By setting a clear vision and providing unified support for circular initiatives, governments have the critical mandate to shape the right conditions for circularity to flourish—levelling the playing field by shifting tax burdens, reorienting subsidies away from linear activities, and redirecting government funds towards circular projects and initiatives. However, no country can tackle resource use reduction in isolation: transition in our highly globalised world ought to be backed by strong regional—and, where possible, international—collaboration to effectively manage global material flows and reduce extraction. Despite growing recognition of the need to tackle resource mismanagement and align economic activity with our planet’s safe limits, this report highlights the lack of both clear targets and a global governance framework to monitor the shift to more sustainable resource use. An international institution on resource management could steer action by providing science-based assessments, policy guidance, and benchmarks to track material use—an approach already reflected in the negotiating text of the legally binding agreement on plastics pollution, for example.¹⁰ At the national level, governments should select and monitor reliable indicators—such as those analysed for this report—to create accountability, identify trends, and refine policies over time, ensuring that circularity efforts have the intended impact.

Businesses that adopt circular practices now can gain a competitive edge, unlock new revenue streams, and future-proof against resource scarcity and market volatility. Although governments set regulatory frameworks, businesses shouldn’t wait for these to come into force to begin shaping their new normal. By staying ahead of the regulatory curve and spearheading the transition now, businesses have a lot to gain: they can gain a competitive edge, unlock new revenue streams (through service models, for example), and mitigate risks associated with resource scarcity and geopolitical trade instability. The global economy is facing increasing supply chain disruptions, particularly for the critical raw materials essential to numerous key industries—including the decarbonisation and digitalisation of the global economy.

Businesses that integrate circular strategies—including material recovery, closed-loop production, and localised supply chains—can reduce reliance on volatile global markets and potentially cut costs. To maximise these benefits, businesses should consider the bigger picture—such as the indicators measured in this report—whilst simultaneously measuring and monitoring circularity for their own operations and value chains. Communicating progress and the benefits of adopting circular practices can inspire industry-wide adoption, but collaboration is key: by sharing knowledge, practising industrial symbiosis, shifting sales and service models, and working closely with governments, businesses can overcome barriers and build circular economies of scale.

1

Introduction

Ensuring human wellbeing while operating within the safe limits of our planet remains the enduring challenge of our time. The economic system should deliver the maximum possible wellbeing to all while preserving and regenerating the natural environment and ecosystem services underpinning it. The circular economy is a means to this end, with strategies that rethink and optimise how we use resources to provide wellbeing. It can provide the deep cuts in material use needed to stave off climate breakdown, bolster biodiversity, and boost resilience. Calculating baselines is an important step to inspire action and inform target setting—essential for creating accountability, driving international cooperation, steering policy and re-orienting financial flows. This report aims to do just this: building on years of experience calculating the Circularity Metric, it now opens up the Circularity Gap. It recognises that although the Metric has been useful in providing a global baseline for circularity, it is only one piece of a large and complex puzzle. This year's edition provides a comprehensive 'report card' on the state of the global circular economy. It quantifies a dashboard of indicators to ground abstract concepts in reality, spark action, pinpoint where targets are missing, and provide a jumping-off point for decision-makers and advisors across government and industry to take action.



Where we are now and where we're heading

Over the past eight years of *Circularity Gap Reports* (CGR®), our opening statements have remained much the same: relentless growth in global resource use—driven by the continued expansion of global economic activity—is putting Earth's systems under extreme pressure. In 2025, the situation is unchanged. The latest *Global Resources Outlook* paints a sobering picture of trends in natural resource use, showing that global material extraction has more than tripled in the last fifty years. We have now surpassed a landmark of 100 billion tonnes of material extraction per year. The global population has not grown at the same rate, showing that this has only played a partial role in spiralling material consumption. Instead, per capita consumption has swelled from 8.4 tonnes in 1970 to 12.2 tonnes in 2020, fuelled by urbanisation, growing GDP and increased affluence. This unfettered growth isn't set to slow—without deep, systematic changes

to the way the global economy operates, material extraction is set to rise by 60% (compared to a 2020 baseline) by 2060.¹¹

Although material consumption has been instrumental in raising living standards over the past century, we've now passed the point of diminishing returns in many parts of the world. The current scale of global resource use is the main driver of the triple planetary crisis of climate change, biodiversity loss and pollution, with material extraction and use driving around two-thirds of greenhouse gas emissions and over 90% of total biodiversity loss and water stress, for example.¹² As of 2023, we've also surpassed six of the nine planetary boundaries vital to life on this planet.¹³ Business as usual simply cannot continue if we're to achieve global climate, biodiversity, and pollution targets and protect and preserve Earth's life support system.

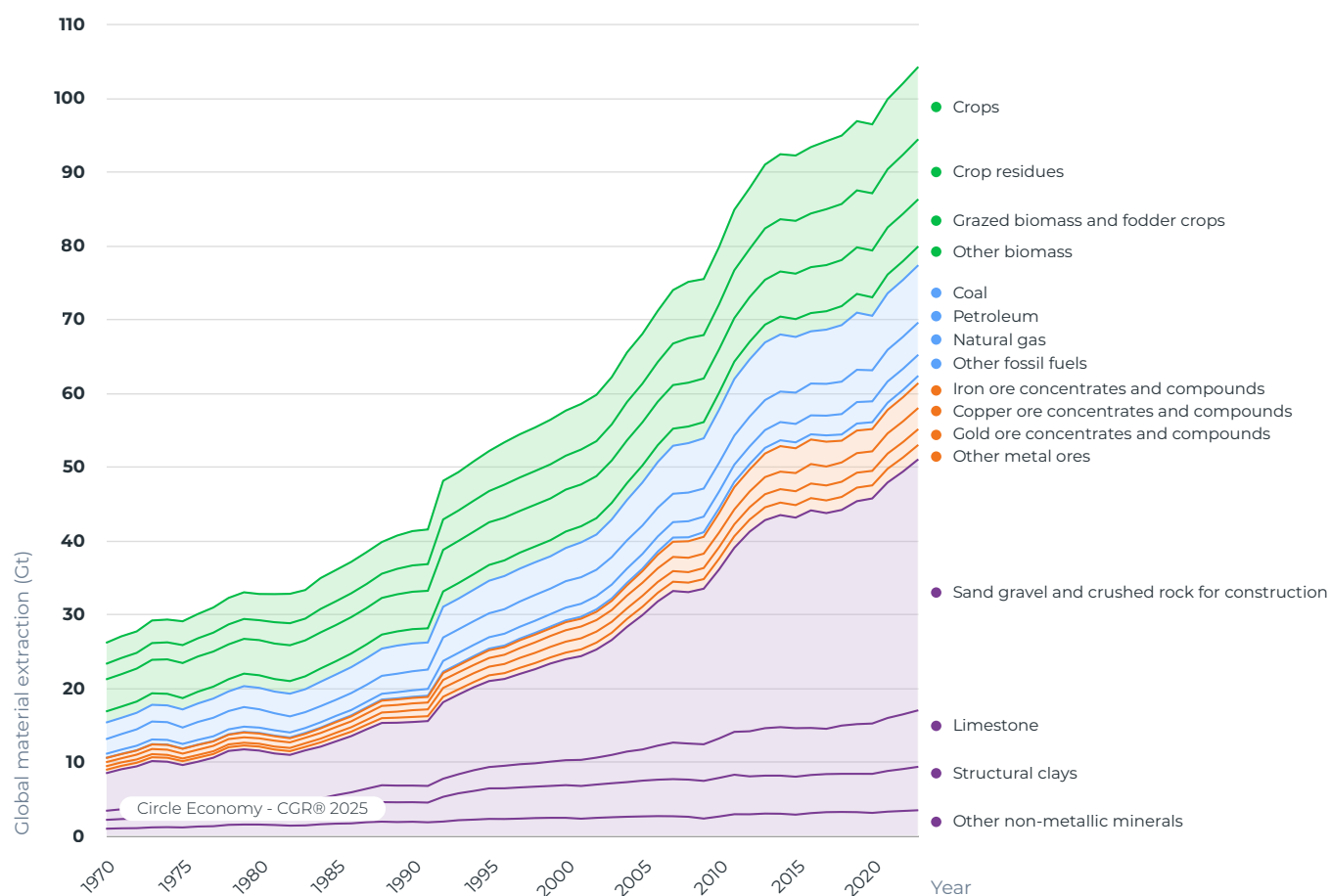


Figure one portrays the evolution of global material extraction from 1970 to 2023 by main material group, as well as the top materials driving this growth.

The widening chasm of resource distribution

Exponential growth in resource consumption hasn't been evenly distributed around the globe: high-income countries have a per capita material footprint six times that of lower-income countries—24 tonnes compared to 4 tonnes.¹⁴ At the same time, high-income countries represent less than one-fifth of the global population, with the EU and US alone consuming more than half the world's materials while housing 10% of the world's population.¹⁵ Much of this material use can be attributed to the build-up of infrastructure and capital equipment, as well as higher consumption among citizens in upper-middle and high-income countries.¹⁶ However, beyond a certain point, increasing material consumption does not necessarily translate to greater well-being: many high-income countries have already reached a saturation point, where further increases in resource use lead to diminishing returns in terms of human development gains (see Figure two). **Striking a balance between resource consumption and human development is crucial.**

At the same time, material consumption has driven environmental degradation in countries with fewer means to mitigate these impacts: per capita, higher-income countries are responsible for ten times the climate impacts of lower-income countries.¹⁷ Lower-income countries bear the brunt of the consequences, with climate-related natural disasters increasing eight-fold in the last decade compared to 1980 levels.¹⁸ Reducing inequality both between and within nations will be key to tackling the triple planetary crisis: in the process of achieving the estimated 'sustainable' level of consumption—8 tonnes per capita—that has served as a benchmark throughout past Circularity Gap analyses, higher-income countries will need to drastically reduce their consumption while lower-income countries can increase consumption to build up necessary service provisioning (renewable energy infrastructure and sustainable housing, for example).¹⁹

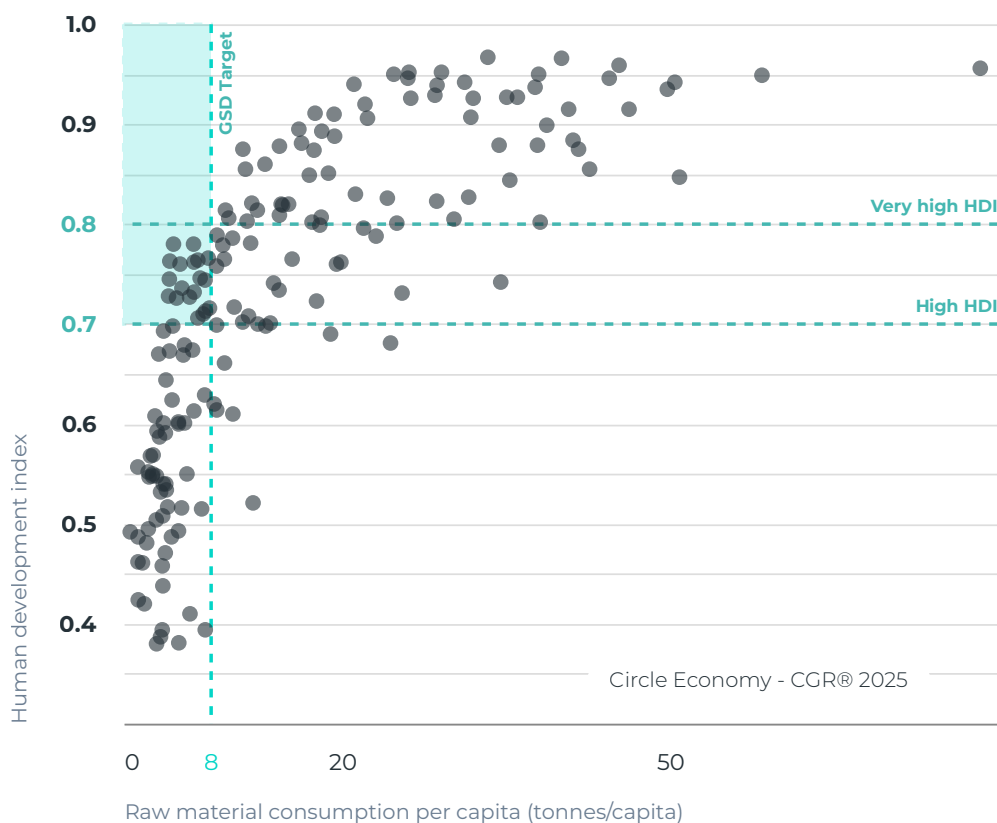


Figure two shows the relationship between raw material consumption per capita (2021) and the Human Development Index (HDI) (2022).

The circular economy as a means to an end

The circular economy, a toolbox of strategies and solutions that rethink and optimise how we consume materials, can deliver wellbeing for all while preserving the environment and ecosystem services that underpin a functioning economy, including clean air, water, natural spaces and biodiversity. Imagine the circular economy as a way to rewire how an economy operates physically: it reduces physical throughputs—and thus environmental impacts—by optimising the transformation of resources into societal needs that contribute to human well-being, such as housing, mobility and nutrition.

We know what the circular economy has to offer: the *Circularity Gap Report 2023* found that we can reverse the overshoot of planetary limits while providing for similar needs with just 70% of the materials we use now.²⁰ This would mean reducing yearly material consumption to around 8.5 tonnes per capita, approximately equal to the weight of two adult elephants, for example. This is roughly on par with 1970s figures. While this may still seem like quite a lot, it's important to remember that per capita consumption averages include far more than an individual's yearly purchases and take into account the construction of buildings, infrastructure and equipment, just to name a few.

Crucially, the linear economy wasn't created by chance—it was designed. The activities supporting the unsustainable, linear production and consumption patterns driving the mismanagement of natural resources are deeply rooted in our existing system. To successfully transition to a circular economy, we need to change the rules of the game. Fundamentally, this requires a shift in behaviours, norms and belief systems, as well as dismantling the tangled web of laws, regulations and policies that allow for—and often incentivise—boundless extraction, emissions, and waste.

Stakeholders, including governments and businesses, have a crucial role to play in generating momentum for the circular transition and creating the necessary market conditions for industry to shift away from business as usual. This could mean levelling the playing field through regulations, taxes, and subsidies, as well as directly supporting, procuring and advocating for low-carbon, resource-efficient energy technologies, circular and regenerative farming practices, and high-value waste management infrastructure, for example. At the same time, businesses have much to gain by not waiting for regulations to change their practices. By proactively applying circular economy solutions in procurement, product and service design, operations, and waste management, businesses can mitigate resource risks, from supply chain disruptions and price volatility to legislative pressure and reputational risks.²¹ What's more, circular products and services allow businesses to increase brand value, increase customer engagement and loyalty, enter new markets, cut costs and stay ahead of the competition in terms of innovation.

Measuring the circular economy

To deliver on the circular economy's potential, we need an effective means to measure how materials are being used at the global level. This provides a solid evidence base for local, national and international changemakers from which to measure and monitor progress. Such oversight is crucial in revealing the true extent and impact of material mismanagement, helping policymakers pinpoint where changes are needed most and helping industries set benchmarks and baselines to start monitoring progress. A more detailed, multifaceted understanding of circularity can bridge gaps between high-level policies and practical, impactful changes across industries, moving us closer to a sustainable, inclusive and regenerative economy. The upcoming **Global Circularity Protocol** for businesses, for example, will play a key role in establishing a shared framework for this effort, ensuring consistency in how circularity is tracked and compared across regions and industries.

We cannot recycle our way out of the current linear economy: regardless of how efficiently we use materials and recycle them at end-of-life, the sheer scale of current material extraction is unsupportable for a healthy and safe planet. This underscores the need to first and foremost focus on the absolute *scales* of extracted materials alongside relative *rates*. As long as extraction continues to increase, incremental improvements in slowing, regenerating and cycling material flows will not be able to offset the significant environmental impacts to come. This principle is illustrated by the Circularity Metric, which has fallen year on year since Circle Economy first began measuring, despite gradual increases in the scale of secondary material use.

Looking at rates—like the Circularity Metric—as opposed to scales alone gives us insight into how quickly resource stocks are depleted and waste is generated, which signals how quickly environmental pressures are building. By monitoring how these rates change over time, we can identify trends in resource efficiency and sufficiency, pinpoint opportunities to decouple wellbeing from material consumption and gauge circular progress. This dual focus on both absolute figures and relative rates is essential to build resilience and shape an environmentally responsible global economy.

The legacy of the global *Circularity Gap Reports*: Updating the circularity metric and expanding our dashboard of indicators

The circular economy agenda has come a long way—particularly regarding monitoring—since the launch of our first *Circularity Gap Report* in 2018. Our Reports have taken a system-wide perspective to monitor and measure the global circular economy. We have historically reported on the Circularity Metric, which measures the proportion of secondary material consumption out of total material consumption for an economy. This is an important indicator for measuring the circular state of an economy. However, this Metric is just one part of a broader picture.

For this reason, the *Circularity Gap Report 2025* aims to **provide a comprehensive report on the state of the global circular economy**, with the view that the Circularity Metric—while important—is only one piece of a large and complex puzzle. This report aims to provide more detail and support practical decision-making by opening up the Circularity 'Gap'.

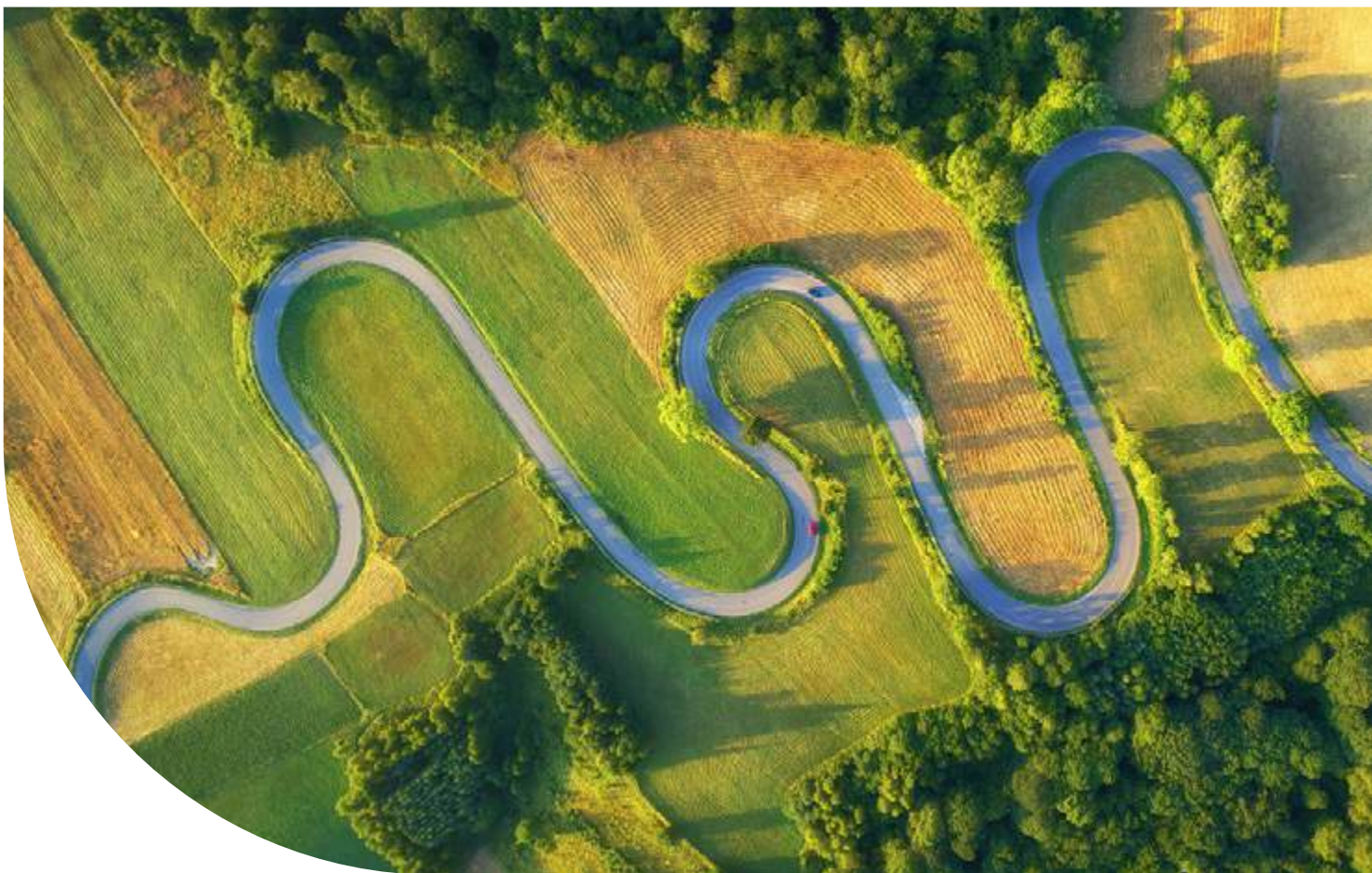
This report presents and builds on the Circularity Indicator Set, a dashboard of 11 indicators that provide a 'report card' for global material circularity. Collectively, the Indicator Set examines the relationships between resources we take from nature, how we use them, and their impact on the environment. Represented as shares that add up to 100% of material inputs and 100% of outputs such as waste, emissions, and recycled materials, these indicators can be viewed as 'levers' to improve the Circularity Metric. By reducing indicators that capture linear processes—such as disposing of materials without recovery or combusting fossil fuels for energy—we have room for the Metric's share to grow.

The Circularity Indicator Set lends itself well to integration with other leading indicator frameworks for the circular economy: the ISO/DIS standard²² and the *Conference of European Statisticians Guidelines for Measuring Circular Economy, Part A: Conceptual Framework, Indicators and Measurement Framework*.²³

This year, the *Circularity Gap Report* provides an expanded report on the state of global circularity. It builds out the Circularity Indicator Set to encompass the beneficial aspects of other leading frameworks and provide further context to the headline indicators. These are elaborated upon through more than 20 other leading indicators—global statistics on waste collection and recycling, energy consumption and land protection, for example. This can help leaders and decision-makers decide where to focus and enact circular solutions that are in alignment with the ultimate goal of improving wellbeing within environmental limits. The result is a cohesive and comprehensive framework suitable for many aims: the headline indicators, for example, are helpful for raising awareness and communicating circular progress at a high level, while lower-tier indicators can provide government officials, policy analysts and other more technical stakeholders with the in-depth information needed to support decision making and agenda setting.

This analysis has a global scope. However, the measurement framework can be set up at the (multi- and sub-)national level to account for trade and the movement of materials between nations for both production and consumption. At the level of businesses and industries, the scope and consequent data collection should be aligned to operations and the relevant aspects of the supply chain, whether regional or multinational.²⁴ The Circularity Indicator Set can be used as a benchmark and reference if these differences in scope are considered during interpretation.

This year, the *Circularity Gap Report* provides a global benchmark for circularity on a range of dimensions relevant to both governments and businesses. Through this report, governments and businesses can gain an understanding of the global state of circularity and the risks of continuing along a linear path.



2

A report card for the global economy

A comprehensive look into the state of global circularity

The circular economy is a means for delivering wellbeing within planetary boundaries—but how can we take meaningful steps towards dismantling entrenched processes and rewire the way we relate to the material world? This chapter opens up the Circularity Metric (6.9%) and Circularity Gap (the remaining 93.1%), exploring 11 headline indicators and 23 sub-indicators for circularity. It quantifies how materials flow in and out of the global economy and clarifies how various levers can be pulled to boost circularity. The data reveals a troubling truth: progress is underway in some areas, but negative trends are offsetting improvements. Secondary material use, for example, has increased—from 7.1 billion tonnes in 2018 to 7.3 billion tonnes in 2021—but the Circularity Metric continues to fall due to rapid growth in material extraction across the board. At the same time, the scale of Virgin, Non-Renewable Materials disposed of without recovery has risen: these are materials that could contribute to the Circularity Metric but currently aren't. The absolute scale of biomass extraction, fossil fuel use and net additions to stocks have all risen between 2018 and 2021 despite rates remaining relatively stable, underscoring the crucial importance of reducing total material throughput. Although some targets are in place—caps on greenhouse gas emissions and targets for land protection, for example—we need concerted action from businesses and others to cut material use. Currently, we are not on track to meet a single indicator explored in this chapter. This chapter's 'report card' shows that we have yet to get a passing grade. The prognosis is clear: we need strong, science-based targets to generate international momentum towards a circular economy and sustainable resource use.



Understanding material flows: How to interpret the Circularity Indicator Set

Extraction and consumption are growing at almost unprecedented levels, but measuring how and where these material flows are directed can give crucial insight into the circular economy's transformative potential. This chapter opens up the Circularity Gap and gives insight into the global material budget through the Circularity Indicator Set, which measures

Circular material flows (Secondary Materials and Carbon-Neutral Biomass), **Linear material flows** (Non-Carbon-Neutral Biomass, Virgin, Non-Renewable Materials, and Fossil Fuels used for energy), and **Net stock build-up** (Net Additions to Stock*). Material flows, whether linear or circular, can be broken down into two 'cycles':

- **The technical cycle** relates to the management of non-renewable and largely non-biological resources that are difficult to reintroduce into the biosphere safely. Examples include concrete, plastics and metals, as well as some processed biological materials, such as timber, paper, textiles and bioplastics—this is referred to as 'technical biomass' throughout this chapter. Materials that are part of the technical cycle fall into one of four categories: they become Secondary Materials, are Virgin, Non-Renewable Materials destined for disposal without recovery, are added to Stocks, or are Fossil Fuels combusted for energy.
- **The ecological cycle** relates to the management of renewable, living resources that can cycle in and out of the biosphere. It includes biomass used for feed, food or fuel. Materials in the ecological cycle are either Carbon-Neutral or Non-Carbon-Neutral biomass. As noted, it's important to understand that not all biomass stays within the ecological cycle, with a portion captured by other indicators.

For each indicator, performance is measured on both the **input** side—how materials flow into the economy—and the **output** side—how these materials are processed as waste at their end-of-life. The Circularity Metric, for example, is an input-focused indicator: it measures the share of secondary materials flowing into an economy and thus differs from the global recycling rate, which is an output-focused indicator.

- **Input:** We start with—and give more relevance to—input-side indicators simply because the materials that enter a system ultimately determine

what comes out. The moment a material leaves the environment and enters the economy—whether extracted from the earth, harvested, or otherwise sourced—sets the stage for its entire lifecycle. In a manufacturing facility, for example, the types and quantities of raw materials (input) influence the quantities of finished products, as well as the waste and emissions generated from the production process.

- **Output:** Each input-side indicator has a corresponding output. While outputs—like waste, emissions and recycled materials—are directly linked to inputs, there's often a time lag between materials entering and exiting the system. This is because materials take different pathways once they enter the economy: some are **short-lived**—like fuels burnt for energy, fertilisers dissipated into the soil or packaging and consumer goods that are discarded soon after use—and pass through the system rapidly, becoming outputs without significant changes in their resource group composition. Other materials enter the economy and become part of **Accumulated Stocks**—like buildings, infrastructure and vehicles—and remain in use for years. Because past and present material use patterns differ in composition, changes between input- and output-side indicators are largely influenced by the dynamics of stock renewal and depletion. Simply put, the materials flowing out of the economy today are not shaped just by what is entering the economy now but largely by the gradual release of materials from Accumulated Stocks. This highlights the importance of stocks in determining outputs and, ultimately, the circularity of the economy: effective stock management is crucial to maximise circularity and reduce waste over time.

* The term 'net' is important in the context of stock-flow dynamics. We can distinguish three different types of stock accumulation: **Accumulated Stock**, which measures the total volume of materials added to socioeconomic stocks over time; **Gross Additions to Stock**, which measures the total amount of materials used in long-lived applications (of over one year) in the accounting year. In the context of this analysis, this can include both virgin and secondary materials; and **Net Additions to Stock**, which measures the net amount of materials in long-lived applications after accounting for materials removed from accumulated stocks through Demolition and Discard in the accounting year. This flow only contains virgin materials, as the amount of secondary materials in both Gross Additions to Stock and Demolition and Discard is assumed to be equal within the same accounting year. This report's analysis measures Net Additions to Stock.

On both the input and output sides, indicators are represented as percentages that sum to 100%, and thus, each represents a fraction of how materials enter and leave the economy globally. Values for each headline indicator are provided in Table one

and Table two for 2021, the data year for this report, and 2018 to give insight into trends over the last years. These indicators are defined and qualified throughout the remainder of this chapter.

	Indicator	2018		2021	
		Rate (%)	Scale (billion tonnes)	Rate (%)	Scale (billion tonnes)
Circular material flows	Circularity Metric (Input Technical Cycling)	7.2%	7.1	6.9%	7.3
	Carbon-Neutral Biomass (Input Ecological Cycling Potential)	21.6%	21.5	21.5%	22.8
Linear material flows	Non-Carbon-Neutral Biomass (Input Non-Renewable Biomass)	2.6%	2.6	2.2%	2.3
	Other Virgin, Non-Renewable Materials (Input Non-Renewable Flows)	18.0%	17.9	18.1%	19.2
	Fossil Fuels used for energy purposes (Input Non-Circular Flows)	13.9%	13.9	13.3%	14.1
Net stock build-up	Net Additions to Stock	36.7%	36.6	38.0%	40.3

Table one provides values for each headline indicator on the input side for 2018 and 2021, the year of latest available data.²⁵

	Indicator	2018		2021	
		Rate (%)	Scale (billion tonnes)	Rate (%)	Scale (billion tonnes)
Circular material flows	Waste destined for recycling (Output Technical Cycling)	11.1%	7.1	11.2%	7.3
	Waste and emissions from Carbon-Neutral Biomass (Output Ecological Cycling Potential)	34.5%	22.1	35.3%	23.2
Linear material flows	Waste and emissions from Non-Carbon-Neutral Biomass (Output Non-Renewable Biomass)	4.1%	2.6	3.4%	2.2
	Waste disposed of without recovery (Output Non-Renewable Flows)	28.3%	18.1	28.6%	18.8
	Emissions and waste from Fossil Fuels used for energy purposes (Output Non-Circular Flows)	22.0%	14.1	21.6%	14.2

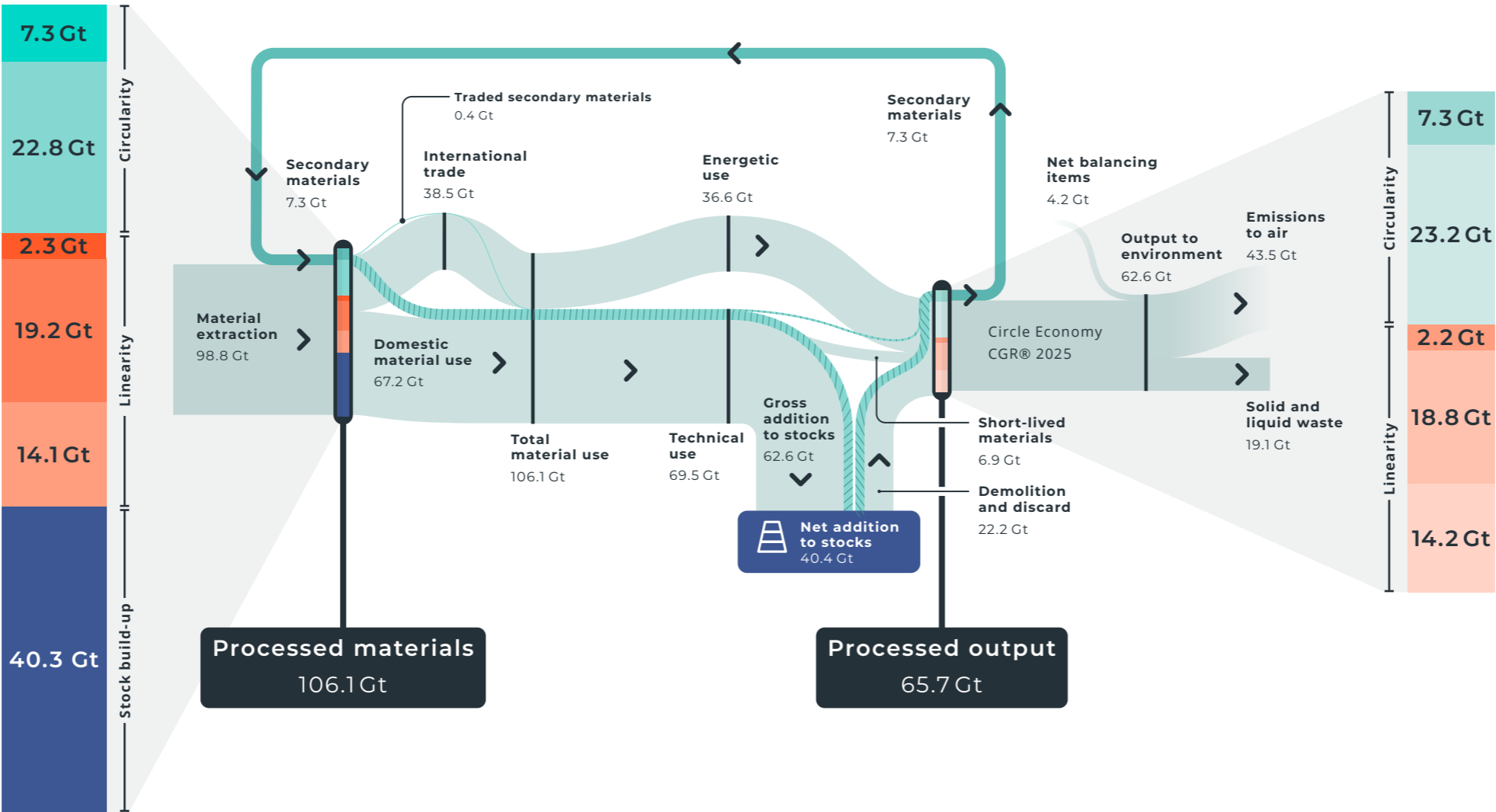
Table two provides values for each headline indicator for the output side for 2018 and 2021, the years with the latest available data.²⁶

Circularity Indicator Set of the global economy

INPUT

Of the **106.1 billion tonnes of processed materials** flowing into the global economy:

- 6.9% are Secondary Materials (Technical Cycling rate)
- 21.5% are Carbon-Neutral Biomass (Ecological Cycling Potential rate)
- 2.2% are Non-Carbon-Neutral Biomass (Non-Renewable Biomass rate)
- 18.1% are other Virgin, Non-Renewable Materials (Non-Renewable rate)
- 13.3% are Fossil Fuels used for energy purposes (Non-Circular Flows rate)
- 38.0% are virgin materials accumulated in Stocks (Net Additions to Stock)



These headline indicators provide a consolidated big-picture overview of the state of circularity, but it's also important to go a layer deeper to provide even more context for what these global, macro-level figures are telling us. This chapter explores relevant sub-indicators for each of the headline indicators listed above, along with insights on their importance and guidance on how these indicators can be interpreted and used to track the transition.

Figure three breaks down the shares of each component of the Circularity Indicator Set for 2021 (the latest available data year), showing how materials enter the economy, are used, and eventually become outputs.

OUTPUT

Of the **65.7 billion tonnes of processed output** flowing out of the global economy:

2.1 Circular material flows

Circular flows refer to materials that flow through the economy in a way that prioritises reuse, recycling, and regeneration over virgin extraction and waste disposal. The Circularity Indicator Set differentiates between two types of circular flows, technical and ecological, corresponding to **Secondary Materials** and **Carbon-Neutral Biomass**, respectively.

2.1.1 Secondary Materials

Secondary Materials represent the materials collected, processed and recovered from waste for secondary use in an economy, whether global, national or local. These can substitute virgin materials, which are extracted directly from nature. This indicator is quantified on the input and output side:

6.9%

of materials flowing into the economy are...

Secondary Materials—including non-metallic minerals, metals, fossil fuels used for material purposes, and technical biomass—both recycled and downcycled. This share represents the portion of secondary materials out of the total material input of the global economy, which includes all primary and secondary materials.

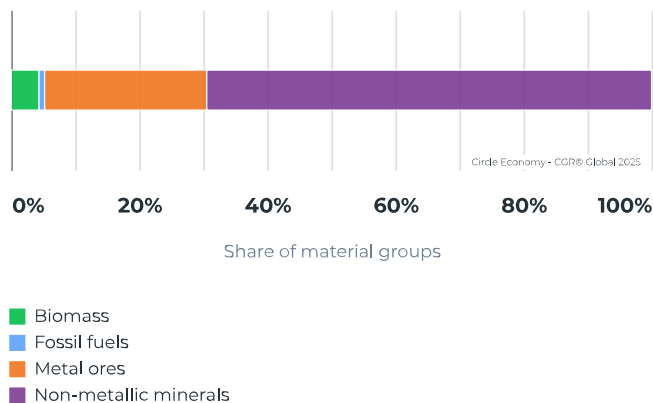
This indicator is referred to as the Circularity Metric.

11.2%

of materials flowing out of the economy are...

Waste destined for recycling.²⁸

(Input) Secondary Materials broken down by material group



Desired outcome:

Maximise the use of secondary materials by: 1) Systematically reducing raw material extraction and overall material throughput, 2) Ensuring that recycled and by-product materials become a more mainstream input across all economic sectors, and 3) Prioritising the optimisation of material recovery from Accumulated Stocks such as buildings and infrastructure.

Commentary:

The share of Secondary Materials entering the global economy is low—and steadily falling year on year, from 7.2% in 2018 to 6.9% as of the latest available data (2021). This decline is largely due to sustained growth in overall material use, which outpaces growth in secondary material use. In other words, as long as material consumption keeps rising, completely closing material loops is incompatible with growth in material throughput. We now know the impact of current and unprecedented levels of virgin material use: high greenhouse gas emissions, biodiversity loss and pollution.²⁹ In fact, our *Circularity Gap Report 2021* found that as much as 70% of global emissions stem from material handling and use.³⁰ This highlights the need to reduce virgin material use while increasing secondary material use—both of which will drive up the **Circularity Metric**. Achieving this will involve cycling all materials that could be cycled but are not (see page 40) and reducing other linear activities, such as fossil fuel use (see page 44).

Increasing circularity is far more complex than just increasing material cycling. While increasing secondary material use as much as possible is important, there's a natural limit to how much the Circularity Metric can grow. Even if all waste currently not being recycled was recycled—without reducing overall material throughput—we would only reach a Circularity Metric of roughly 25%. This puts our conception of 'circularity' in perspective: true circularity isn't about recovering and recycling more,

it requires fundamentally restructuring how we extract, produce and consume materials. The *Circularity Gap Report 2021*, for example, found that rolling out these deep structural changes across key systems—such as housing, food, and mobility—would reduce material use by approximately one-third—shifting us much closer to a sustainable level of material use, estimated at 8 tonnes per capita.³¹ This exemplifies the importance of understanding the absolute scale of virgin and secondary material use, alongside rates like the Circularity Metric.



By breaking down current sources of secondary material use, we can better understand opportunities for improvement (see Figure four). Approximately half (49.6%) of the Circularity Metric is composed of recycled **construction and demolition waste**—a heavy waste stream by mass. The built environment can be seen as a huge repository or ‘bank’ of materials that can be recovered and reused at their end-of-life. However, only 22% of construction and demolition waste is recycled, leaving potential for improvement. What’s more, it’s likely that a significant portion of ‘secondary’ construction and demolition materials is represented by aggregates used for low-value applications such as backfilling. **Industrial waste**—comprising metal scrap, sludges, chemical waste, offcuts, and industrial packaging, for example—is a close second, representing 44% of secondary material use. Of all industrial waste generated, approximately 41% re-enters the economy. **Municipal solid waste**—the everyday items we use and then recycle—contributes a much smaller portion, at just 3.8% of the total. It should be noted that global municipal solid waste collection rates average around 80%, but only 15% of the total makes its way back into the cycle—indicating

significant potential for improvement. **Special wastes** like healthcare waste, hazardous waste and electronic waste represent just 2.6%.

Boosting secondary material use at a macro level is a complex challenge. What concrete actions are needed to move the needle and ensure more materials make their way back into the cycle? To understand and measure progress towards higher secondary material use, it’s important to break down the factors influencing these indicators using a set of sub-indicators for both material inputs and outputs. Table three provides an overview of these indicators, their current status, and whether or not they have relevant global or sub-global targets.

Input: Virgin material use has a significant impact on the Circularity Metric. At a global level, it directly corresponds to **material extraction**, which provides a snapshot of the volume and type of materials extracted from the Earth and signals the extent to which economies depend on them. Global material extraction³² has more than tripled in the last 50 years, reaching 99.8 billion tonnes in 2021 (see Figure one). As extraction continues to rise, the ability of secondary materials to meaningfully reduce reliance on new extraction is shrinking.

Global secondary material consumption

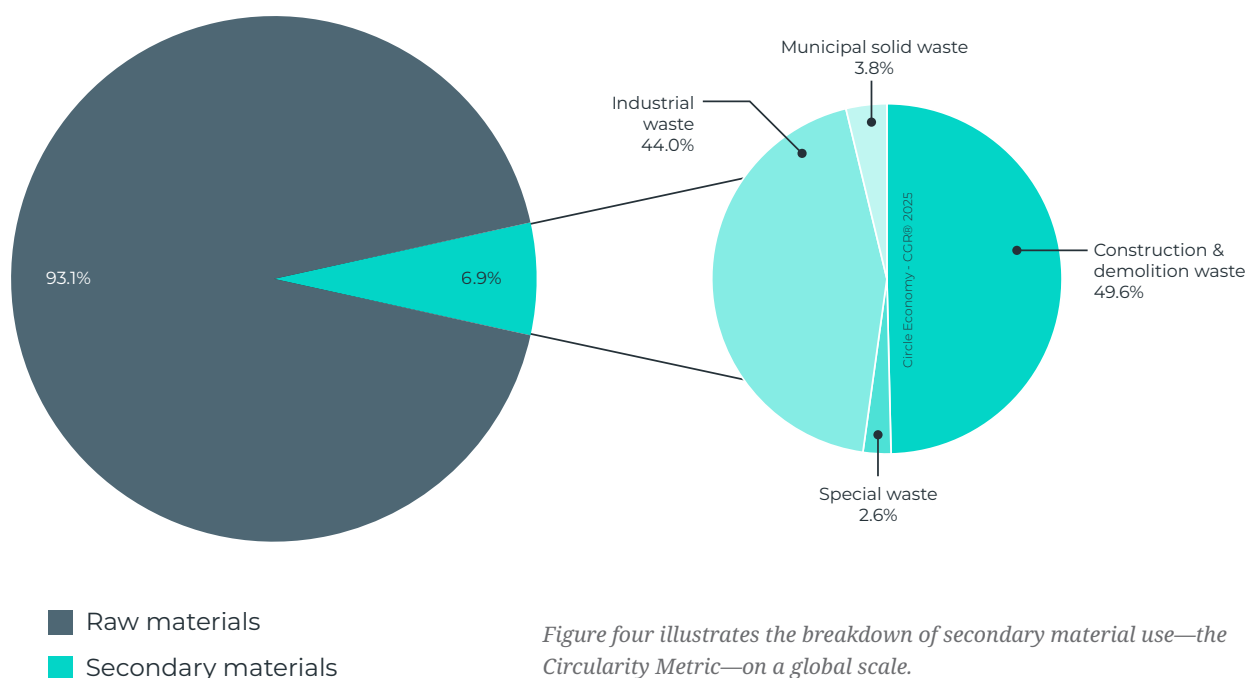


Figure four illustrates the breakdown of secondary material use—the Circularity Metric—on a global scale.

Output: As material use grows, so does **waste generation**, totalling 26.4 billion tonnes globally.³³ While a large part of the materials extracted remain within the economy for years as Accumulated Stocks (see page 23), a share becomes ‘output’—in the form of emissions and solid and liquid waste—in a relatively short amount of time. Although minimising waste generation should be the priority, measuring **waste as a share of Processed Outputs**—the materials that leave an economy as either emissions or physical waste—gives insight into which portion of these outputs can be recovered and, ideally, recycled. This share stands at 45.2% globally.³⁴ A higher share of waste compared to emissions (see page 44) points to a larger pool of resources available for recovery. Optimising how these outputs are dealt with—whether they are sent to landfill, incineration, or recycling, for example—will be key to minimising the share that actually

becomes waste. The relatively high **global waste collection rate** (82%) and low **global recycling rate** (27%³⁵) shed light on the effectiveness of recycling systems on a global scale, revealing a significant gap between collection and recycling. These figures are important to track as waste must be collected, sorted, processed and recycled to be transformed into secondary materials, which can then re-enter the economy. However, a portion of collected waste is instead directed to controlled or uncontrolled disposal. In countries where waste management infrastructure is still developing, tracking the **controlled disposal rate** (globally 15.6%) will be an important interim step. Strengthening controlled disposal systems can help reduce uncontrolled waste dumping while laying the groundwork for expanding recycling capacity in the future.

Indicator	Value in (year)	Trend	Global Target	Status	Sub-Global Targets (Y/N)
Global material extraction (tonnes) ³⁶	12.6 tonnes per capita (99.8 billion tonnes) (2021) 12.3 tonnes per capita (95.0 billion tonnes) (2018)	↑	8 tonnes per capita per year ³⁷	Off-track	No
Total waste generation (tonnes) ³⁸	26.4 billion tonnes (2021) 26.1 billion tonnes (2018)	↑	None	n.a.	Yes
Waste as a share of Processed Outputs (%) ³⁹	45.2% (2021) 44.6% (2018)	↑	None	n.a.	No
Waste collection rate (%) ⁴⁰	82% (various reference years)*	No data**	None	n.a.	Yes
Recycling rate (%) ⁴¹	27.0% (2021) 27.4% (2018)	↓	None	n.a.	Yes, although most countries set recycling rates for specific waste streams rather than overall targets.
Controlled disposal rate (%) ⁴²	15.6% (2021) 16.0% (2018)	↓	None	n.a.	No

Table three lists each sub-indicator, elaborating on how these figures have changed over a five-year period and whether we are on track to meet global targets (if any).

* Based on the latest available data from each country.

** Data gaps make it difficult to provide a coherent trend.

2.1.2 Carbon-Neutral Biomass

This indicator concerns biomass used for food, feed, and fuel, such as food crops, agricultural residues or wood. It does not include certain biomass flows like timber used for building up stock, or packaging applications, for example. There are four criteria for biomass to be considered circular, described in depth on page 32.⁴³ Circular biomass must:

- 1. Minimise environmental impact:** Assess and reduce the impact of biomass extraction on ecosystem services.
- 2. Ensure renewability and regeneration:** Use biological materials in a way that respects their natural renewal rates and prioritise regenerative practices that lead to improved outcomes (afforestation and rewilding, for example).
- 3. Cascade use:** Reuse bio-based products and cascade materials before discarding them.
- 4. Close the nutrient cycle:** Ensure nutrients return safely to the biosphere at their end-of-life.

Measuring the circularity of 'technical' materials is easier than that of biological materials, as they are processed and reused within industrial systems. While biological materials do flow into the industrial system, their circularity broadly relates to how they're returned to the natural system and the health of the broader ecosystem that they belong to. This is not always concretely defined nor easily measured.

Because determining the circularity of biological materials is conceptually complex and difficult to measure,⁴⁴ this indicator captures biomass that meets the minimum criterion of carbon neutrality, meaning it absorbs as much carbon during its growth as it emits when used. This partially addresses the first and last criteria listed above. While some biomass captured by this indicator may meet some or even all of the remaining criteria, measuring or guaranteeing this is not possible due to data limitations. Biomass that meets none of the criteria is measured by another indicator: Non-Carbon-Neutral Biomass.

All biomass that stays within the ecological cycle falls into two categories: carbon-neutral and non-carbon-neutral. Carbon-Neutral Biomass meets certain criteria to be considered carbon neutral, while Non-Carbon-Neutral Biomass exceeds these limits and is considered 'in the red'. This distinction between the

two doesn't relate to how the biomass is extracted, but just that a portion is in excess. For more information on Non-Carbon-Neutral Biomass, skip to page 37.

This indicator is quantified on the input and output side:

21.5%

of materials flowing into the economy are...

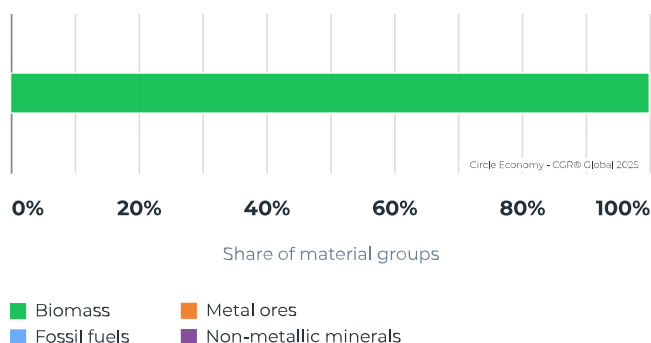
Carbon-Neutral Biomass. This figure quantifies the share of renewable primary biomass inputs in processed materials.

35.3%

of materials flowing out of the economy are...

Waste and emissions from Carbon-Neutral Biomass.

(Input) Carbon-Neutral Biomass broken down by material group



Desired outcome:

Transition to exclusively using biomass that:

1) Respects natural cycles—such as the carbon, nitrogen and water cycles—and ensures carbon neutrality and full nutrient cycling in the right place and at the right pace; 2) Prevents land degradation to preserve and enhance complex, biodiverse ecosystems with healthy soils, and 3) Maximises its value through cascading where possible: reusing it multiple times, through multiple stages, before it is eventually discarded.



Measuring the circularity of biomass

Current circular economy monitoring systems are largely designed to track and interpret technical cycles and focus on the reuse of materials within this sphere. However, this approach means that it's difficult to monitor and capture circular economy potential fully, as the circularity of biomass is not adequately captured. Biomass is not inherently circular, and the ecological costs of its (over)extraction, from land-use change and the disruption of nutrient cycles to habitat and biodiversity loss, can no longer be overlooked. To be fully circular, biomass must:

- 1. Minimise environmental impact:** This means assessing and reducing the impact of resource extraction on ecosystem services—the benefits nature provides to humans, including clean air and water, climate regulation, and natural resources—including those resulting from land-use change and resource depletion. It also involves accounting for the carbon balance by tracking biogenic carbon flows—sequestration, storage, and release—and their impact on the global climate. These flows differ from fossil carbon in that they cycle through the atmosphere over much shorter timescales.
- 2. Ensure renewability and regeneration:** This means using biological resources in a way that, at the very least, respects their natural renewal rate, prioritising sustainable sourcing to maintain long-term availability. This includes recognising that old, wild ecosystems—such as mature forests—provide far greater biodiversity, carbon sequestration, and ecosystem stability compared to new plantations. Preserving and sustainably managing natural ecosystems is critical to maintaining these unique and irreplaceable benefits.
- 3. Optimise cascading use:** This means maximising the value of biological resources⁴⁵ by identifying pathways for their multiple uses and streams, ensuring resources are reused effectively before they reach their end-of-life. For example, agricultural residues can first be used for materials such as bioplastics or paper, then as animal bedding or compost, and finally for bioenergy.

- 4. Close the nutrient cycle:** This means that biological materials can biodegrade and safely return to the biosphere at their end-of-life. This involves improving material separability and biodegradability, minimising harmful substances in emissions to the environment and returning nutrients to the ecosystem in a place and at a rate that supports regeneration. 'In place' refers to the principle that nutrients should be returned to the place in an ecosystem where they are needed to sustain biological processes rather than deposited where they could cause harm—for example, eutrophication in water bodies. 'At rate' refers to the principle that nutrient cycling should align with an ecosystem's natural regenerative capacity, being reintroduced at a pace that an ecosystem can absorb, process and use without being disrupted. Note that 'nutrients' here refer to nitrogen, phosphorus, sulphur, carbon and water.

Due to methodological constraints and current data availability, it is not possible to assess all of these criteria. This is why Ecological Cycling Potential takes **carbon neutrality** as a minimum criterion, which partially addresses the first and fourth criteria listed in this box. This approach considers land use, land-use change and forestry emissions to determine which changes in ecosystem carbon stocks result from biomass extraction. This is a minimal requirement but an incomplete one: consider, for example, a sustainably managed forest where trees are replanted to replace those harvested. These activities may be carbon neutral, but only considering this aspect does not account for the loss of the ecological complexity and biodiversity that are hallmarks of old-growth forests. Managed forests may be monocultures or have a limited number of species, making them less resilient and valuable—even if they're carbon neutral.

Commentary:

There are no established methodologies for reliably measuring the circularity of biomass use, but considering the carbon balance of biomass use is a first step. This indicator considers biomass that is carbon neutral as a minimum criterion for measuring its circularity. While a rate of 21.5% may seem positive, biomass extraction remains synonymous with a number of uncaptured negative environmental impacts. Because of this, a more circular and sustainable world would not necessarily result in an increase in the rate or scale of Carbon-Neutral Biomass extraction. Regardless of whether this indicator grows or shrinks, it's crucial that all materials captured by it undergo full nutrient cycling: as discussed, this important criterion is not aptly reflected. In the future, identifying certification labels that rigorously assess all four criteria—as defined on pages 30 and 32—could be a practical approach to calculating the share of circular biomass.

The scale of biomass extraction is high and a key driver of environmental impacts. Despite its declining share in global material extraction (from 41% in 1970 to 26% in 2021), in absolute terms, biomass extraction has more than doubled in the past 50 years, increasing from 10.8 billion tonnes in 1970 to 26.3 billion tonnes in 2021 (see Figure five). Within this context—and contrary to common assumptions—biomass extraction and use is a significant driver of environmental impacts. It's among the largest contributors of greenhouse gas emissions, representing 18% of the total—largely linked to food and feed production—while clearing land for crops is a key driver of habitat destruction and accounts for over 90% of land-use-related biodiversity loss.⁴⁶ Many of these impacts are driven by global food systems, with food and feed production accounting for 79% of the global biomass demand considered under this indicator and Non-Carbon-Neutral biomass (see page 37).⁴⁷ A further 12% is represented by fuel, and 9% is represented by other uses, such as straw.

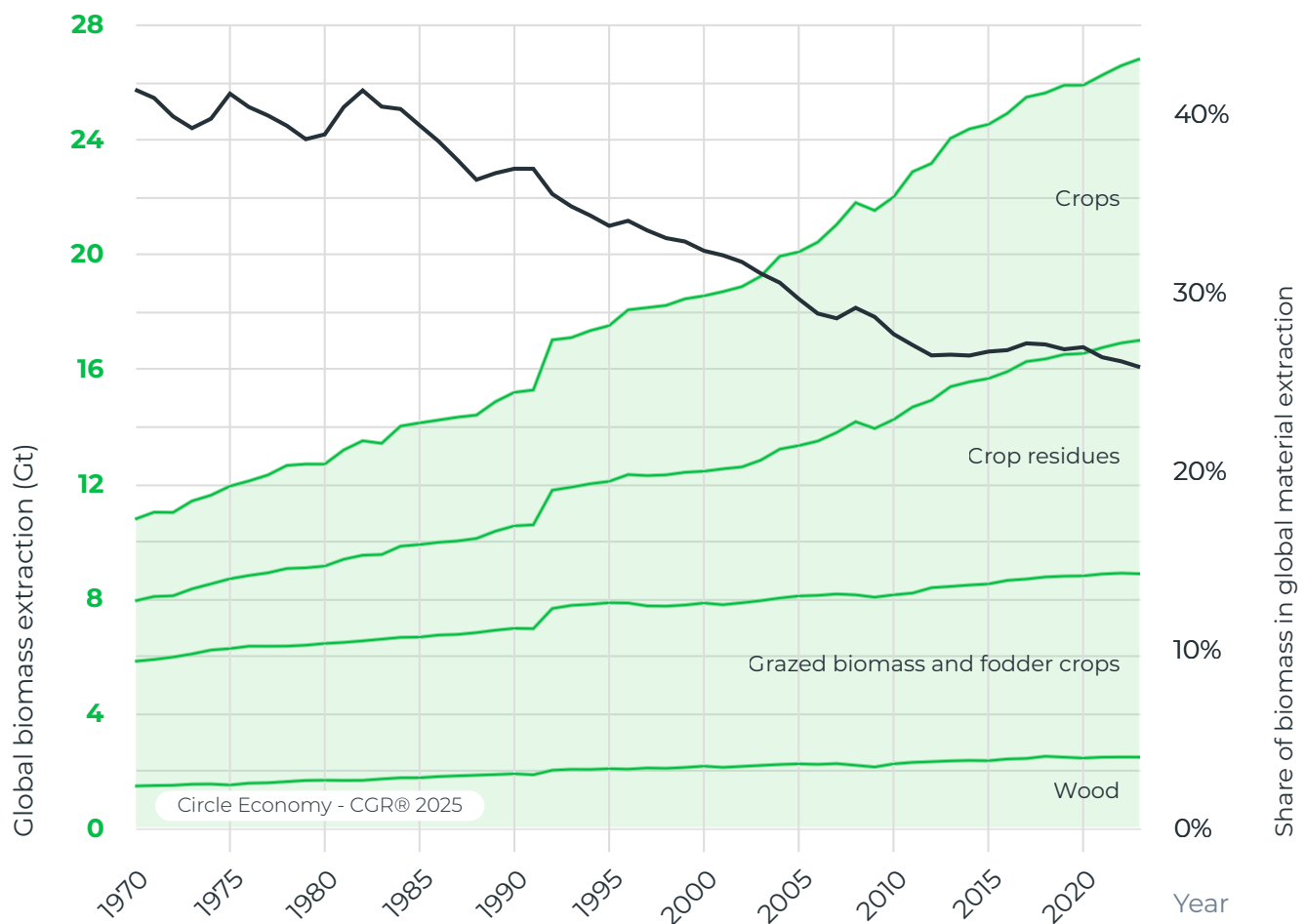


Figure five illustrates the evolution of global biomass extraction and its share of total material extraction between 1970 and 2021.

Developing a more sustainable and circular global economy requires transforming land use and agriculture.

A disproportionate fraction of global land is used intensively, primarily for agricultural purposes such as pasture and animal feed production:⁴⁸ half the world's habitable land is used for agriculture, with 80% of this dedicated to livestock. Despite the space required to rear livestock and grow feed crops, livestock provides only a fraction of the global calorie supply.⁴⁹ On a planet with limited space, this inefficiency has significant consequences. As agricultural land continues to expand—often encroaching on forests, wetlands and other wild ecosystems—we continue to witness a severe retreat of nature. This is the main cause of land use and land-use change emissions through deforestation, as well as biodiversity loss and soil degradation.⁵⁰ At the same time, we waste about one-third of all food produced, contributing as much as 10% of global emissions.⁵¹ This means valuable land is used for food that never gets consumed—land that could instead contribute to carbon sequestration and biodiversity. To rebalance global land use, we need to redesign the food system into a holistic, circular and regenerative system that safeguards planetary and human health.⁵² Leveraging a sustainable global food system's full potential requires transforming both production and consumption patterns. This includes minimising synthetic fertilisers that pollute soil and water, prioritising regenerative practices like agroforestry and integrated livestock systems, and promoting nourishing diets with more plant-based foods and fewer ultra-processed products.^{53,54} These practices can decrease demand for land and other resources, such as water, freeing up space for rewilding and reforestation, helping restore damaged ecosystems, expanding global carbon sinks, and allowing biodiversity to flourish. It will also build up the resilience of food production and improve food security in many countries and regions.

Building a sustainable, circular bioeconomy is essential for advancing sustainable resource use, but there is no harmonised methodology to measure and monitor it. Measuring the rate of Carbon-Neutral Biomass is also important to monitor the sustainability and circularity of the bioeconomy, which covers all sectors and activities that rely on biological resources (animals, plants, microorganisms and derived biomass, including organic waste) and their ecological functions.⁵⁵ A 'circular bioeconomy' is an economic model that combines the principles

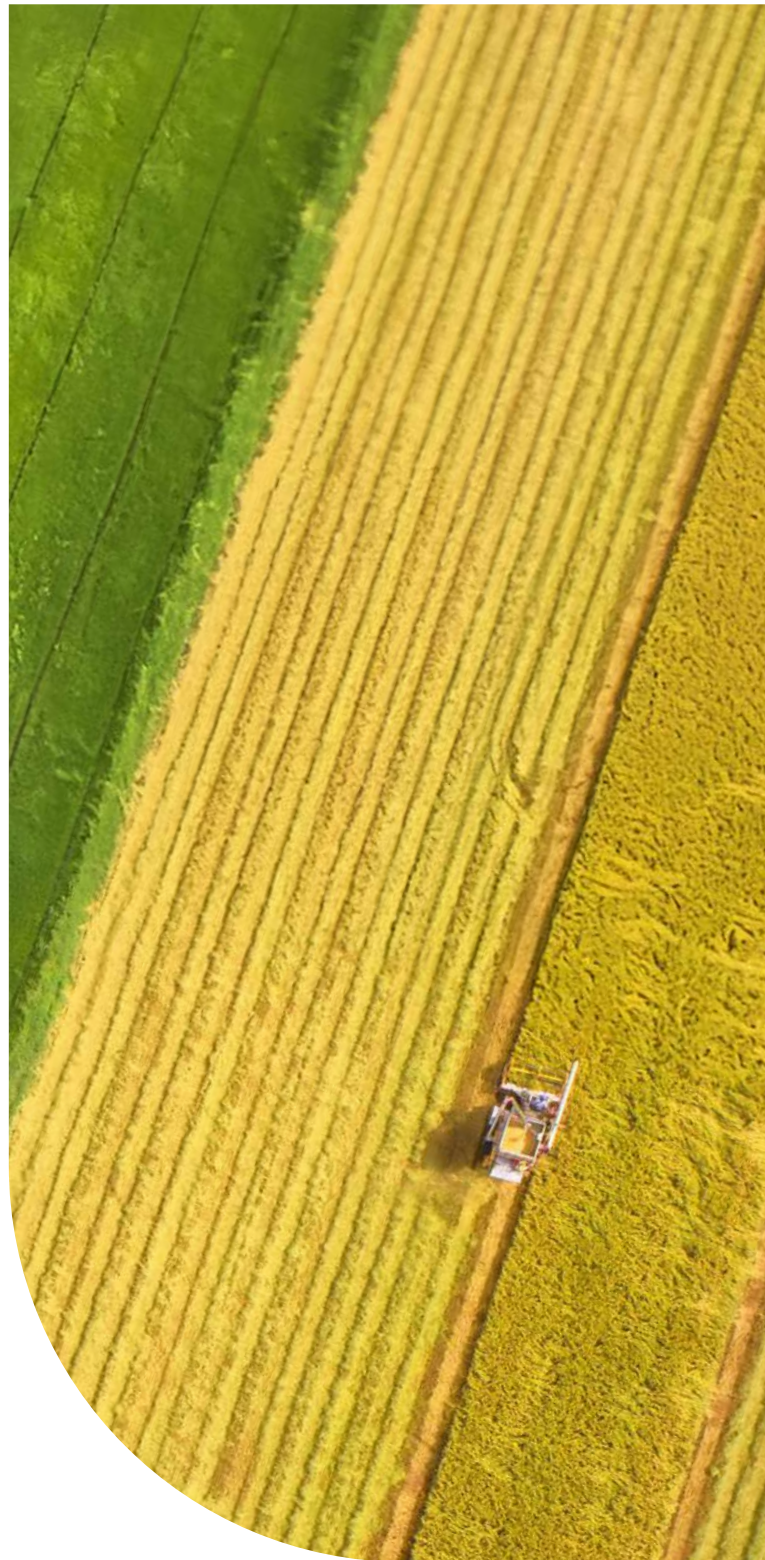
of both the circular economy and the bioeconomy and aims to optimise the use of renewable biological resources while minimising waste and environmental impact through circular practices.

To understand and measure progress towards a more circular bioeconomy, it is therefore important to break down the factors influencing these indicators through a number of sub-indicators. These indicators' status—and whether or not they have relevant global or sub-global targets—is summarised in Table four.

*Input: **Global biomass extraction*** is a key driver of environmental impacts: its scale is crucial to track. In 2021, this indicator stood at 26.3 billion tonnes, equivalent to 3.3 tonnes per capita.⁵⁶ Various biomass materials and farming practices have different associated impacts: livestock systems, for example, have much higher material, carbon and land footprints than crops cultivated for direct human use.⁵⁷ This is why measuring extraction indicators by **biomass type and activity** can help indicate where the most impact can be made. **Water stress**—which measures the share of total human water withdrawals relative to available freshwater resources—provides important insight into the sustainability of biomass production, especially in water-scarce regions.⁵⁸ Globally, water stress is 18.6%, but levels vary substantially by region. Central and Southern Asia have high water stress levels—surpassing 75%—while Northern Africa's water stress exceeds 100%, requiring groundwater depletion or desalination, for example. In 2020, 2.4 billion people lived in water-stressed countries.⁵⁹ Measuring water requirements alongside biomass types and activities can ensure that land use and biomass extraction align with hydrological cycles, allowing water resources to be regenerated.⁶⁰ Sustainably optimising biomass use requires regenerative agriculture, better water management, and shifting demand away from resource-intensive products such as meat and dairy. This is especially important given that agriculture is a key driver of water stress, accounting for 72% of global freshwater withdrawals.⁶¹

At the same time, positive indicators, such as the **share of forested land** (31.1%) (bolstered by **land protection rates**), are essential to show where and to what extent progress is being made. In 2021, forested areas (including non-natural forests) represented nearly one-third of global land area, down from 32.5% in 1990.⁶² The average forest area per person has decreased from 1.4 hectares in 1960 to about 0.5 hectares as of 2019, reflecting both population growth and forest loss.⁶³ Similarly, tracking the **reclamation rate of organic substances** can play a crucial role in enhancing the circularity of global biomass inputs by ensuring that organic waste—like food scraps, agricultural residues, manure, and biodegradable products—is effectively reintegrated into the biological cycle. This indicator is key for monitoring full nutrient cycling, a key criterion for ‘circular’ biomass. However, no global data on this indicator is available.

Output: On the output side, measuring global **emissions from land use, land-use change and forestry (LULUCF)** captures the impact of activities like deforestation, the draining of peatlands, and the expansion of agricultural land, livestock pastures and human settlements. These activities deplete potential carbon storage and destroy natural habitats, damaging biodiversity. Global net LULUCF emissions account for roughly 2 (between 1.3⁶⁴ and 2.7⁶⁵) billion tonnes of CO₂e, or about 5% of total anthropogenic emissions, a significant share of which stems from deforestation.⁶⁶ Although carbon sequestration has the potential to offset fossil-based emissions through natural ecological processes, LULUCF currently acts as a net source of global emissions. Better land management thus holds significant potential to capture and reduce emissions, with preserving and regenerating natural carbon sinks essential to limiting warming to 1.5-degrees. Safeguarding and restoring natural ecosystems offers numerous benefits in addition to carbon sequestration—bolstering biodiversity, for example.



It's also crucial to understand the impact of nutrients used for agricultural practices (in fertilisers, for example), which often end up in water systems, by measuring **safely treated wastewater flows**⁶⁷ (not available at the global level). Properly treated wastewater supports nutrient recycling, enabling the recovery of nutrients essential to agriculture: nitrogen and phosphorus. This reduces reliance on synthetic fertilisers and promotes the circular use of nutrients

in the biological cycle. Proper wastewater treatment can also contribute to broader environmental goals. For example, organic matter recovered from wastewater can be used to generate biogas or nourish soils while treatment processes prevent the runoff of nitrogen and phosphorus in water bodies, where they can cause harm (eutrophication, for example).

Indicator	Value in (year)	Trend	Global Target	Status	Sub-Global Targets (Y/N)
Global biomass extraction (tonnes per capita) ⁶⁸	3.3 tonnes per capita (26.3 billion tonnes) (2021) 3.3 tonnes per capita (25.7 billion tonnes) (2018)	Stable (per capita)	2 tonnes per capita per year ⁶⁹	Off-track	Yes
Water stress (%) ⁷⁰	18.6% (2021) 18.3% (2018)	↑	None	n.a.	Yes
Share of forested land (%) ⁷¹	31.1% (2020)* 31.2% (2018)	↓	33.7% ⁷²	Off-track	Yes
Land protection rate (%) ^{73, 74}	17.6% (2024) 16.6% (2020)	↑	30% ⁷⁵	Off-track	Yes
Reclamation rate of organic substances (%)	No data	No data	None**	n.a.	No
Emissions from LULUCF (tonnes of CO₂e) ⁷⁶	1.3–2.6 billion tonnes (2021)***	No data	None	n.a.	None
Safely treated wastewater flows (%)	Not available at the global level	No data	60% ⁷⁷	n.a.	Yes

Table four lists each sub-indicator, elaborating on how these figures have changed over a five-year period and whether we are on track to meet global targets (if any).

* Latest available data.

** Overall reclamation and recycling rates for organic waste are typically lacking and targets tend to focus on food waste reduction.

*** LULUCF data is uncertain and fluctuating, making it difficult to determine an accurate trend.

2.2 Linear material flows

Linear flows make up the Circularity Gap: they're materials that follow a take-make-dispose model and aren't cycled back into either technical or ecological systems. This category comprises three indicators: **Non-Carbon-Neutral Biomass, other Virgin, Non-Renewable Materials** (materials that *could* be recycled but currently are not), and **Fossil Fuels used for energy** (these are combusted into the atmosphere and thus do not have the potential for cycling, making them inherently non-circular).

2.2.1 Non-Carbon-Neutral Biomass

This indicator captures the share of virgin Non-Carbon-Neutral Biomass—including, for instance, crops on the input side and manure and agricultural residues on the output side—out of total resource use. This means that extracting and using this biomass resulted in net positive emissions due to land use and land cover change.

2.2%

of materials flowing into the economy are...

Non-Carbon-Neutral Biomass.

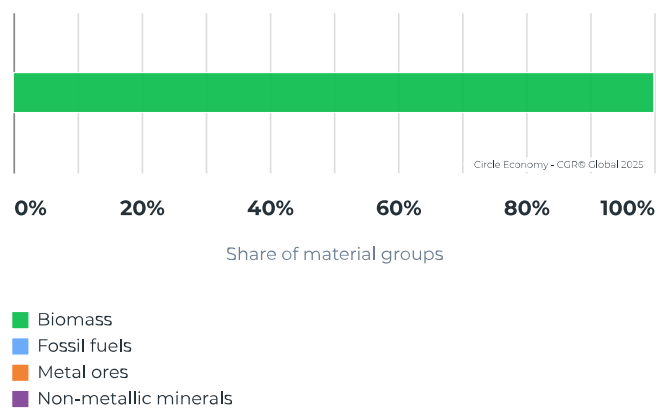
This figure quantifies the share of non-renewable virgin biomass inputs in processed materials.

3.4%

of materials flowing out of the economy are...

Waste and emissions from Non-Carbon-Neutral Biomass.

(Input) Non-Carbon-Neutral Biomass broken down by material group



Desired outcome:

Eliminate the use of biomass that:

- 1) Surpasses the natural rate of regeneration or leads to net positive carbon emissions due to land use change,
- 2) Disrupts ecological timescales and existing carbon and nutrient balances.

drive deforestation—particularly in tropical forests⁸³—and forest degradation and land conversion for agriculture, for example. This could include forest biomass harvesting for large-scale bioenergy production and practices like shifting cultivation, where plots of land are temporarily converted for agriculture and then abandoned and are unable to be fully restored. The drainage and excavation of peat for agricultural purposes also contribute to emissions. Although peatlands represent just 3% of the world's land area,⁸⁴ they store vast amounts of carbon, and disrupting them releases large volumes of methane, the most potent greenhouse gas.⁸⁵

Commentary:

This indicator represents biomass that does not meet the minimum criterion of carbon neutrality.

This non-carbon-neutral portion is not linked to a specific source or process but rather represents systemic inefficiencies in biomass extraction. This indicator captures the portion of biomass harvested at a **rate** that cannot be sustainably regenerated or taken from a **place** that disrupts natural ecological balances (input) or that is not returned to the environment 'in place' and 'at rate' (output). The presence of hazardous substances must also be accounted for on both the input and output side. This could include chemicals used to harvest or process biomass, for example, as well as the discharge of contaminated biomass into the environment.

Excessive extraction rates and unsustainable practices make biomass a non-renewable, and thus linear, resource. Harvesting biomass at a rate that exceeds its natural capacity for regeneration essentially makes it a finite, rather than renewable, resource.⁷⁸ If biomass is harvested faster than it can regrow or reabsorb the same amount of carbon, it is no longer carbon neutral because the total carbon stock declines. The same applies to soil, another rapidly degrading key renewable resource strongly linked to biomass extraction.⁷⁹ For this reason, understanding the climate impact of biomass use means understanding the time-explicit nature of carbon flows: the rate at which carbon is sequestered, how long it's stored, and how quickly it's released back into the atmosphere.^{80, 81, 82} Non-Carbon-Neutral Biomass is that which results in emissions from land use and land-cover change through activities that



Although the current share of Non-Carbon-Neutral Biomass use is small, it needs to be reduced to zero. At just 2.2%, the share of Non-Carbon-Neutral Biomass accounts for a small portion of total material consumption. However, Non-Carbon-Neutral Biomass represents approximately one-tenth of total biomass use, a share that is still crucial to minimise. In fact, this figure may also be higher than estimated, as various studies have demonstrated that different accounting methods can significantly affect the share of biomass considered carbon neutral.^{86, 87} For example, the Kyoto Protocol's guidelines for national accounting—used by many countries—have been criticised for allowing countries to adjust forest management definitions to their advantage, leading to underreported emissions.⁸⁸ As discussed in the Carbon-Neutral Biomass section on page 30, carbon neutrality is just one of many concerns linked to biomass extraction. Biomass production can also lead to additional environmental risks, including disruptions to natural

nutrient cycles. For example, excessive nitrogen and phosphorus can be introduced into agricultural systems, and nutrients from the soil can be depleted through erosion and runoff. The overuse of non-renewable water resources—where water is taken faster than it can be replenished—is also a significant concern linked to biomass harvesting. Five of nine planetary boundaries have a direct link to the bioeconomy,⁸⁹ with biomass extraction linked to the overexploitation of forest resources, land use change, biodiversity loss, and increased competition for land from fuel, feed and food.

Non-Carbon-Neutral Biomass shares the same sub-indicators as Carbon-Neutral Biomass: global biomass extraction, biomass types and activities, afforestation and land protection rates, ecological overshoot, level of water stress, average recycling/reclamation of organic substances rates, and proportion of safely treated domestic wastewater flows.



2.2.2 Virgin, Non-Renewable Materials

This indicator measures materials that potentially can be cycled but are not. These are heavy mining and industrial wastes, products that are short-lived (such as paper, packaging, chemicals and some consumer products, including fossil fuels used for material purposes) and longer-lived products reaching their end-of-life (such as discarded appliances, vehicles, or construction materials). Products and materials captured by this indicator will become waste within the year measured. This indicator does not capture fossil fuels used for energy nor biological materials such as food, feed and biofuels, but does represent a small fraction of unsustainably managed renewable resources, such as discarded timber from Accumulated Stocks or wood used for short-lived packaging applications.

18.1%

of materials flowing into the economy are...

Other virgin, mostly Non-Renewable Materials, including non-metallic minerals, metals, fossil fuels used for material purposes, and very small amounts of technical biomass destined for disposal. Materials in this flow are finite resources extracted from the environment in the current as well as previous accounting years, and are disposed of without recovery in the current accounting year.*

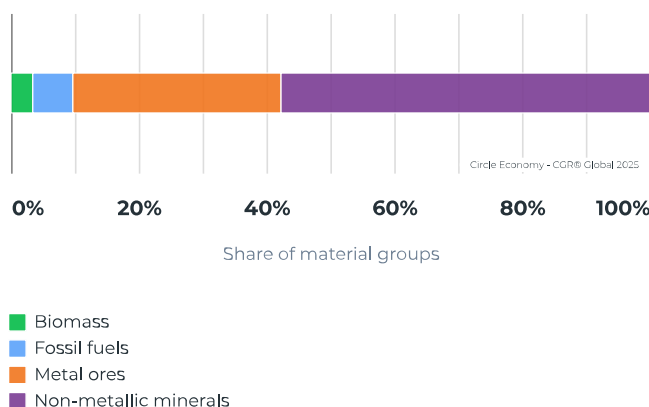
* To capture the time lag in stock dynamics in a snapshot of a single year, our framework considers Gross Additions to Stock (on the input side) to be equal to Net Additions to Stock plus demolished and discarded materials. In this context, Demolition and Discard refers to materials extracted from the environment and added to stocks in previous years that become waste in the current year. This approach is more useful for circularity measurement than just reporting Gross Additions to Stock on the input side, as it allows us to better understand this portion of inflows from a circularity perspective.

28.6%

of materials flowing out of the economy are...

Waste disposed of without recovery within the accounting year. This includes waste from both short- and long-lived applications in Accumulated Stocks.

(Input) Virgin, Non-Renewable Materials broken down by material group



Desired outcome:

Minimise all non-renewable material flows and transform how materials are managed throughout their lifecycle

by: 1) Prioritising circular strategies that design out waste and reducing waste from extraction as much as possible, 2) Recovering the highest value materials from products at their end-of-life, 3) Eliminating the need for and providing alternatives to fossil-based feedstocks, and 4) Improving collection and recycling systems for all recyclable materials.

This indicator primarily reflects heavy, hard-to-recycle waste, underscoring the importance of circular strategies that minimise waste from the outset. While we don't have a granular breakdown of the materials and products captured by this indicator, we can see that a majority on the input side is represented by construction minerals (53%), with metal ores (33%), industrial minerals (5%), fossil fuels (6%)⁹⁰ and biomass (3%) contributing smaller shares. While a portion of the 86% represented by construction minerals and metal ores could be waste from construction and demolition—a very heavy waste stream by weight—the bulk of it likely comprises waste from used and unused extraction from mining and quarrying, for example, including waste rock, tailings and soils.⁹¹ Much of this wouldn't be suitable for high-value recycling, and options to repurpose these materials are limited, often depending on material composition and economic feasibility.

Commentary:

This indicator reveals significant potential to bolster Secondary Material use. This indicator can be interpreted as the antithesis of the Circularity Metric: it includes everything that *could* be contributing to Secondary Material use but isn't. At 18.1% and 28.6%, the input and output rates of Virgin, Non-Renewable Materials reveal substantial room for increasing global circularity. Ideally, the rate of this indicator would fall as close to zero as possible, with these materials instead contributing to Secondary Material use. The absolute scale of Virgin, Non-Renewable Materials should also drop: this indicator grew from approximately 17.9 billion tonnes in 2018 to 19.2 billion tonnes in 2021. Reducing this indicator on the input side will require cutting consumption to prevent difficult-to-manage wastes in the first place, alongside circular design strategies that minimise waste generation and allow for material recovery. On the output side, the emphasis should be on increasing high-value applications for waste and improving waste management infrastructure. For example, when dealing with construction waste, disassembly and reuse are preferable to recycling and highly preferable to backfilling, a low-value application. However, a large portion of materials captured by this indicator are heavy, lower-value waste streams—soils, for example—without higher-value applications.



Waste rock can be crushed and used as aggregate for various construction projects, while tailings can sometimes be used to produce brick and tile. However, many mining byproducts can contain heavy metals or hazardous substances that make them difficult to cycle without extensive treatment, which is costly and poses additional environmental risks. This underscores the importance of reducing material demand and improving processes to reduce the generation of these hard-to-manage wastes in the first place.

While heavy waste streams do make up the majority of Virgin, Non-Renewable Materials, this should not overshadow the importance of better managing smaller waste streams, such as municipal solid waste. It's estimated that the world generates more than 2 billion tonnes of municipal solid waste yearly—a figure set to increase by 70% by 2050.⁹² In many parts of the world, the informal sector plays a vital role in municipal waste management, though this often means that these activities aren't properly captured by official statistics nor recognised and supported by waste management policy. Better managing this waste and diverting it from

landfills—alongside other damaging waste streams like medical and e-waste—will still have an important role to play in boosting circularity and improving other environmental outcomes. Landfilling remains a persistent social and environmental challenge, with uncontrolled disposal—representing 57% of global waste treatment (see Figure six)—causing uncontained negative impacts, such as pollution from leachate and harmful gases, health hazards and land degradation. These landfills also incur financial costs that often impact local communities. While controlled landfills are better than uncontrolled dumpsites, they are still not ideal: they cause environmental, social and health impacts and potentially lock away valuable resources, making them unavailable for cycling.⁹³ A shift towards higher-value waste management will be crucial in reducing this indicator's share, which can be driven by suitable infrastructure and legislation, including landfill diversion targets, taxes and bans—all of which have had success at reducing landfilling rates in the EU.⁹⁴ However, their success hinges on the availability of fit-for-purpose waste processing infrastructure and technology for plastics, textiles and organic waste, for example.

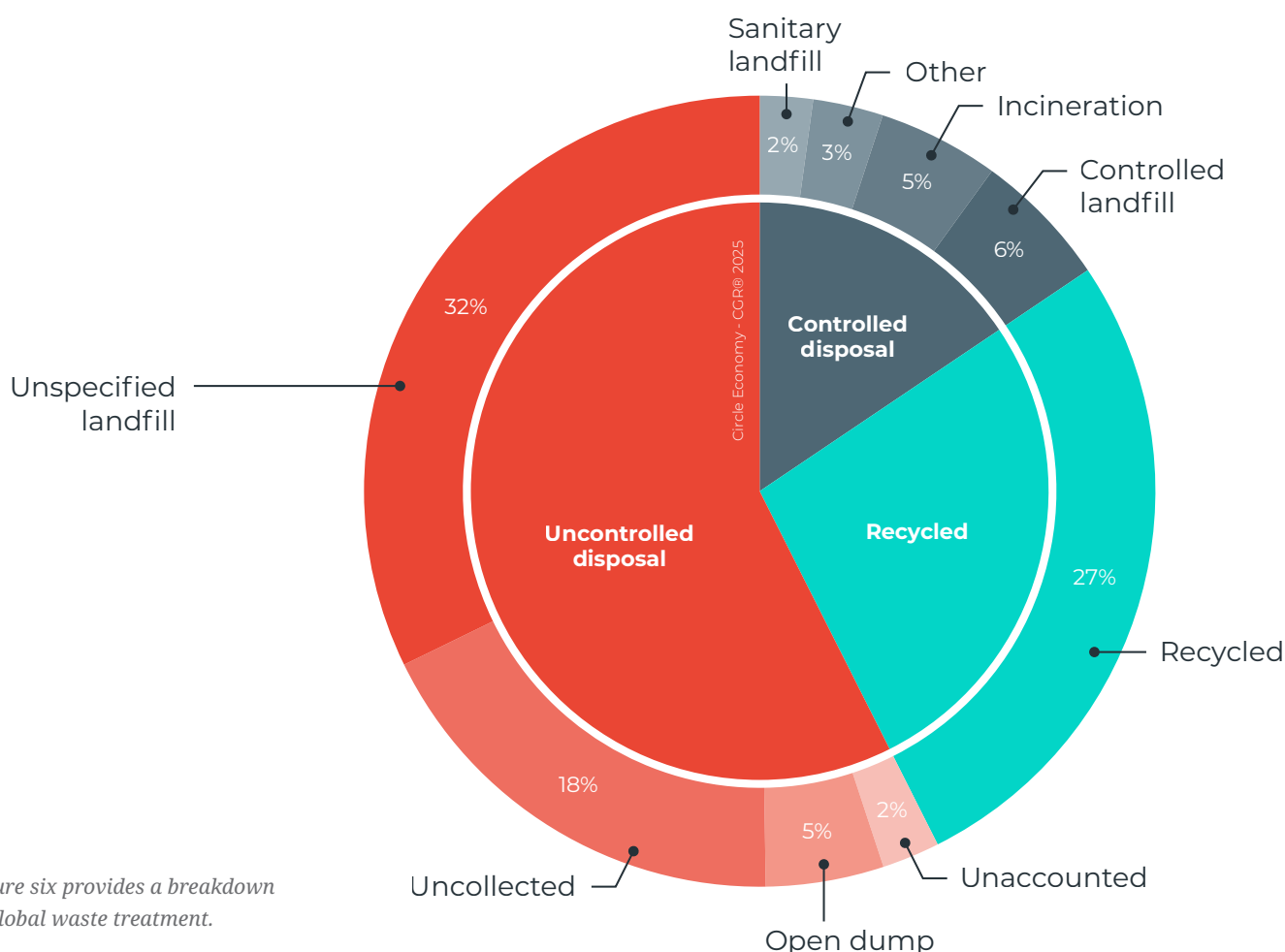
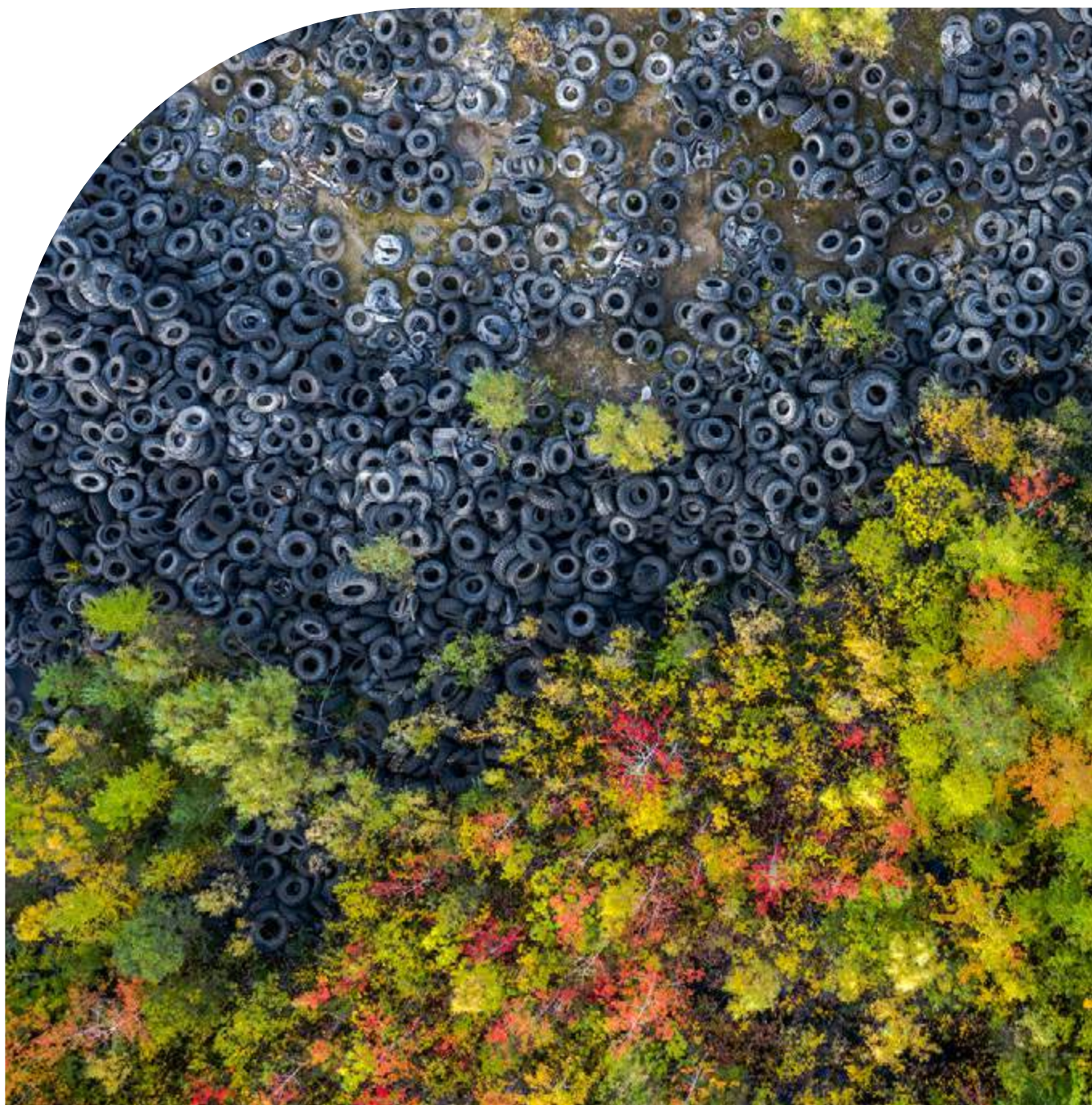


Figure six provides a breakdown of global waste treatment.

Being tied to the Circularity Metric, this indicator shares its sub-indicators: total material extraction, total waste generation, waste as a share of Processed Outputs, the global waste collection rate, the global recycling rate, and the controlled disposal rate. As material extraction decreases and global waste collection and recycling rise, the share of Virgin, Non-Renewable Materials will fall; tracking these indicators thus gives insight into the factors underpinning current rates and scales of non-renewable inputs.



2.2.3 Fossil Fuels

This indicator represents fossil-based energy carriers—such as those derived from petroleum, oil shale and tar sands, coal, and natural gas—burnt for energy. These flows are inherently non-circular: as they are combusted, they release greenhouse gas emissions into the atmosphere. Once released, these emissions are almost impossible to recapture or reuse at the speed, scope and scale necessary to limit warming to 1.5-degrees.⁹⁵

13.3%

of materials flowing into the economy are...

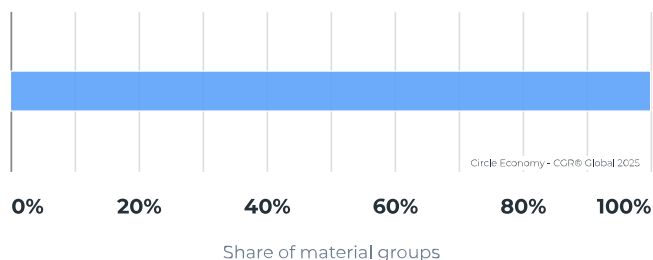
Fossil Fuels used for energy purposes.

21.6%

of materials flowing out of the economy are...

Emissions and waste from Fossil Fuels used for energy purposes.

(Input) Fossil Fuels broken down by material group



■ Biomass
■ Fossil fuels
■ Metal ores
■ Non-metallic minerals



Desired outcome:

Initiate a managed transition away from fossil fuel use for energy by:

1) Prioritising improvements in systemic efficiency and 2) Transitioning to an energy system that's electrified where possible and based on renewables.

capacity and meet additional energy needs. At the same time, the circular economy itself will require significant energy inputs, from reverse logistics to recycling and material recovery technologies. This underscores the importance of minimising energy demand and bolstering systemic efficiency while ensuring that energy is generated through clean, renewable sources.

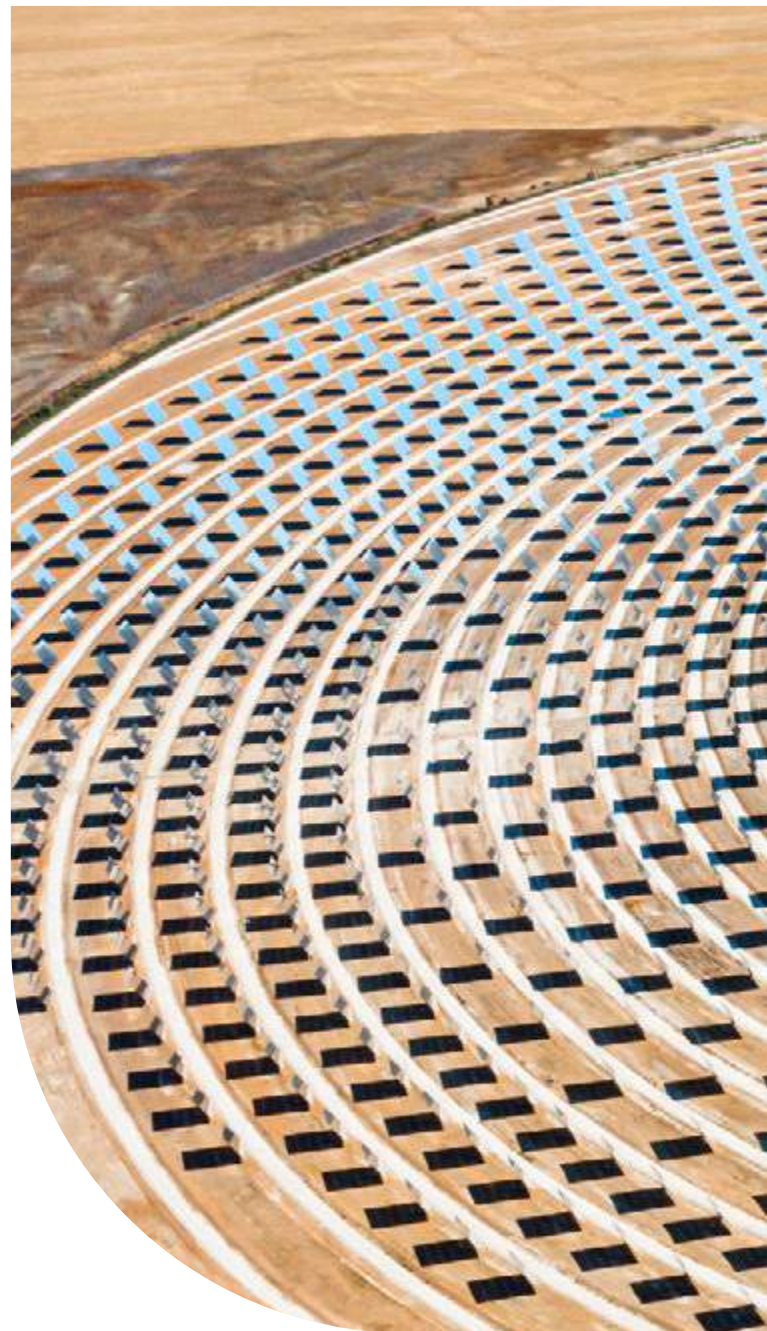
Commentary:

As a key contributor to climate change and other environmental impacts, fossil fuels are one of the most impactful material groups

 (see Figure seven).

This mirrors global economic growth, with the two having a tight historical relationship. Fossil fuels are also the most traded natural resource, accounting for around half of traded materials globally in 2020.⁹⁶ As fossil fuels remain the dominant energy source today, the scale of fossil fuel use poses a risk to planetary health.⁹⁷ Their applications are vast: coal is used for power generation and processing materials such as metals and chemicals, oil primarily powers transport, and natural gas is used for electricity generation, heat, and as chemical feedstock. Without systematically restructuring how we power transport, generate electricity and process materials—in addition to scaling down these activities—fossil fuel demand is set to grow.

Rising global energy demand is driving fossil fuel dependence—but the circular economy transition can support a sustainable, responsible energy transition. Global economic growth and energy demand have historically been closely coupled, with energy demand increasing by 1 to 2% per year. This growth can partially be attributed to population growth, but it is also driven by a rise in average energy use per capita. For example, global average energy use per person increased from 1.55–1.65 tonnes of oil equivalent in 2000 to 1.78–1.80 tonnes in 2021.⁹⁸ Without making systemic improvements in efficiency, total energy consumption will continue to grow—making the shift from fossil fuels to a low-carbon energy system even more difficult, as new renewable energy will have to both replace existing fossil fuel



Circular economy principles should be at the foundation of the energy transition to achieve sustainable resource management. The energy transition is a physical transformation and is, therefore, material-intensive. Building a low-carbon economy will require a cumulative scale-up of material extraction, particularly metals.⁹⁹ The energy transition will result in a surge in demand for critical raw materials like lithium, cobalt, and rare earth elements—resources concentrated in a few countries, creating new dependencies and supply risks.¹⁰⁰ A circular economy approach is crucial to reducing reliance on sensitive supply chains, enhancing resource security, and building resilience against price volatility and supply shortages—supporting a more sustainable and responsible energy transition.¹⁰¹

Decarbonisation is part of a more global circular economy: resource-light and low-carbon economies go hand in hand. The current fossil-based energy system is inherently material-intensive and linear, requiring a constant flow of carbon-intensive fossil fuels to sustain it. At the same time, developing renewable energy systems will also be initially material-intensive, especially metals and critical minerals. Many of these materials have high supply risks and environmental and social costs. Circular economy strategies can help scale renewable energy sustainably by reducing its environmental footprint—minimising both the resource extraction required and other environmental impacts of cutting carbon emissions.¹⁰² A circular economy approach that maximises systemic efficiency in the energy system and follows circular design principles at the product, asset and system levels is essential to reduce both fossil fuel reliance and minimise the raw material footprint of the energy transition.¹⁰³

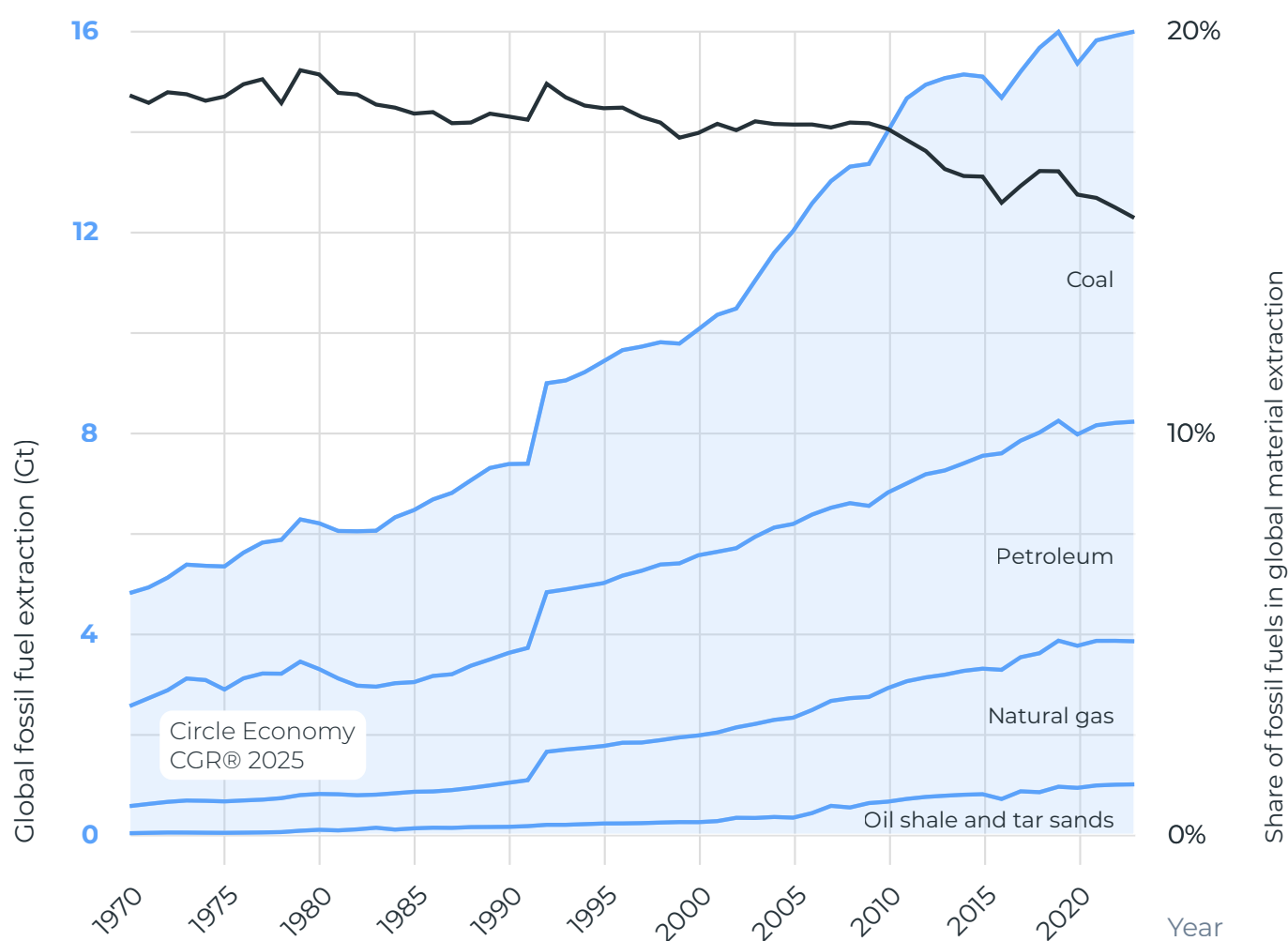


Figure seven illustrates the evolution of global fossil fuel extraction and its share of total material extraction between 1970 and 2021.

Realigning financial incentives to support circular and low-carbon solutions is important for reducing global fossil fuel demand and accelerating the transition to sustainable energy systems.

High subsidies and other financial incentives can reinforce global dependence and slow the shift to circular, low-carbon alternatives. Redirection of financial flows will be needed to help the scaling down of fossil fuels. In 2021, explicit subsidies—such as the direct transfer of government funds, price support, and other forgone tax revenue—represented an estimated US\$1.4 trillion (about 0.94% of global GDP).¹⁰⁴ Reorienting financial flows from subsidies towards decarbonisation—through a systemically efficient energy system based on electrification and powered by abundant renewables—will be necessary to reduce fossil fuel demand, mitigate environmental impacts and optimise long-term resource use.

Ultimately, the global economy should aim to reduce the rate of fossil fuel consumption while also minimising the scale of these materials used. To understand and measure progress towards reducing fossil fuel usage, it's important to break down the factors influencing these indicators

through a number of sub-indicators. These indicators' status—and whether or not they have relevant global or sub-global targets—are summarised in Table five.

Input: On the input side, a number of sub-indicators give insight into the structural factors that currently contribute to the global material footprint of fossil fuel-based energy carriers. We know that transitioning to a decarbonised energy system is key to reducing fossil fuel dependence and mitigating climate change. This process has a few key components, measured by three indicators. Ultimately, we need to:

1) Optimise the energy system to help reduce **total primary energy supply**, which stands at about 579–597 exajoules¹⁰⁵ (or 13.8–14.3 billion tonnes of oil equivalent), with 82% coming from fossil fuels in 2021. Improving systemic efficiency in energy-intensive sectors, such as mobility, manufacturing and heating, will reduce both end-use energy demand and material use. Within the current system, improving systemic efficiency can be incredibly effective: analysis shows that global energy demand in 2050 could be up to 40% lower than today if all possible efficiencies are implemented.¹⁰⁶

Indicator	Value in (year)	Trend	Global Target	Status	Sub-Global Targets (Y/N)
Total primary energy supply (exajoules)	579 ¹¹¹ –597 ¹¹² exajoules (2021) 570 ¹¹³ –581 ¹¹⁴ exajoules (2018)	↑	464.5 exajoules (2030), 553.2 exajoules (2050) ¹¹⁵	Off-track	Yes
Share of final energy consumption from renewable sources (%) ¹¹⁶	18.7% (2021) 17.3% (2018)	↑	50–60% ¹¹⁷	Off-track	Yes
Share of electricity in total global energy consumption (%) ^{118, 119}	20.1% (2021) 19.5% (2018)	↑	None	n.a.	Yes
Global anthropogenic greenhouse gas emissions (excluding emissions from LULUCF) (tonnes of CO₂e) ¹²⁰	53.0 billion tonnes (2021) 52.4 billion tonnes (2018)	↑	28.4 billion tonnes ¹²¹	Off-track	Yes
Emissions as a share of Processed Outputs (%) ¹²²	54.8% (2021) 55.4% (2018)	↓	None	n.a.	No

Table five lists each sub-indicator, elaborating on how these figures have changed over a five-year period and whether we are on track to meet global targets (if any).

2) Prioritise electrification from renewable energy to increase the **share of electricity in total final energy consumption** (which was 20.1% in 2021, up from 19.5% in 2018). Because electricity (from renewable energy technologies) requires less primary energy supply to generate, electrifying as many activities as possible—from transportation (think small electric vehicles) to building heating (through heat pumps, for example) and steel production (through green hydrogen)—will be crucial for decreasing fossil fuel dependence.¹⁰⁷ Electrification is increasing, but at a slower rate than overall energy demand, while the carbon intensity of electricity generation keeps growing, not decreasing.¹⁰⁸

3) Systemically optimise and scale up decarbonised electrification across industries to rapidly increase the **share of total final energy consumption from renewable sources** (18.7% in 2021, up from 17.3% in 2018).¹⁰⁹ This is important because, so far, new renewable energy has overall *supplemented* not *replaced* existing fossil-based energy capacity.

Output: On the output side, indicators capture the environmental impact of fossil fuel consumption, giving insight into the consequences of using these materials. **Global anthropogenic greenhouse gas emissions** (excluding emissions from LULUCF) totalled 53 billion tonnes of CO₂e in 2021, with fossil fuel combustion as the primary driver: 72% of this stems from energy use. This underscores the urgent need to transition away from fossil fuels to curb climate change. Measuring **emissions as a share of Processed Outputs**—the materials that leave an economy as either emissions or physical waste—gives insight into fossil fuel dependence, with a high share indicating that an economy depends heavily on emissions-intensive activities. Of the total output produced by the global economy, over half (54.8%)¹¹⁰ is emissions. Unlike solid waste, which can often be recovered and recycled, capturing emissions for reuse is not yet feasible at scale. This limits the pool of waste available for circular recovery, reducing opportunities for reuse and recycling. This indicator varies by region: industrialised regions like North America (65%), Europe (61%) and Asia & Oceania (53%) have higher shares, while Latin America (32%) and Africa (21%) have significantly lower shares.



2.3 Stock build-up

This category includes a single indicator that measures the share of virgin material flows being added to global stocks—such as buildings, infrastructure, machinery, and vehicles—in net terms. Stock build-up refers to the input and accumulation of materials within an economy over time—crucial for understanding the long-term dynamics of material use and its implications for sustainability and resource management. These additions to stocks are not inherently good or bad. They can be necessary to meet societal needs like housing and transportation. However, they are also significant drivers of material use, contributing to the high level of resource consumption that limits circularity. While materials captured by this indicator may have circular ‘potential’, considering the time element is also important here. These materials are locked into long-lived assets and unavailable as secondary material inputs for many years or even decades, and this delay creates a temporal gap or ‘lag’ in circularity. For this reason, strategies that optimise stock build-up, extend the lifetimes of existing assets, and enhance future material recovery are crucial for improving circular flows over time.

While this indicator captures net stock additions—the difference between inflows and outflows—this dynamic is also influenced by reuse, remanufacturing, or repurposing taking place ‘within’ stocks. Many products are recirculated but not recycled: they aren’t classified as Secondary Materials and captured by the Circularity Metric. Examples include second-hand electronics and furniture reused on a smaller scale or asphalt or vehicles on a larger scale. While this indicator does not capture the scale at which reuse and other R-strategies take place, we can broadly assume that these strategies will lessen demand for new stock build-up,¹²³ thus optimising Net Additions to Stock.

** While a large portion of secondary materials is used in long-lived applications and contributes to Gross Additions to Stocks, the net accumulation shown by the Net Additions to Stock indicator does not include secondary materials. In a static EW-MFA accounting framework, the amount of secondary materials entering (in Gross Additions to Stock) and recyclable waste leaving (in the Demolition and Discard flow) from Accumulated Stocks will always be the same. In this framework, all secondary materials and recyclable waste—whether used in long-lived or short-lived applications—are recorded by the inflows and outflows of Secondary Materials.*

2.3.1 Net Additions to Stock

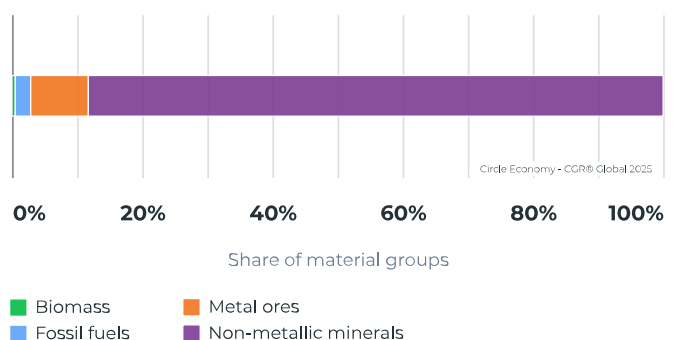
Net Additions to Stock measures the rate of physical growth in an economy’s material accumulation. This indicator represents the difference between the virgin materials* added to the accumulated physical stock and those removed over a given period of time, usually upwards of one year. Unlike material flows—which track how materials *move* through the economy—stocks represent materials that *accumulate* in the economy. As economies develop, material flows contribute to material stocks—a relationship that shapes future resource demand for maintenance and replacement and influences future waste generation and management. Both flows and stocks should be examined to understand how materials are extracted, processed, accumulated and ultimately either lost or cycled.

38.0%

of materials flowing into the economy are...

Net additions of virgin materials—largely non-metallic minerals and metals, but also small amounts of fossil fuels used for material purposes and technical biomass—accumulated in stocks.

Net Additions to Stock broken down by material group



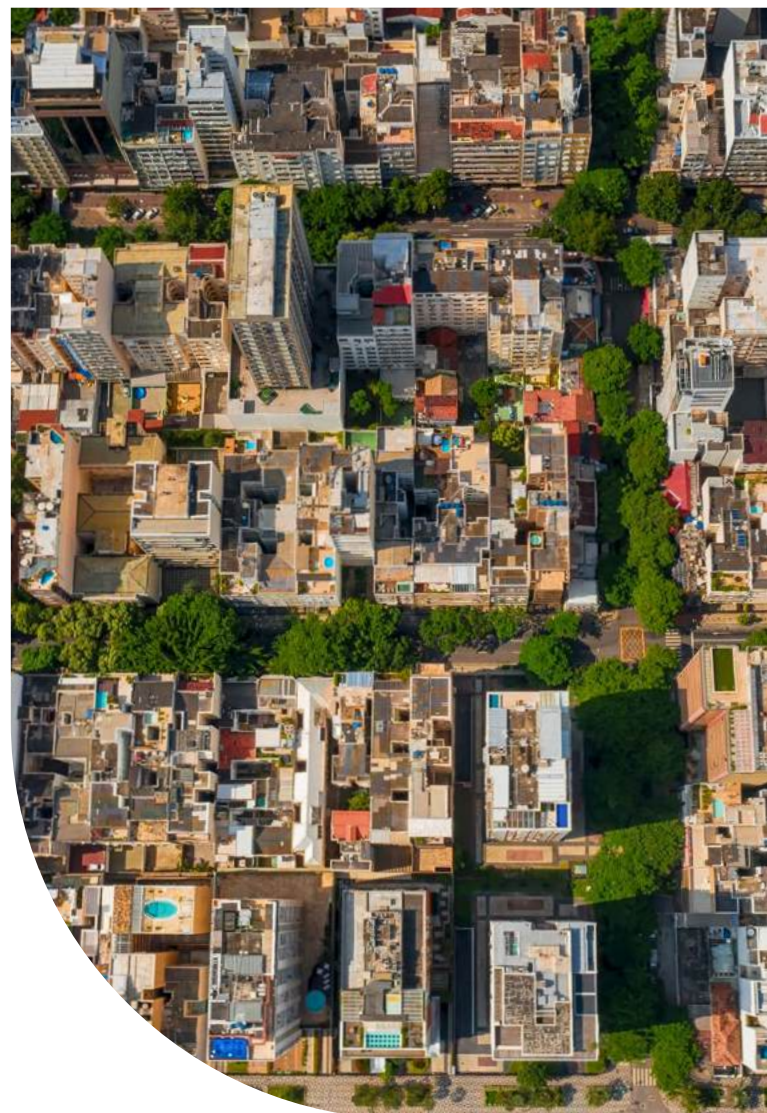
Desired outcome:

Optimise material accumulation in stocks by: 1) Maximising the use and adaptation of existing physical assets, such as buildings, infrastructure, and machinery, instead of building/producing new, 2) Increasing the share of sustainably-managed renewable materials in stock composition, and 3) Prioritising circular design principles—such as design for durability, repairability, disassembly and recyclability—in new stock additions.

The combination of rapid urbanisation and economic growth is driving the increasing accumulation of stock worldwide.¹²⁵ The amount of built-up land is a key driver of per capita material demand, as expanding infrastructure and urban areas require substantial resource inputs.¹²⁶ Urbanisation is accelerating, with the share of people living in cities growing from 47% in 2000 to 56% in 2021.¹²⁷ Projections suggest this could reach 68% by 2050,¹²⁸ adding 2.5 billion more people to urban areas. Significant stock additions in cities will be necessary to accommodate this growth and to provide decent living conditions for the one-third of urban residents who currently live in slums and informal settlements, often without access to basic services. Going forward, it will be crucial to balance the provision of essential services with optimised material use and the integration of circular principles.

Commentary:

Stock build-up plays a crucial role in shaping global material flows, waste generation, and emissions, acting as both a driver of and a constraint on circularity. Net Additions to Stock represent a significant portion of global material use, with approximately 38% of materials entering the economy remaining in use for an extended period. However, this indicator doesn't capture the materials required to operate Accumulated Stocks. When those are included, this figure increases to more than 70%, highlighting just how many materials are used to construct, maintain and operate them. The rate of stock growth—recorded by Net Additions to Stock—has grown spectacularly, causing Accumulated Stocks to increase 23-fold over the 20th century and to roughly double every two decades.¹²⁴ The scale and pace of this build-up have profound implications for resource efficiency, emissions, and waste management. While growing material stocks contribute to economic development and improved living standards, they may also increase long-term resource dependency and pose challenges for future material circularity. This is because poorly designed stock—an energy-inefficient building that requires natural gas to heat, for example—increases the long-term material requirement related to it. On the other hand, long-lived assets designed with circular principles—a modular, timber-based, energy-efficient building with solar panels and a heat pump, for example—can reduce long-term material dependency.



Embedding circular economy principles into urban planning and development will be key to reducing global resource use and achieving a more circular economy. As urban areas grow, so too does stock build-up, thus locking in materials for decades, shaping material demand patterns and slowing the rate at which these resources can re-enter the system through reuse or recycling. Without strategies to optimise urban planning and stock build-up—such as localised operations, material-efficient construction, adaptive reuse, and designing for longevity—cities risk becoming long-term hotspots of growing material demand, exacerbating resource depletion and environmental pressures. By 2050, urban material consumption is projected to grow by 150%, from 40 billion tonnes in 2010 to 90 billion tonnes.¹²⁹ However, designing compact, resource-efficient cities based on circular economy principles could cut greenhouse gas emissions by 36–56% while also lowering demand for metals, land, energy and water.¹³⁰ At the same time, actively ‘mining’ materials from Accumulated Stocks—instead of the natural environment—provides another key opportunity to boost circularity by increasing the pool of secondary materials available.

The sheer scale of non-metallic mineral use—driven by stock build-up—has fuelled the unprecedented accumulation of human-made materials. While all material groups are linked to stock build-up, non-metallic minerals make up the largest portion. This is in part due to their substantial weight: the sand and limestone used to produce cement and gravel used to build roads and fill construction sites, for example. Non-metallic mineral extraction has grown exponentially in past decades, from 8.5 billion tonnes in 1970 to 47.9 billion tonnes in 2021 (see Figure one). This is a key reason why, in 2020, humanity reached a new milestone when the mass of human-made things surpassed that of all living things on Earth—plants, animals and humans.¹³¹ The weight of Accumulated Stocks on Earth has also significantly increased over the past decades, estimated at over 1 trillion tonnes in 2016. The majority of these materials are found in roads (313 billion tonnes), residential buildings (290 billion tonnes), civil engineering (243 billion tonnes) and non-residential buildings (234 billion tonnes). Machinery and other shorter-lived products contribute far less, with the weight of motor vehicles totalling just

3 billion tonnes, for example.¹³² Projections indicate continued stock expansion: for example, residential building stock is projected to grow by 50% by 2050, while the global service-related building stock is projected to increase by 150%.¹³³

While stock build-up has become a key driver of global resource use, a single global indicator overlooks significant differences between regions and countries. Upper-middle and especially high-income countries have historically built up their stock,¹³⁴ while lower-income countries are still developing stock to meet their residents’ societal needs. Total floor space is expected to grow by 97 billion square metres between 2022 and 2030, with the bulk of this notable increase likely to be driven by lower- and middle-income countries.¹³⁵ This underscores the need for sustainable practices in construction and resource management to mitigate the environmental impacts associated with this growth: Lower-income countries should develop stock in line with circular principles that maximise resource efficiency—such as prioritising secondary and low-carbon materials and designing for durability, reuse and disassembly at end-of-life—and sustainably optimise and manage stock expansion.¹³⁶ At the same time, the current weight of per capita stocks is higher in industrialised countries than in developing countries:¹³⁷ residents of high-income nations consume significantly more materials than those in low-income nations, regardless of urbanisation levels. For this reason, higher-income, stock-rich countries should aim to minimise new stock growth, prioritise renovation and adaptation over building new, maximise the intensity of building use, and maximise material efficiency for long-lasting manufactured goods, for example. Durable, repairable, and modular design approaches can significantly extend the usability of these assets.

Setting a specific goal for the share of Net Additions to Stock is complicated, as this will vary significantly by context. For example, a country's target for a given year would depend on historic stock build-up, how current Accumulated Stock is being managed, and how needs for new stock additions are being met. It's more important that the materials captured by this indicator are sustainably optimised so that the full potential for circularity can be met. Stock build-up is measured using input-side sub-indicators, as inputs inherently account for both outputs and net accumulation. However, stock dynamics introduce a significant time lag because materials entering the system today do not immediately translate into outputs. Many of these materials become part of long-lived assets—such as buildings, infrastructure, and vehicles—remaining in use for years or decades. Over time, these materials gradually exit the economy, shaping output-side indicators. This means that current outputs are largely influenced by past inflows rather than present material use. Resources that leave the system as outputs are classified under different indicators: either waste destined for recycling or waste disposed of without recovery (see Figure three).

These indicators' status—and whether or not they have relevant global or sub-global targets—is summarised in Table six.

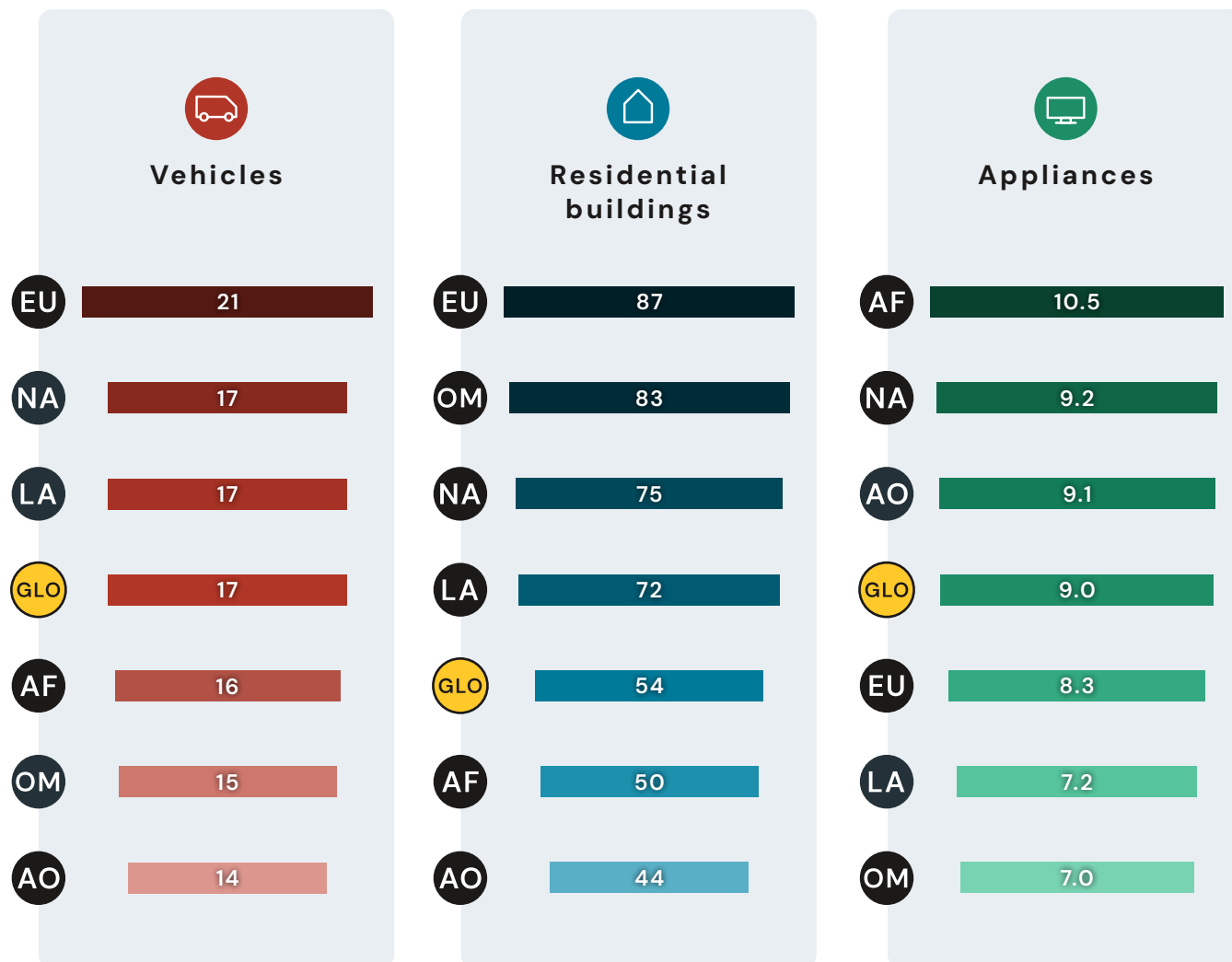
Input: Input-side sub-indicators for Net Additions to Stock give insight into the flows of materials included in societies' physical stocks, as well as their longevity. The **global growth rate in built-up areas**—an increase of 33% between 2000 and 2022—reveals the rising material demand for new buildings, infrastructure, and transport systems.¹³⁸ This is particularly noticeable in rapidly developing regions where built-up areas in Asia or Africa have grown 40% over the past two decades, compared to 20% for Europe and North America. Measuring the **share of renewable biomass out of Net Additions to Stock** (0.4%) helps track progress towards a bioeconomy. Most of this progress, at least from a mass perspective, will relate to changes in the composition of stocks as opposed to other (still important) applications such as biorefinery products. However, to achieve this, we need to respect the principles of a circular bioeconomy, as explored on page 34: minimising carbon emissions and cycling nutrients back into the ecosystem at the right place and rate.

Additionally, optimising the **average lifetimes of asset categories**—such as residential buildings, vehicles, and appliances (see Figure eight)—provides insight into their durability and replacement cycles. This directly influences the rate at which new materials are needed. By slowing material turnover, we can minimise resource demand in the long term.



Global stock optimisation

Lifetime of selected assets compared to the global average



Legend

GLO Global average

EU Europe

AO Asia and Oceania

NA North America

LA Latin America

AF Africa

OM OECD mixed

Includes: Australia, Switzerland, Chile, Island, Israel, South Korea, Norway, Mexico, New Zealand and Turkey

This visual is built using data from different sources and with different reference years ranging between 2007 and 2015.

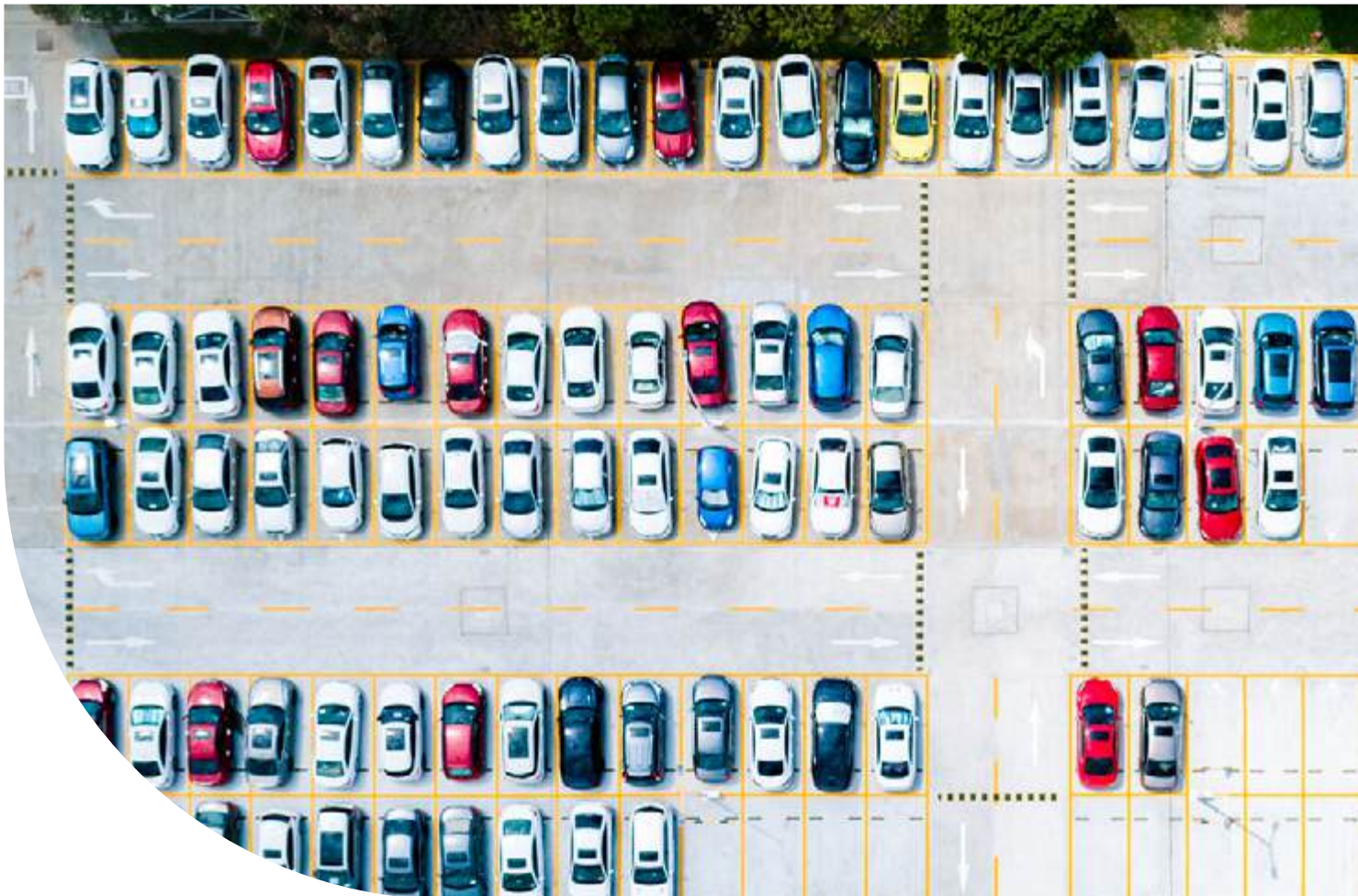
Unit: years

Figure eight illustrates the lifetimes of three asset categories across world regions.

Indicator	Value in (year)	Trend	Global Target	Status	Sub-Global Targets (Y/N)
Growth rate in global built-up area (%) ¹³⁹	+ 33% (2000–2020)	↑	None	n.a.	No
Renewable biomass as a share of Net Additions to Stock ¹⁴⁰	0.4% (2021) 0.6% (2018)	↓	None	n.a.	No
Average lifetime of residential buildings (years) ¹⁴¹	54 years (various years)*	n.a.	None	n.a.	No
Average lifetime of vehicles (years) ¹⁴²	17 years (various years)*	n.a.	None	n.a.	No
Average lifetime of appliances (years) ¹⁴³	9 years (various years)*	n.a.	None	n.a.	No

Table six lists each sub-indicator, elaborating on how these figures have changed over a five-year period and whether we are on track to meet global targets (if any).

* Based on the latest available data from each country or group of countries.



A circularity indicator set fit for the future

Now that you know the breakdown of the various parts of the Circularity Indicator Set, you may wonder: what is a ‘better’ allocation of material inputs? The Circularity Metric is too low, and our use of Non-Carbon-Neutral Biomass, Virgin, Non-Renewable Materials, and Fossil Fuels is too high, but estimating appropriate rates for some indicators—such as Carbon-Neutral Biomass and Net Additions to Stock—is complex. Table seven demonstrates the results of a thought experiment using key global targets to reimagine the distribution of the Circularity Indicator Set in a more sustainable and circular world. It’s assumed that:

- The Circularity Metric increases to 17% by 2032;¹⁴⁴
- Virgin material use is capped at the estimated sustainable level of 8 tonnes per capita¹⁴⁵—close to the level of consumption in 1970—for a projected population for 2032;¹⁴⁶
- Emissions are reduced by 25 billion tonnes of CO₂e by 2030, to stay below 1.5-degrees of warming;¹⁴⁷

- Biomass consumption is reduced by 75% by 2050 (compared to 2020 levels),¹⁴⁸ compatible with a cap on bio-based material consumption at 2 tonnes per capita.¹⁴⁹

Crucially, the absolute volume of material throughput must decrease. As shown in Table seven below, applying these targets results in a significant reduction in the scales of each indicator. This highlights the importance of considering overall **scales**, at the very least, in conjunction with—if not instead of—rates. In this scenario, for example, the rate of Carbon-Neutral Biomass—a potentially ‘circular’ indicator—falls simply because less materials are being used overall.

	2021		2032	
	Rate (%)	Scale (billion tonnes)	Rate (%)	Scale (billion tonnes)
Secondary Materials/Circularity Metric (Input Technical Cycling)	6.9%	7.3	17.0%	14.3
Carbon-Neutral Biomass (Input Ecological Cycling Potential)	21.5%	22.8	20.4%	17.1
Non-Carbon-Neutral Biomass (Input Non-Renewable Biomass)	2.2%	2.3	0.0%	0.0
Other Virgin, Non-Renewable Materials (Input Non-Renewable Flows)	18.0%	19.2	14.4%	12.1
Fossil Fuels used for energy purposes (Input Non-Circular Flows)	13.3%	14.1	6.9%	5.8
Net Additions to Stock	38.0%	40.3	41.2%	34.6
Total	100%	106.1	100%	83.9

Table seven presents the results of a thought experiment, illustrating how achieving various global sustainability targets could impact the distribution of the Circularity Indicator Set and, more crucially, the scale of material throughput.

Circular economy metrics for businesses

While governments define regulatory frameworks within their jurisdictions, businesses—by operating global value chains—directly shape the actual performance of global resource flows. This is why a growing number of businesses are measuring and reporting on the circular economy performance of their own operations and value chains. A growing number of measurement frameworks and reporting standards¹⁵⁰ are making it easier for businesses to report on such matters using language and indicators that are well-understood and defined. While the indicators explored throughout this chapter are macro-level and perhaps better suited to national or regional governments, the importance of businesses in driving the circular transition should also be recognised.

Measuring the circularity of global resource flows requires a very different set of indicators than measuring the circular economy performance of individual actors—like businesses—that are engaged with those resource flows. Businesses can set out to measure the performance of individual products, businesses, value chains, or entire sectors, each time setting different system boundaries for their assessments. This makes it very important for organisations to clearly communicate which scope they have applied to their analysis when reporting on circular economy performance, much like the use of Scope 1, 2 or 3 in communications on greenhouse gas emissions. More guidance on proper scope setting in the field of circular economy performance measurement can be found in our white paper on this topic: *Circular Economy Boundary Framework: Setting circularity scopes for impact and material measurements*.



3

The way forward

Calls to action for stakeholders in government and business

Based on years of research, we know the potential of the circular economy to meet the needs of people around the globe while bringing material use back within the safe limits of our planet—helping to decouple wellbeing from resource consumption and environmental impacts. We also now know that we’re not yet leveraging this potential: much remains to be harnessed. The previous chapter of this report outlined the ‘what’, highlighting trends of concern, pinpointing where we’re not on track and quantifying baselines from which to measure and monitor progress. It showed how various headline indicators relate to and interact with each other, acting as levers to boost the Circularity Metric. By minimising ‘linear’ inputs, optimising stock build-up, and ensuring the circularity of biomass, we could be well on our way to a more circular world. Now that we know what needs to be done, this chapter synthesises our key findings into five crucial and interconnected goals to rally behind and explores the ‘how’. It highlights the actions key stakeholders across government and industry should take to create the right environment for a global circular economy to flourish and implement real circular solutions on the ground.



The rate of secondary material use is steadily decreasing, and the vast majority of materials entering the economy are virgin. We need to reduce global resource demand and scale down material throughput with sufficiency strategies that avoid demand for materials, energy, land and water while providing for people's wellbeing within planetary boundaries.

Although the scale of secondary material use is slowly increasing, the rate is falling, outpaced by overall growth in virgin material use. In 2021, we reached a historical milestone, reaching 100 billion tonnes of material extraction in one year. This is more than a three-times increase from 1970, with average growth of 2.3% per year.

Why is this critical? Growing global resource use is the main driver of the triple planetary crisis of climate change, biodiversity loss and pollution.¹⁵¹ At the same time, concerns related to resource depletion and long-term resilience enable governments and businesses to explore ways to make economies less material intensive.

We should boost secondary material use and reduce extraction in tandem, and help ensure governments and businesses embrace principles of resource efficiency and sufficiency. This means promoting circular design principles, optimising the lifetime of existing products and components, and ensuring recycled material inputs become the norm for businesses in many industries and regions.

We're consuming more and more biomass at the expense of the safety and stability of the natural world, driving climate change and biodiversity collapse. Biomass extraction and use aren't sustainable by default: they need to meet strict sustainability criteria to safeguard ecosystems.

Ecological cycling, a cornerstone of the circular economy, is a major blindspot that requires more critical attention. Although it's widely accepted that renewable resources play a starring role in a circular economy, it's crucial not to assume that using more renewable resources is sustainable by default. Biomass extraction has more than doubled in the last 50 years, and poor practices like heavy fertiliser use, inefficient land allocation and use, and food waste generation are commonplace.

Why is this critical? Biomass extraction drives a range of environmental impacts worldwide: it represents nearly one-fifth of global emissions and accounts for over 90% of land-related biodiversity loss.¹⁵² All nations and industries inherently depend on biomass and the ecosystem services it sustains—from clean air and water to soil fertility and climate regulation. A functioning natural ecosystem is fundamental to economic stability and human well-being.

We should make biomass use (and ultimately, land use management) truly sustainable by ensuring extraction allows for sustainable regeneration, prevents waste and pollution, and supports biodiversity. Nutrients need to be cycled back into the ecosystem in the right place and at the right rate, and carbon emissions should be minimised.

Rapid stock build-up is a key driver of growing resource use. Optimising material stock build-up will be key to achieving long-term resource efficiency and sufficiency while reducing excessive material accumulation.

Almost two-fifths of materials consumed by the global economy each year feed into stock build-up—net materials accumulated in new buildings, infrastructure and machinery that stay in use for many years. This rate has grown spectacularly, with stocks increasing 23-fold over the 20th century. Stock build-up is not inherently ‘bad’; on the contrary, many countries need to invest to ensure that the local populations have access to basic services, and we need to build up infrastructure globally to support renewable energy generation, distribution and storage capacity. However, stocks should be built up and managed with care to ensure optimal resource use.

Why is this critical? Stock build-up is a key determinant of past, present and future material flows. To reduce waste, emissions, and overconsumption, preventing the excess accumulation of materials in stock is essential. What’s more, materials available for stock build-up are finite: as increasingly-rare metal inputs become locked up in long-lived assets, for example, nations and industries will not be able to maintain current infrastructure levels without adopting circular approaches to resource management.

We should flatten the spike in global material use by minimising unnecessary stock growth in high-income economies—prioritising renovation and adaptation over building new, for example. At the same time, we need to sustainably optimise and manage stock expansion through compact, urban development and circular design principles in lower-income countries. Increasing high-value resource recovery from construction and demolition waste and recovering critical metals from infrastructure and equipment will also be crucial.

To transition away from fossil fuel consumption, we must accelerate electrification and scale up the deployment of well-designed, renewable energy systems to sustainably meet growing energy needs.

From a raw materials perspective, the share of fossil fuels relative to total material extraction has shrunk over the past fifty years—but absolute fossil fuel use is still increasing. While there’s been some progress in terms of electrification and renewable energy deployment, this is not occurring at the speed and scope necessary to reach

global targets. To progress towards an electrified world powered by renewables, we need to undertake the physical transformation needed to decarbonise economies, following circular principles.

Why is this critical? Fossil fuel use is the largest contributor of global greenhouse gas emissions, responsible for 78%.

We should reduce the rate and scale of fossil fuel consumption—transitioning existing fossil-based energy capacity to renewable technologies designed for longevity, reuse and recycling, reducing the need for ongoing material use in the long-term.

The overall scale of virgin, non-renewable materials destined for landfill is growing. We need to minimise wasteful processes across key resource-intensive supply chains by prioritising circular design, sufficiency and efficient resource use, and better manage unavoidable waste.

More than one-fifth of global material use is represented by materials that could be cycled but currently are not. This indicator has grown by more than one billion tonnes between 2018 and 2021. Consumption and extraction are growing rapidly, greatly outpacing improvements in resource recovery technologies and waste management capacity. While collection rates are improving, value recovery remains far too low. Secondary raw materials still face price competition from cheaper virgin materials, so advancements in recycling technologies and environmental regulations are needed to shift the market.

Why is this critical? A large portion of the waste produced by the global economy isn't properly handled, and materials mismanaged along the supply chain represent a huge lost opportunity for value recovery. At the same time, landfilling and uncontrolled disposal remain a pervasive social and environmental challenge linked to a range of impacts, from pollution to health hazards to land degradation.

We should reduce this indicator to as close to 0% as possible. Circular design principles can prevent the generation of difficult-to-manage wastes. Infrastructure should be developed to increase high-value applications for waste, and waste management infrastructure should be improved and backed by regulation.



What governments can do

Take the lead in enabling circular resource use: system-level transformation requires governments to set a clear vision and drive the much-needed economic upgrade. This means driving a strategic approach to resource policy, ensuring decisive actions follow intentions. It goes without saying: the shift to a circular economy cannot happen without the right policy environment and government action that phases out wasteful practices and promotes and supports smarter ways of meeting people's needs. Political leadership is crucial to set priorities, drive investment, and build public support for change. Governments may have a bigger role to play than correcting market failures: they should actively shape economies to reduce dependence on virgin materials, cut waste and emissions, and create viable new opportunities for businesses and workers. They rally behind and unify circular initiatives and set the objectives necessary to address urgent socioeconomic challenges in a rapid, socially just way. In parallel, there is room to embed circular economy thinking and interventions into existing climate policy efforts by building circularity into Nationally Determined Contributions, for example.¹⁵³

Shape the right economic conditions for circularity to flourish. Governments have the potential to reshape economic incentives in line with circular economy principles, ensuring that they become the default rather than the exception. Market designs and pricing mechanisms need to be aligned with circular economy goals: rethinking fiscal policies and regulating finance so that flows of capital are redirected to sustainable resource use and away from linear, resource-depleting, polluting activities. A smart policy mix can level the playing field and encourage businesses to transform their operations. Governments can also strengthen extended producer responsibility (EPR) and eco-design regulations to not only promote smarter waste management but drive circular design by encouraging circularity upstream, ensuring products are designed for durability, repairability

and recyclability from the outset.¹⁵⁴ These measures both drive sustainability and help build more resilient economies by reducing dependence on finite resources, mitigating supply chain risks, and fostering long-term economic stability.

Actively support and participate in global governance, as no country can tackle resource use reduction in a vacuum. In our highly globalised world, international collaboration is essential to effectively managing global material flows and reducing extraction. Despite increasing recognition of resource overconsumption, there is no global governance framework to help ensure sustainable resource use nor targets to work towards. An international body—akin to the Intergovernmental Panel on Climate Change or Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services—could help steer action by providing science-based assessments and policy guidance. This body would focus on shaping long-term resource management by setting global benchmarks, tracking material use, and guiding value chain transformation. This aligns with suggestions made in the negotiating text of the legally binding agreement on plastics pollution, for example.¹⁵⁵ This would provide countries and companies with ambitious, science-based insights to inform material use targets alongside climate and biodiversity goals. Immediate efforts towards this end goal could build upon existing work in this area, such as the International Law Association's *Guidelines for Sustainable Natural Resources Management*¹⁵⁶ and the International Resource Panel's *Mineral Resource Governance in the 21st century*.¹⁵⁷

Establish an International Materials Agency to guide governments in measuring and monitoring sustainable resource use and circular economy progress. Robust data and transparency are essential for both monitoring the transition and creating accountability. Improved transparency, data collection, and reporting mechanisms aligned with international standards are needed to drive smarter decision-making. These systems help identify trends, evaluate the impact of policies, and refine strategies over time. They are also crucial to ensure that policy action is driving real change rather than merely shifting impacts elsewhere. Crucially, however, this agency's role would be distinct from target-setting—it would focus solely on data provision. By providing access to consolidated material flows and presenting their

impacts, an International Materials Agency could provide relevant insights at the national level. In this sense, it could provide better: (1) **Orientation** through material consumption targets and related science-based guidance, including a target akin to a 'net zero for materials', (2) **Measurement** through data, indicators and metrics that capture the wellbeing performance and material efficiency of key provisioning systems such as housing, mobility, food, and energy, and (3) **Economic incentives** to realign financial flows with resource-light, low-carbon and nature-positive solutions. It could also ensure the best-practice transfer of knowledge and facilitate collaboration among practitioners across policy and business.





What *businesses* can do

Set clear, measurable goals towards a circular transition that is both environmentally responsible and financially sustainable.

Businesses need to adopt circular metric frameworks such as the Global Circularity Protocol and Circular Transition Indicators to set clear, measurable goals for the transition. This will provide clarity to both internal and external stakeholders about their commitment to reducing material use, promoting the reuse of products, and enhancing transparency—whilst remaining competitive. Through clearly defined resource targets tied to business strategy and operations, businesses can demonstrate tangible progress on their circular economy journey while aligning their operations with sustainability goals.

Invest in the circular economy now to ensure that they remain competitive and future-proof.

Transitioning to circular models provides new market opportunities. By investing in renewable resources, sustainable production technologies, reverse logistics infrastructure, and circular product design, businesses can secure long-term success, enhance their competitive edge, and reduce risks related to geopolitical matters, resource scarcity and regulatory changes. Rethinking product portfolios to align with circular principles—such as designing for durability, repairability, and recyclability—will be key to adapting to evolving market demands. The global economy is now facing increasing supply chain disruptions, particularly for the critical raw materials essential to decarbonisation and digitalisation, as well as a number of key manufacturing industries. With escalating demand, businesses that integrate circular strategies and localise their operations can shorten supply chains and ultimately reduce dependence on global markets. Circular business models can drive value through cost reduction, resource efficiency, and innovation, and the metrics used to track these activities—such as circular inflow (the use of recycled materials), circular outflow (end-of-life management), and waste/resource consumption avoided—will be essential to evaluate and scale their impact.

Collaborate and work together within value chains to optimise resource use and drive innovation.

Businesses should collaborate across the full value chain to optimise material use and overcome economic split incentives. By joining forces with suppliers, manufacturers, and other partners, companies can drive innovation and invest in the changes needed to make circular solutions viable. Collaboration helps to build economies of scale, reduce costs, and share knowledge, ultimately accelerating the adoption of circular practices across entire industries. In doing so, businesses can also address the risks inherent in the current linear economy, such as supply chain disruptions, resource scarcity, and increasing regulatory burdens. By working together to shift to circular solutions, companies can unlock opportunities to create new markets, optimise materials use, and ensure long-term resilience.



Appendix A: Glossary

Accumulated Stock measures the total volume of materials added to socioeconomic stocks over time.

Cascading is a method of retaining the ‘added value’ of materials for as long as possible through the sequential use of resources for different purposes—usually (or ideally) through multiple material (re) use phases before energy extraction/recovery operations. [\[Source\]](#)

Consumption refers to the usage or consumption of products and services meeting demand. *Absolute consumption* refers to the total volume of either physical or monetary consumption of an economy, domestic or global, as a whole. In this report, when we talk about *consumption*, we are referring to absolute consumption.

Cycling refers to the process of converting a material into a material or product of a higher (upcycling), same (recycling) or lower (downcycling) embodied value and/or complexity than it originally was.

Decoupling refers to a trend that occurs when the growth rate of an environmental impact (for example, CO₂ emissions) is less than that of its economic driving force (for example, gross domestic product) over a given period. Decoupling can be either absolute or relative. **Absolute decoupling** is defined as when the environmental impact is stable or decreases when the economic driving force is growing. **Relative decoupling** is defined as when the growth rate of the environmental impact is positive but less than the growth rate of the economic driving force. [\[Source\]](#)

Domestic Material Consumption is an environmental indicator that covers the flows of both products and raw materials by accounting for their mass. It can take an ‘apparent consumption’ perspective—the mathematical sum of domestic production and imports minus exports—without considering changes in stocks. It can also take a ‘direct consumption’ perspective, in that products for import and export do not account for the inputs—be they raw materials or other products—used in their production. [Own elaboration based on [Source](#)]

Economy-wide material flow accounts is a ‘statistical accounting framework describing the physical interaction of the economy with the natural environment and with the rest of the world economy in terms of flows of materials.’ [\[Source\]](#)

Greenhouse gases (GHG) refers to a group of gases contributing to global warming and climate breakdown. The term covers seven greenhouse gases divided into two categories. Converting them to **carbon dioxide equivalent** (CO₂e) through the application of characterisation factors makes it possible to compare them and to determine their individual and total contributions to Global Warming Potential (see below). [\[Source\]](#)

Gross Additions to Stock measures the total amount of materials used in long-lived applications (of over one year) in the accounting year. In the context of this analysis, this can include both virgin and secondary materials.

High-value recycling refers to the extent to which, through the recycling chain, the distinct characteristics of a material (the polymer, the glass or the paper fibre, for example) are preserved or recovered so as to maximise their potential to be re-used in a circular economy. [\[Source\]](#)

Materials, as referred to in this report, are non-metallic minerals, metal ores, biomass, and fossil fuels, used as inputs to production or manufacturing because of their properties. Materials are a type of natural resource, alongside land and water, for example.

Material extraction is an environmental indicator that measures, in physical weight, the amount of raw materials extracted from the natural environment for use in any economy. It excludes water and air. At the national level, this indicator is called Domestic Material Extraction. [\[Source\]](#)

Material footprint, also referred to as Raw Material Consumption, is the attribution of global material extraction to the domestic final demand of a country—referred to as a **consumption-based approach**. The material footprint equals the total volume of virgin materials embodied within the supply chain to meet final demand. At the global level, Raw Material Consumption is equivalent to material extraction (see above). [\[Source\]](#)

Material flows represent the amounts of materials in physical weight that are available to an economy. These material flows comprise the extraction of materials within the economy as well as the physical imports and exports (such as the mass of goods imported or exported). Air and water are generally excluded. [\[Source\]](#)

Net Additions to Stock measures the net amount of materials long-lived applications after accounting for materials removed from existing Accumulated Stocks through Demolition and Discard. This flow only contains virgin materials, as the amount of secondary materials in both Gross Additions to Stock and Demolition and Discard is assumed to be equal within the same accounting year.

Planetary boundaries define the 'safe operating space' for humanity based on the planet's key biophysical processes. Originally developed by Rockström et al. (2009), the framework quantifies nine 'limits' for ensuring a stable and resilient Earth system. Six of nine boundaries have now been transgressed. [\[Source\]](#)

Resources include, for example, arable land, freshwater, and materials. They are seen as parts of the natural world that can be used for economic activities that produce goods and services. Material resources are biomass (like crops for food, energy and bio-based materials, as well as wood for energy and industrial uses), fossil fuels (in particular coal, gas and oil for energy), metals (such as iron, aluminium and copper used in construction and electronics manufacturing) and non-metallic minerals (used for construction, notably sand, gravel and limestone). [\[Source\]](#)

Resource efficiency means creating more (economic) value with less input of resources (for example, raw materials, energy, water, air, land, soil, and ecosystem services) and reducing the environmental impacts associated with resource use to break the link between economic growth and the use of nature. Therefore, resource efficiency is closely linked to the concept of (relative/absolute) decoupling. [\[Source\]](#)

Secondary materials are materials that have been used once and are recovered and reprocessed for subsequent use. This refers to the amount of the outflow that can be recovered to be re-used or refined to re-enter the production stream. One aim of dematerialisation is to increase the amount of secondary materials used in production and consumption to create a more circular economy. [\[Source\]](#)

Sufficiency, as defined by the IPCC, is a set of policy measures and daily practices that avoid demand for energy, materials, land, water, and other natural resources while delivering human wellbeing for all within planetary boundaries. [\[Source\]](#)

Total material consumption is calculated by adding Raw Material Consumption (material footprint) and secondary material consumption (cycled materials).

Endnotes

1. Note that the use of 'we' and 'our' throughout this report often refers to Circle Economy, this report's author, with the exception of the use of the general societal 'we'.
2. International Resource Panel (IRP). (2024). *Global Resources Outlook 2024: Bend the trend: Pathways to a liveable planet as resource use spikes*. United Nations Environment Programme: Nairobi. Retrieved from: [UNEP website](#)
3. Our analysis does not consider technical and economic feasibility.
4. IRP. (2024). *Global Resources Outlook 2024: Bend the trend. Pathways to a liveable planet as resource use spikes*. UNEP: Nairobi. Retrieved from: [UNEP website](#)
5. Gütschow, J., Busch, D., & Pflüger, M. (2025). The PRIMAP-hist national historical emissions time series (1750-2023) v2.6.1 (v2.6.1) [Data set]. Zenodo. doi:10.5281/zenodo.15016289
6. Energy Institute. (2024). *Statistical review of world energy*. Retrieved from: [Energy Institute website](#)
7. UNEP. (n.d.). Indicator 12.c.1. Retrieved from: [UNEP website](#)
8. Krausmann, F., Wiedenhofer, D., Lauk, C., Haas, W., Tanikawa, H., Fishman, T., ... Haberl, H. (2017). Global socioeconomic material stocks rise 23-fold over the 20th century and require half of annual resource use. *Proceedings of the National Academy of Sciences*, 114(8), 1880–1885. doi:10.1073/pnas.1613773114
9. UN. (2018). *World urbanisation prospects 2018: Highlights*. Department of Economic and Social Affairs, Population Division. Retrieved from: [UN website](#)
10. UNEP. (2024). *Intergovernmental Negotiating Committee to develop an international legally binding instrument on plastic pollution, including in the marine environment*. Retrieved from: [UNEP website](#)
11. International Resource Panel (IRP). (2024). *Global resources outlook 2024: Bend the trend: Pathways to a liveable planet as resource use spikes*. United Nations Environment Programme: Nairobi. Retrieved from: [UNEP website](#)
12. International Resource Panel (IRP). (2024). *Global resources outlook 2024: Bend the trend: Pathways to a liveable planet as resource use spikes*. United Nations Environment Programme: Nairobi. Retrieved from: [UNEP website](#)
13. Richardson, K., Steffen, W., Lucht, W., Benndsten, J., Cornell, S., Donges, J., et al. (2023). Earth beyond six of nine planetary boundaries. *Science Advances*, 9(37). doi:10.1126/sciadv.adh2458
14. International Resource Panel (IRP). (2024). *Global resources outlook 2024: Bend the trend: Pathways to a liveable planet as resource use spikes*. United Nations Environment Programme: Nairobi. Retrieved from: [UNEP website](#)
15. Hickel, J., O'Neill, D. W., Fanning, A., & Zoomkawala, H. (2022). National responsibility for ecological breakdown: a fair-shares assessment of resource use, 1970–2017. *The Lancet Planetary Health*, 6(4), E342–E349. doi:10.1016/S2542-5196(22)00044-4
16. Wang, R., Hertwich, E. G., Fishman, T., Deetman, S., Behrens, P., Chen, W., ... Zimmerman, J. B. (2023). The legacy environmental footprints of manufactured capital. *Proceedings of the National Academy of Sciences*, 120(24). doi:10.1073/pnas.2218828120
17. IRP. (2024). *Global resources outlook 2024: Bend the trend. Pathways to a liveable planet as resource use spikes*. UNEP: Nairobi. Retrieved from: [UNEP website](#)
18. International Development Association. (2021). *IDA20 special theme: climate change*. Retrieved from: [World Bank website](#)
19. IRP. (2024). *Global resources outlook 2024: Bend the trend. Pathways to a liveable planet as resource use spikes*. UNEP: Nairobi. Retrieved from: [UNEP website](#)
20. Other research suggests that we could provide decent standards of living to a global population of 8.5 billion with just 35% of the resources we use now. Source: Vélez-Henao, J.A. & Pauliuk, S. (2023). Material requirements of decent living standards. *Environmental Science & Technology*, 57(38), 14206–14217. doi:10.1021/acs.est.3c03957
21. Circle Economy, PGGM, KPMG, WBCSD, & EBRD. (2018). *Linear risks: How business as usual is a threat to companies and investors*. Retrieved from: [Circle Economy website](#)
22. International Organization for Standardization (ISO). (2024). *ISO 59020:2024 Circular economy — Measuring and assessing circularity performance*. Retrieved from: [ISO website](#)
23. United Nations Economic Commission for Europe (UNECE) & Organisation for Economic Co-operation and Development (OECD). (2023). *Conference of European Statisticians guidelines for measuring circular economy: Part A: Conceptual framework, indicators and measurement framework*. Geneva: United Nations. Retrieved from: [UNECE website](#)

24. United Nations Economic Commission for Europe (UNECE) & Organisation for Economic Co-operation and Development (OECD). (2023). *Conference of European Statisticians guidelines for measuring circular economy: Part A: Conceptual framework, indicators and measurement framework*. Geneva: United Nations. Retrieved from: [UNECE website](#)
25. Circle Economy analysis.
26. Circle Economy analysis.
27. Circle Economy analysis.
28. Due to data limitations, it is assumed that waste destined for recycling is a good proxy for secondary materials that will be deployed in the economy within the accounting year, according to [Eurostat](#) (page 12). In reality, there are time lags and inefficiencies in the waste management system: this means that the amount of waste available for recycling and the secondary materials flowing into the economy in the same year are not necessarily the same.
29. IRP. (2024). *Global resources outlook 2024: Bend the trend. Pathways to a liveable planet as resource use spikes*. UNEP: Nairobi. Retrieved from: [UNEP website](#)
30. This analysis attributes 'material handling and use' to all final uses that serve material purposes: for example, energy use in freight transport and non-residential buildings is classified as serving material purposes because these activities directly support the movement and sale of goods. It's important to note that other research takes a narrower scope in linking material use and emissions, with the International Resource Panel, for example, estimating that 23% of emissions are linked to the 'production of materials'. From [source](#).
31. IRP. (2011). *Decoupling natural resource use and environmental impacts from economic growth*. Retrieved from: [IRP website](#)
32. On the national scale, it's important to note that relevant sub-indicators change slightly, as material extraction is no longer equivalent to virgin material use due to trade between economies: here, measuring indicators like **Domestic Extraction**, **Domestic Material Consumption** and **Raw Material Consumption** can indicate to what extent material extraction and use is surpassing safe levels and hindering progress towards a broad range of environmental goals. Refer to the glossary on page 64 for definitions of these indicators.
33. This number excludes combustion-related solid and liquid waste, such as ashes and sludges.
34. This number excludes combustion-related solid and liquid waste, such as. ashes and sludges. This share of waste out of Processed Outputs may therefore be slightly underestimated.
35. The difference between this figure and the recycling rate as calculated with the Sankey data (27.7%) is due to slightly different totals for waste generation following the harmonisation and reconciliation of different data sources. We report on the actual result from the database for a consistent comparison with 2018 data.
36. Extraction data: International Resource Panel. (2024). Global material flows database. Retrieved from: [IRP website](#); Population data: United Nations, Department of Economic and Social Affairs, Population Division (2024). World population prospects: The 2024 revision. Retrieved from: [UN website](#)
37. Or 68 billion tonnes. Target to be achieved by 2030. This is an unofficial target based on planetary boundaries, from: Fanning, A., O'Neill, D., Hickel, J., & Roux, N. (2022). The social shortfall and ecological overshoot of nations. *Nature Portfolio*. doi:10.1038/s41893-021-00799-z
38. Circle Economy analysis.
39. Circle Economy analysis.
40. Circle Economy analysis.
41. Circle Economy analysis.
42. Circle Economy analysis.
43. Navare, K., Muys, B., Vrancken, K. C., & Van Acker, K. (2021a). Circular economy monitoring – how to make it apt for biological cycles? *Resources, Conservation and Recycling*, 170, 105563. doi:10.1016/j.resconrec.2021.105563
44. Navare, K., Muys, B., Vrancken, K. C., & Van Acker, K. (2021a). Circular economy monitoring – how to make it apt for biological cycles? *Resources, Conservation and Recycling*, 170, 105563. doi:10.1016/j.resconrec.2021.105563
45. For food and feed, cascading is more difficult due to spoilage, safety concerns, and the biological nature of consumption. For this reason, cascading largely applies to non-food biomass.
46. IRP. (2024). *Global resources outlook 2024: Bend the trend. Pathways to a liveable planet as resource use spikes*. UNEP: Nairobi. Retrieved from: [UNEP website](#)
47. This does not consider timber or wood-based packaging, for example, which could be considered under Secondary Materials, Virgin, Non-Renewable Materials or additions to Stock, for example, depending on its fate.
48. Winkler, K., Fuchs, R., Rounsevell, M., & Herold, M. (2021). Global land use changes are four times greater than previously estimated. *Nature Communications*, 12(1). doi:10.1038/s41467-021-22702-2
49. Our World in Data. (2024). Half of the world's habitable land is used for agriculture. Retrieved from: [Our World in Data website](#)

50. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). (2019). *Global assessment report on biodiversity and ecosystem services*. Retrieved from: [IPBES website](#)
51. UNEP. (2024). *Food waste index report 2024*. UNEP. Retrieved from: [UNEP website](#)
52. Deloitte. (2024). Turning point: Feeding the world sustainably. Retrieved from: [Deloitte website](#)
53. van Zanten, H. H., Simon, W., van Selm, B., Wacker, J., Maindl, T. I., Frehner, A., ... Herrero, M. (2023). Circularity in Europe strengthens the sustainability of the Global Food System. *Nature Food*, 4(4), 320–330. doi:10.1038/s43016-023-00734-9
54. EAT. (2019). *Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems [Summary report]*. Retrieved from: [EAT website](#)
55. Bianchi, M., Cascavilla, A., Diaz, J. C., Ladu, L., Blazquez, B. P., Pierre, M., ... Yilan, G. (2024). Circular Bioeconomy: A review of empirical practices across implementation scales. *Journal of Cleaner Production*, 477, 143816. doi:10.1016/j.jclepro.2024.143816
56. At the national level, considering both the domestic material consumption and raw material consumption of biomass is essential to both optimise biomass use and avoid burden shifting between countries through trade.
57. Halpern, B. S., Frazier, M., Verstaen, J., Rayner, P.-E., Clawson, G., Blanchard, J. L., ... Williams, D. R. (2022). The environmental footprint of Global Food Production. *Nature Sustainability*, 5(12), 1027–1039. doi:10.1038/s41893-022-00965-x
58. Stenzel, F., Greve, P., Lucht, W., Tramberend, S., Wada, Y., & Gerten, D. (2021). Irrigation of biomass plantations may globally increase water stress more than climate change. *Nature Communications*, 12(1). doi:10.1038/s41467-021-21640-3
59. FAO. (2024). *Progress on the level of water stress*. Retrieved from: [UN Water website](#)
60. For example, although growing biomass for renewable energy can help mitigate climate change, irrigating such crops can also cause significant water stress—with severe consequences for the people living in these areas.
61. FAO. (2024). *Progress on the level of water stress*. Retrieved from: [UN Water website](#)
62. Ritchie, H. (2021). Deforestation and forest loss. Retrieved from: [OurWorldinData website](#)
63. Estoque, R. C., Dasgupta, R., Winkler, K., Avitabile, V., Johnson, B. A., Myint, S. W., ... Lasco, R. D. (2022). Spatiotemporal pattern of global forest change over the past 60 years and the forest transition theory. *Environmental Research Letters*, 17(8), 084022. doi:10.1088/1748-9326/ac7df5
64. Gütschow, J., Busch, D., & Pflüger, M. (2025). The PRIMAP-hist national historical emissions time series (1750–2023) v2.6.1 (v2.6.1) [Data set]. Zenodo. doi:10.5281/zenodo.1501628
65. Singh, C., Persson, U. M., Croft, S., Kastner, T., & West, C. D. (2024). Commodity-driven deforestation, associated carbon emissions and trade 2001–2022 (2.0) [Data set]. Zenodo. doi:10.5281/zenodo.10633818
66. United Nations Climate Change. (n.d.). Land use, land-use change and forestry (LULUCF). Retrieved from: [UNFCCC website](#)
67. Sustainable Development Goal 6.3.1: Proportion of safely treated domestic wastewater flows by country can be used as a proxy for ‘pollutant discharges from production activities to water bodies & proportion safely treated’. From [source](#).
68. Extraction data: International Resource Panel. (2024). Global material flows database. Retrieved from: [IRP website](#); Population data: United Nations, Department of Economic and Social Affairs, Population Division (2024). World population prospects: The 2024 revision. Retrieved from: [UN website](#)
69. Target based on: Bringezu, S. (2015). Possible target corridor for sustainable use of global material resources. *Resources*, 4(1), 25–54. doi: 10.3390/resources4010025
70. FAO & UN Water. (2024). *Progress on the level of water stress: Mid-term status of SDG Indicator 6.4.2 and acceleration needs, with special focus on food security*. Rome: FAO. Retrieved from: [UN Water website](#)
71. Circle Economy analysis.
72. With 2011 as a baseline year.
73. Protected Planet. (2024). *The protected planet report 2024*. Retrieved from: [Protected Planet website](#)
74. Protected Planet. (2021). *The protected planet report 2021*. Retrieved from: [Protected Planet website](#)
75. Target based on: Convention on Biological Diversity. (2022). Kunming-Montreal global biodiversity framework. Retrieved from: [Convention on Biological Diversity website](#)
76. Circle Economy analysis.
77. This target is based on Sustainable Development Goal 6.3, which calls for a 50% reduction in untreated wastewater. It’s estimated that the share of untreated wastewater is 80%. This should shift to 40% untreated and 60% treated. While this data comes from a 2018 report, more recent sources only consider reported data and thus highly underestimate the share of untreated wastewater. Source: UN Water. (2018). *Water quality and wastewater*. Retrieved from: [UN Water website](#). Also see: UN Water. (2024). *Progress on the proportion of domestic and industrial wastewater flows safely treated*. Retrieved from: [UN Water website](#)

78. This indicator also covers the harvest of wild animal stocks—fish catch, for example, where respecting regeneration rates is equally crucial and over-extraction has devastating impacts on biodiversity.
79. Borrelli, P., Robinson, D. A., Fleischer, L. R., Lugato, E., Ballabio, C., Alewell, C., ... Panagos, P. (2017). An assessment of the global impact of 21st century land use change on soil erosion. *Nature Communications*, 8(1). doi:10.1038/s41467-017-02142-7
80. Carbon is sequestered from and emitted to the biosphere through these cycles, as carbon dioxide is absorbed from the atmosphere through photosynthesis and stored in biomass, and emitted back to the atmosphere when biomass is incinerated or decomposed. These emissions balance out the initial carbon sequestration, resulting in a carbon balance.
81. Navare, K., Muys, B., Vrancken, K. C., & Van Acker, K. (2021a). Circular economy monitoring – how to make it apt for biological cycles? *Resources, Conservation and Recycling*, 170, 105563. doi:10.1016/j.resconrec.2021.105563
82. Peng, L., Searchinger, T. D., Zionts, J., & Waite, R. (2023). The carbon costs of Global Wood harvests. *Nature*, 620(7972), 110–115. doi:10.1038/s41586-023-06187-1
83. Houghton, R., & Castanho, A. (2022). *Annual emissions of carbon from land use, land-use change, and forestry 1850–2020*. doi:10.5194/essd-2022-351
84. Doelman, J. C., Verhagen, W., Stehfest, E., & van Vuuren, D. P. (2023). The role of peatland degradation, protection and restoration for climate change mitigation in the SSP scenarios. *Environmental Research: Climate*, 2(3), 035002. doi:10.1088/2752-5295/acd5f4
85. International Union for Conservation of Nature (IUCN). (2021). *Peatlands and climate change*. Retrieved from: [IUCN website](#)
86. Hansis, E., Davis, S. J., & Pongratz, J. (2015). Relevance of methodological choices for accounting of Land Use Change Carbon Fluxes. *Global Biogeochemical Cycles*, 29(8), 1230–1246. doi:10.1002/2014gb004997
87. Peng, L., Searchinger, T. D., Zionts, J., & Waite, R. (2023). The carbon costs of Global Wood harvests. *Nature*, 620(7972), 110–115. doi:10.1038/s41586-023-06187-1
88. Macintosh, A. K. (2012). Lulucf in the post-2012 regime: Fixing the problems of the past? *Climate Policy*, 12(3), 341–355. doi:10.1080/14693062.2011.605711
89. Navare, K., Muys, B., Vrancken, K. C., & Van Acker, K. (2021). Circular economy monitoring – How to make it apt for biological cycles? *Resources, Conservation and Recycling*, 170, 105563. doi:10.1016/j.resconrec.2021.105563
90. This is waste related to fossil-fuel based products—such as plastics, chemicals and fertilisers—rather than fossil fuels used for energy purposes, which are captured under ‘Fossil Fuels’.
91. Blight, G. (2011). Mine waste. *Waste*, 77–88. doi:10.1016/b978-0-12-381475-3.10005-1
92. World Bank Group. (2018, September 20). Global waste to grow by 70 percent by 2050 unless urgent action is taken: World Bank report. *World Bank Group*. Retrieved from: [World Bank website](#)
93. United Nations Office for Disaster Risk Reduction (UNDRR). (n.d.). Landfilling. Retrieved from: [UNDRR website](#)
94. EEA. (2024). Diversion of waste from landfill in Europe. Retrieved from: [EEA website](#)
95. World Resources Institute (WRI). (2023). Seven things to know about carbon capture, utilization and sequestration. Retrieved from: [WRI website](#)
96. IRP. (2024). *Global resources outlook 2024: Bend the trend. Pathways to a liveable planet as resource use spikes*. UNEP: Nairobi. Retrieved from: [UNEP website](#)
97. International Energy Agency (IEA). (2024). *World Energy Outlook 2024*. Paris: IEA. Retrieved from: [IEA website](#)
98. Enerdata. (2024). World energy & climate statistics: Yearbook 2024. Retrieved from: [Enerdata website](#)
99. Energy Transitions Commission. (2023). *Material and resource requirements for the energy transition*. Retrieved from: [Energy Transitions Commission website](#)
100. IRENA. (2023). *Geopolitics of the energy transition: Critical materials*. Retrieved from: [IRENA website](#)
101. UNEP. (2024). *Critical Transitions: Circularity, equity, and responsibility in the quest for energy transition minerals - Working Paper*. Retrieved from: [UNEP website](#)
102. Watari, T., Nansai, K., Nakajima, K., & Giurco, D. (2021). Sustainable energy transitions require enhanced resource governance. *Journal of Cleaner Production*, 312, 127698. doi:10.1016/j.jclepro.2021.127698
103. IEA. (2021). *The role of critical minerals in clean energy transitions*. IEA: Paris. Retrieved from: [IEA website](#)
104. UNEP. (n.d.). Indicator 12.c.1. Retrieved from: [UNEP website](#)
105. Estimate based on the following source, applied to IEA data: Enerdata. (2024). World energy & climate statistics: Yearbook 2024: Total energy production. Retrieved from: [Enerdata website](#)
106. Grubler, A., Wilson, C., Bento, N., Boza-Kiss, B., Krey, V., McCollum, D., Rao, N., Riahi, K., Rogelj, J., De Stercke, S., Cullen, J., Frank, S., Fricko, O., Guo, F., Gidden, M., Havlik, P., Huppmann, D., Kiesewetter, G., Rafaj, P., Schöpp, W., et al. (2018). A low energy demand scenario for meeting the 1.5 °C target and sustainable development goals without negative emission technologies. *Nature Energy*, 3 (6), 517–525. doi:10.1038/s41560-018-0172-6
107. IEA. (2024). *Electricity 2024: Analysis and forecast to 2026*. Retrieved from: [IEA website](#)

108. Fossil fuels still account for about half of global electricity generation: coal about 36% and natural gas about 24%. [Source](#).
109. IEA & UN Statistics Division. (2024). *The energy progress report*. Retrieved from: [Tracking SDG 7 website](#)
110. This number excludes the oxygen in emissions, but does include some combustion-related solid and liquid waste, such as ashes and sludges. The share of emissions out of Processed Outputs is therefore slightly overestimated.
111. Estimate based on the following source, applied to IEA data: Enerdata. (2024). World energy & climate statistics: Yearbook 2024: Total energy production. Retrieved from: [Enerdata website](#)
112. Energy Institute. (2024). *Statistical review of world energy*. Retrieved from: [Energy Institute website](#)
113. IEA. (2018). *World energy outlook 2019*. Retrieved from: [IEA website](#)
114. Energy Institute. (2024). *Statistical review of world energy*. Retrieved from: [Energy Institute website](#)
115. Reduction to be achieved by 2030 and 2050. Target based on: IPCC. (2018). *Special report: Global Warming of 1.5 °C (Table 2.6)*. Retrieved from: [IPCC website](#)
116. International Energy Agency & UN Statistics Division. (2024). *The energy progress report*. Retrieved from: [Tracking SDG 7 website](#)
117. Increase to be achieved by 2030, with 70–85% of electricity generation from renewable sources by 2050. Target based on: IPCC. (2018). *Special report: Global Warming of 1.5 °C*. Retrieved from: [IPCC website](#)
118. IEA. (2018). *World energy outlook 2019*. Retrieved from: [IEA website](#)
119. IEA. (2022). *World energy outlook 2022*. Retrieved from: [IEA website](#)
120. Jones, M.W., Peters, G., Gasser, T., Andrew, R.M., Schwingshackl, C., Gütschow, J., Houghton, R.A., Friedlingstein, P., Pongratz, J., & Le Quéré, C. (2024). National contributions to climate change due to historical emissions of carbon dioxide, methane and nitrous oxide. Scientific Data. Zenodo. doi:10.5281/zenodo.14054503.
121. This reduction is compared to 2010 levels and should be achieved by 2030. Further targets include -65% by 2035 and net zero by 2050. Target based on: IPCC. (2023). *Sixth assessment report*. Retrieved from: [IPCC website](#)
122. Circle Economy analysis.
123. This is only the case if there is no overall growth in material demand and/or stock build up. It's important to note that R-strategies won't inherently lead to more sustainable outcomes if the use of virgin materials continues to grow.
124. Krausmann, F., Wiedenhofer, D., Lauk, C., Haas, W., Tanikawa, H., Fishman, T., ... Haberl, H. (2017). Global socioeconomic material stocks rise 23-fold over the 20th century and require half of annual resource use. *Proceedings of the National Academy of Sciences*, 114(8), 1880–1885. doi:10.1073/pnas.1613773114
125. Schiller, G., & Roscher, J. (2023). Impact of urbanization on construction material consumption: A global analysis. *Journal of Industrial Ecology*, 27(3), 1021–1036.
126. Duro, J.A., Perez-Laborda, A., Löw, M., Matej, S., Plank, B., Krausmann, F., Wiedenhofer, D., & Haberl, H. (2024). Spatial patterns of built structures co-determine nations' level of resource demand. *Journal of Industrial Ecology*, 28, 289–302. doi:10.1111/jiec.13470
127. World Bank Group. (n.d.). Urban population (% of total population). Retrieved from: [World Bank website](#)
128. UN. (2018). *World urbanisation prospects 2018: Highlights*. Department of Economic and Social Affairs, Population Division. Retrieved from: [UN website](#)
129. IRP. (2018). *The weight of cities: Resource requirements of future urbanization*. Nairobi: UNEP. Retrieved from: [IRP website](#)
130. IRP. (2018). *The weight of cities: Resource requirements of future urbanization*. Nairobi: UNEP. Retrieved from: [IRP website](#)
131. Elhacham, E., Ben-Uri, L., Grozovski, J., Bar-On, Y. M., & Milo, R. (2020). Global human-made mass exceeds all living biomass. *Nature*, 588(7838), 442–444. doi:10.1038/s41586-020-3010-5
132. Wiedenhofer, D., Streeck, J., Wieland, H., Grammer, B., Baumgart, A., Plank, B., et al. (2024). From extraction to end-uses and waste management: Modeling economy-wide material cycles and stock dynamics around the world. *Journal of Industrial Ecology*, 28, 1464–1480. doi:10.1111/jiec.13575
133. Deetman, S., Marinova, S., Voet, E., Vuuren, D., Edelenbosch, O., & Heijungs, R. (2020). Modelling global material stocks and flows for residential and service sector buildings towards 2050. *Journal of Cleaner Production*. doi:10.1016/j.jclepro.2019.118658
134. Wang, R., Hertwich, E. G., Fishman, T., Deetman, S., Behrens, P., Chen, W., ... Zimmerman, J. B. (2023). The legacy environmental footprints of manufactured capital. *Proceedings of the National Academy of Sciences*, 120(24). doi:10.1073/pnas.2218828120
135. Statista. (2024). Aggregated floor area of buildings worldwide from 2010 to 2022 with a forecast for 2030. Retrieved from: [Statista website](#)
136. Circle Economy. (2024). *The circularity gap report 2024*. Amsterdam: Circle Economy. Retrieved from: [CGR website](#)

137. Lanau, M., Liu, G., Kral, U., Wiedenhofer, D., Keijzer, E., Yu, C., & Ehlert, C. (2019). Taking stock of built environment stock studies: Progress and prospects. *Environmental Science & Technology*, 53(15), 8499–8515. doi:10.1021/acs.est.8b06652
138. Schiller, G., & Roscher, J. (2023). Impact of urbanization on construction material consumption: A global analysis. *Journal of Industrial Ecology*, 27(3), 1021–1036. doi:10.1111/jiec.13392
139. Circle Economy analysis.
140. Circle Economy analysis.
141. Circle Economy analysis.
142. Circle Economy analysis.
143. Circle Economy analysis.
144. This goal stems from Circle Economy's research conducted for the *Circularity Gap Report 2021*, which found that circular strategies applied across key sectors could reduce material use by approximately one-third and boost the Circularity Metric to 17%.
145. Target based on: Fanning, A., O'Neill, D., Hickel, J., & Roux, N. (2022) The social shortfall and ecological overshoot of nations. *Nature Portfolio*. doi:10.1038/s41893-021-00799-z
146. According to the UN medium-fertility variant from [source](#).
147. Target based on: UNEP. (2022). *Emissions gap report 2022*. Retrieved from: [UNEP website](#)
148. Target based on: Fritsche, U., Brunori, G., Chiaramonti, D., Galanakis, C., Matthews, R. & Panoutsou, C. (2021). *Future transitions for the bioeconomy towards sustainable development and a climate-neutral economy - foresight scenarios for the EU bioeconomy in 2050*. Luxembourg: Publications Office of the European Union. doi:10.2760/469550, JRC123532.
149. Target based on: Bringezu, S. (2015). Possible target corridor for sustainable use of global material resources. *Resources*, 4(1), 25-54. doi: 10.3390/resources4010025
150. Prominent examples of measurement frameworks and reporting standards that can guide businesses in measuring their circular economy performance include the Circular Transition Indicators (CTI), the European Sustainability Reporting Standard on Resource Use and Circular Economy (ESRS E5), the GRI 301 and 306, and ISO 59020. Harmonisation efforts across these standards are also underway by the development of the Global Circularity Protocol by the WBCSD and the UN One Planet Network.
151. IRP. (2024). *Global resources outlook 2024: Bend the trend. Pathways to a liveable planet as resource use spikes*. UNEP: Nairobi. Retrieved from: [UNEP website](#)
152. IRP. (2024). *Global resources outlook 2024: Bend the trend. Pathways to a liveable planet as resource use spikes*. UNEP: Nairobi. Retrieved from: [UNEP website](#)
153. UNEP's One Planet Network, UNDP & UNFCCC Secretariat. (2023). Building circularity into Nationally Determined Contributions (NDCs) – a practical toolbox. Retrieved from: [UNEP website](#)
154. Global Alliance on Circular Economy and Resource Efficiency (GACERE). (2024). *Circular economy and extended producer responsibility* [Webinar report]. Retrieved from: [UNIDO website](#)
155. UNEP. (2024). *Intergovernmental Negotiating Committee to develop an international legally binding instrument on plastic pollution, including in the marine environment*. Retrieved from: [UNEP website](#)
156. Cordonier Segger, M.-C., & Schrijver, N. J. (2021). ILA guidelines for Sustainable Natural Resources Management for Development. *Netherlands International Law Review*, 68(2), 315–347. doi:10.1007/s40802-021-00190-x
157. IRP. (2020). *Mineral resource governance in the 21st Century: Gearing extractive industries towards sustainable development*. Retrieved from: [IRP website](#)

Acknowledgements

Circle Economy would like to **thank the funders, authors, contributors and interviewees** for their contribution to the preparation of this edition of the *Circularity Gap Report*. Authors, contributors and interviewees have contributed to the report in their individual capacities. Their affiliations are only mentioned for identification purposes.

Lead authors (Circle Economy)

Ana Birliga Sutherland, Álvaro Conde, Marijana Novak, Alex Collorichio

Contributing authors (Circle Economy)

Mathijs Nelemans, Wen-Yu Chen, Pau Ruiz, Jacco Jochemsen, Marc de Wit

Contributors (Circle Economy)

Shelby Kearns, Krijn Smits, Matthew Fraser, Andrew Keys, Sofia Ferrando, Irlanda Mora, Amy Kummetha, Luibov Glazunova, Megan Murdie, Alexandru Grigoras, Lieke Pijpers

Contributors (Deloitte)

David Rakowski, Dieuwertje Ewalts, Cecilia Dall Acqua, Christiaan Kusters, Lian van Rooij, Michelle Varney, Blythe Aronowitz, Freedom-Kai Phillips, Tom Horigan, Sue Harvey Brown

Coalition

Jerome Stucki (UNIDO), Rebecca Tauer (WWF Germany), Dieuwertje Ewalts (Deloitte), Christiaan Kusters (Deloitte), Edward Sims (Deloitte), Georgine Roodenrys (Deloitte), Kari Herlevi (Sitra), Jelmer Hoogzaad (Shifting Paradigms), Myriam Linster (OECD), Frithjof Laubinger (OECD)

Version 1.0 (May 2025)

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License



How to cite this report: Circle Economy. (2025). *The circularity gap report 2025*. Amsterdam: Circle Economy.



circle-economy.com