

July 2019

# The road to circularity

Why a circular economy  
is becoming the new normal



At PwC, our purpose is to build trust in society and solve important problems. We're a network of firms in 158 countries with more than 250,000 people who are committed to delivering quality in assurance, advisory and tax services. Find out more and tell us what matters to you by visiting us at [www.pwc.com](http://www.pwc.com). PwC refers to the PwC network and/or one or more of its member firms, each of which is a separate legal entity. Please see [www.pwc.com/structure](http://www.pwc.com/structure) for further details.

# Table of contents

<b>Foreword</b>	<b>4</b>
<b>Introduction - An alternative economic model</b>	<b>6</b>
 <b>Part 1 - The theory</b>	
<b>What's the problem?</b>	<b>11</b>
- The challenge facing our planet	11
- Environmental degradation and resource scarcity	14
<b>The economics of it all</b>	<b>16</b>
- Negative externalities and public goods	16
- People are becoming concerned	17
<b>How do we solve the problem?</b>	<b>19</b>
- Market dynamics and incentives for change	19
- Responding effectively	19
- Creating markets for second-hand products and materials	20
<b>Many successes, but still just the beginning</b>	<b>22</b>
- Why we still need circularity	22
 <b>Part 2 - The business perspective</b>	
<b>Why? Reasons for companies to go circular</b>	<b>27</b>
- The benefits of becoming circular	27
- Increase resilience against external shocks	27
- Make your brand more attractive	27
- Preempt regulatory pressures down the line	29
- Become more digitally enabled	29
<b>What? Circular principles and strategies</b>	<b>33</b>
- The ten circular strategies in practise	33
<b>How? Accepting challenges, setting goals and measuring progress</b>	<b>44</b>
- Taking action	44
- Deciding direction and setting goals	45
- Measuring progress	46
 <b>Part 3 - Bringing it all together</b>	
<b>The way forward</b>	<b>49</b>
 <b>Part 4 - How we can help</b>	
<b>PwC's circular service offering</b>	<b>51</b>



# Foreword

Basic economics shows that the planet simply cannot carry our linear production path any longer. The circular economy represents a significant opportunity, as well as a challenge, for all of us. The consequences of our current production model are becoming increasingly evident. As a solution the circular economy proposes a new radically different way of thinking about economic activity - a way that also safeguards economic prosperity in the long term.

This report is a contribution to the on-going discussion in the business community of how taking environmental aspects into consideration also makes business sense. By laying down the economics behind a circular model, the report shows the inevitability of a drastic transformation of our linear model. It provides the theoretical foundation to further explore the topic. It shows that increased prosperity and care for the environment are not polar opposites. Instead, in a circular economy, those concepts complement each other.

By mimicking nature a circular economy enables us to (re-)organise our economy as a continuous cycle where nothing is wasted and value creation is maximised. It creates closed loop material and energy cycles where all materials re-enter the system in a continuous cycle, thus decoupling economic activity from the consumption of finite resources.

As Assurance Leader for PwC Germany and the Markets Leader for PwC Netherlands, we feel strongly that it is important for PwC as a firm to lead the way in the circular transition. In-house we have seen both the opportunities and the challenges of going circular first hand.



For several years, PwC has been applying circular principles to the resources it uses in its own business, including energy, water, food, paper, electronics and more. Many individual member firms have their own objectives. As an example, PwC Netherlands aims to have a net zero carbon footprint and a fully circular way of working by 2030. We therefore know that going circular is hard work, but is also enormously rewarding, as employees and clients alike appreciate our efforts.

Circularity challenges our current way of thinking and spurs us into action. It confronts us with uncomfortable questions, but also begs for new solutions. We therefore call upon our ecosystem-partners – whether in government, business or civil society – to develop their circular strategies, acknowledging our interdependencies for system change. We need to jointly shape our new circular economic model to create an innovative and competitive economy that recognises and operates within the boundaries of what our Earth can provide.

We don't deny that a transition of this scale will be difficult, but it is inevitable, and we believe it will be worthwhile - and most of all achievable as a concerted effort. We must go circular – and we can.



**Petra Justenhoven**

Assurance Leader, PwC Germany  
and PwC Europe



**Renate de Lange-Snijders**

Markets Leader, PwC Netherlands

# Introduction

## An alternative economic model

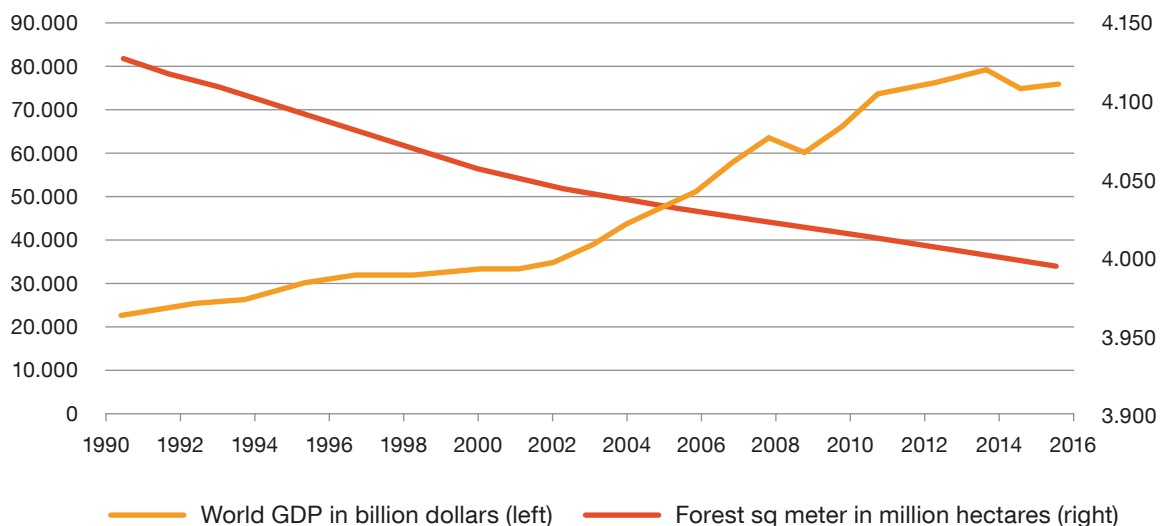
Today's global economic system is based on a linear model that became dominant after the first industrial revolution introduced the concept of mass production. This model has delivered economic growth and increased prosperity over the past 200 years. Particularly since the end of the 1940's, technological and social innovation has boosted living standards for a majority of people on our planet.<sup>1</sup> In terms of economic growth it has been a story of incredible success.

Within the same period of time, however, the Earth's ecosystems have started to show signs of serious stress (see *Figure 1*). The linear model involves extracting natural resources to make products, that are used for a limited period of time, before being discarded as waste. It is often referred to as the 'take-make-dispose' industrial model.

In contrast, a circular economy is an alternative economic model that involves decoupling economic activity from the consumption of finite resources. A circular economy model derives its inspiration from nature's biological cycle and creates closed loop material and energy cycles where waste is a problem because it is seen as value leakage.


A circular model means using resources efficiently and prioritising renewable inputs, maximising a product's usage and lifetime in order to extract the maximum value, and recovering and reusing by-products and waste to make new materials or products (see *Figure 2*). It is about responsibly managing the flow of renewable resources and the stock of finite materials.

**Figure 1** Wealth creation versus environmental degradation (deforestation as a proxy)



Sources: The World Bank and the Food and Agriculture Organization

<sup>1</sup> Hans Rosling, Ola Rosling and Anna Rosling Rönnlund (2018), *Factfulness: Ten Reasons We're Wrong About the World – and Why Things Are Better Than You Think*.

A photograph of a clear plastic bottle lying on its side on a dark, wet beach. The bottle is covered in water droplets and is partially filled with water. The background shows the ocean and a sunset sky with warm orange and yellow tones. A semi-transparent orange box is overlaid on the upper right portion of the image, containing white text.

A circular economy is an alternative economic model that involves decoupling economic activity from the consumption of finite resources.

### What's new?

The concept of circularity is as old as time itself – because our planet has always functioned in this way. Ever since life first emerged on Earth, organic material has been created and recreated in an abundant manner. Nothing in nature is wasted because all materials re-enter the ecosystem through a circular biological process that forms a continuous cycle.

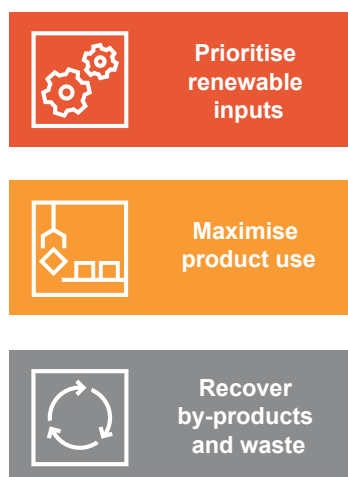
It is only in the last 200 years since the industrial revolution that human production has started to operate according to a linear model. In many ways, the modern world that humankind has built is an anomaly when viewed in the full context of the history of our species and our planet.

If successful, the transition to a circular economy has the potential to take us back to where we began, and organise our economy in a way that mirrors nature. Organic material will re-enter the ecosystem through circular biological processes, as part of a continuous cycle where nothing is wasted.

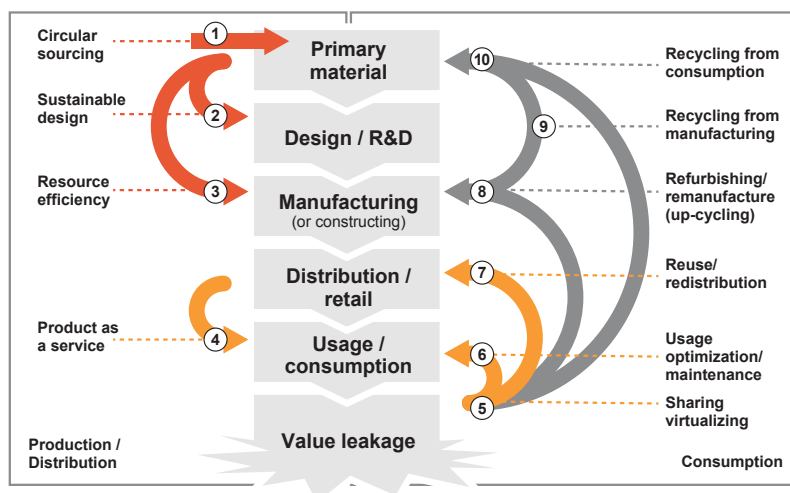
A circular economy regenerates ecosystems to better support health and well-being of both our planet and people. By converting the take-make-waste approach into value loops, creating more from less, the circular economy decouples resource use from value creation.

**Figure 2** The concept of a circular economy

### 3 Principles



### & 10 Corresponding Strategies

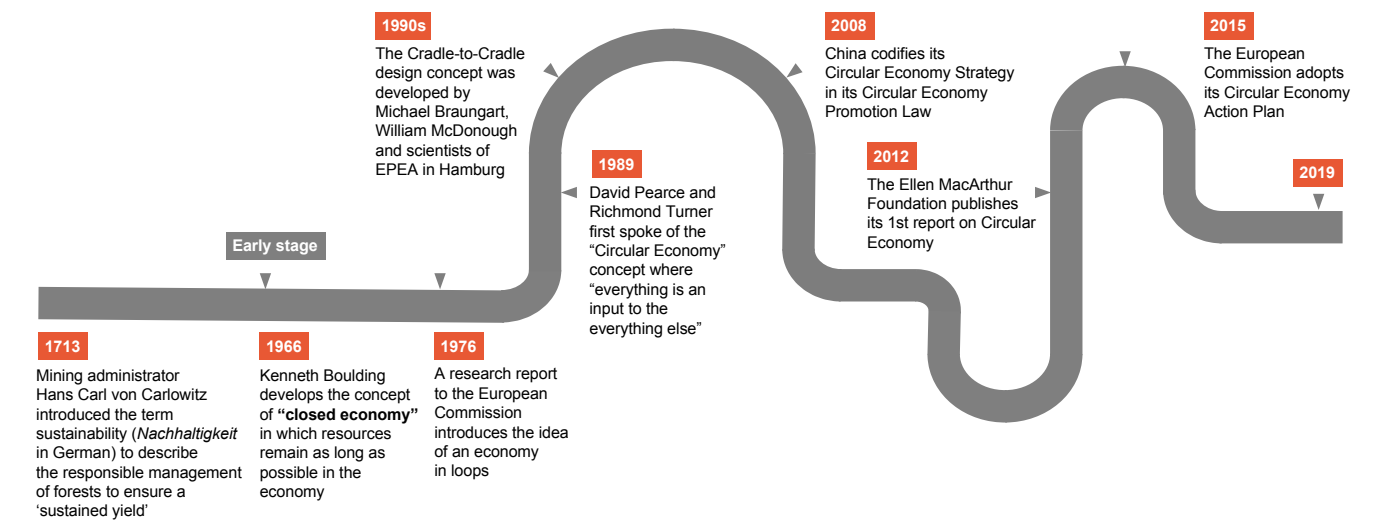


- Circularity can be centred around three overarching principles, which define ten corresponding strategies.
- The diagram illustrates the continuous flow of resources in both the production/ distribution phase and the consumption phase.
- Circularity in the production/ distribution phase is anchored in four strategies (1-4) that aim to maximise the use of renewables and minimise value leakage across the value chain.

- Circularity in consumption has six strategies (5-10) that reduce value leakage by circulating products and materials at their highest utility through sharing, reuse, repair, remanufacturing, and recycling.
- The end-of life of a product represents value leakage as important by-products are not collected for productive use. Instead of leaking value by discarding products and materials after use, the circular economy stops this value leakage in order to yield more value.

Source: PwC analysis

**Figure 3** The concept of a circular economy has gained momentum since the 1970s, led by a small number of academics, thought-leaders, businesses and policy-makers



Source: PwC



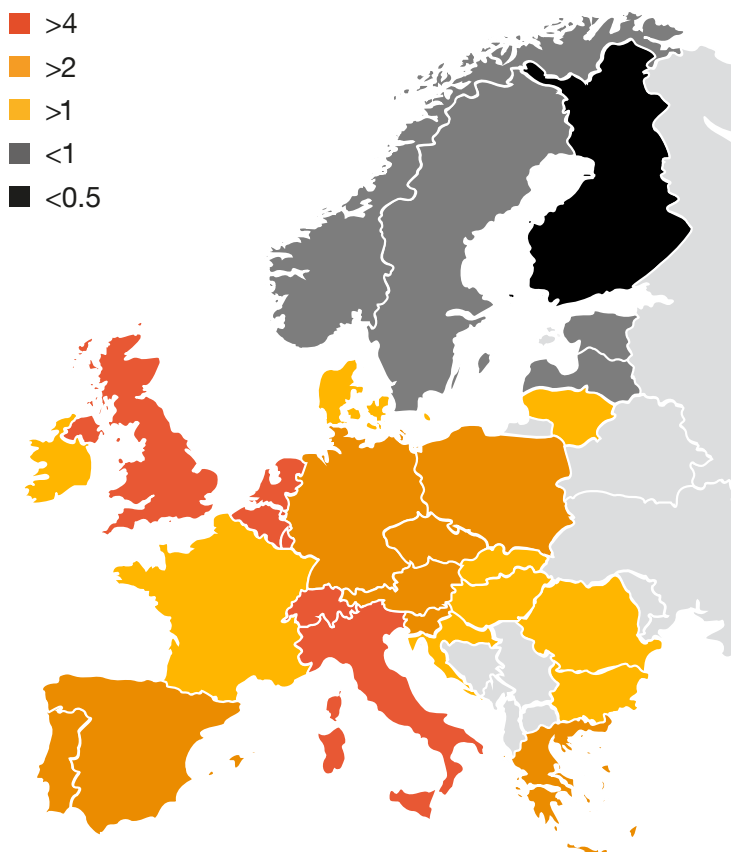
A satellite image of Earth showing North and Central America. The image is a high-resolution view from space, showing the curvature of the planet and the blue of the oceans. The landmasses are green and brown, with white clouds swirling over them. The text 'Part 1' is overlaid on a black rectangular background in the upper left quadrant.

## Part 1

# The theory

# What's the problem?

**Figure 4** The ecological footprint of selected EU countries ('number of countries' needed to sustain consumption at the current level)



## Ecological deficit or reserve

One method of measuring the impact that human activity has on nature is the Global Footprint methodology. This quantifies the pressures that human economic activity puts on nature. It does so through a supply and demand methodology, where the supply is what nature can regenerate in a given period of time, and demand represents the demands of human activity on those resources in this same time period. This is measured across a set geographical area.

An ecological deficit occurs when the consumption by a population exceeds the biocapacity of the area available to that population. A national ecological deficit means that a nation is importing biocapacity through trade, liquidating national ecological assets or emitting carbon dioxide into the atmosphere.

An ecological reserve exists when the biocapacity of a territory exceeds its population's consumption needs.

A small surface area and a dense population generally results in a higher ecological deficit. In addition, the structure of a country's economy (i.e. the type of industries that are dominant) will also influence the score.

Some countries have such a large ecological deficit that they consume their biocapacity multiple times. Figure 4 shows which countries in Europe have an ecological deficit versus a reserve.

Source: PwC analysis based on Global Footprint Network data

## The challenge facing our planet

Since the 1970's, humankind has effectively been running an ecological deficit in terms of its impact on the environment.<sup>2</sup> This means that the global annual demand for resources has exceeded what the Earth can regenerate each year.

Today, the global economy uses the equivalent of 1.7 planets to produce global output and absorb waste (see textbox for an explanation of the methodology). In a business-as-usual scenario, the global ecological footprint is projected to exceed what nature can regenerate by 75 percent by 2020.<sup>3</sup>

Multiple other measures also point to large-scale environmental damage, showing alarming rates of biodiversity loss, deforestation, land degradation, depletion of stocks of finite resources, disruption of the Earth's freshwater cycle, chemical pollution and climate change, to name just a few examples.

This presents risks because if these developments are allowed to continue, the environmental damage caused may become irreversible, or even reach 'tipping points' where self-reinforcing feedback loops produce above-proportionate effects.

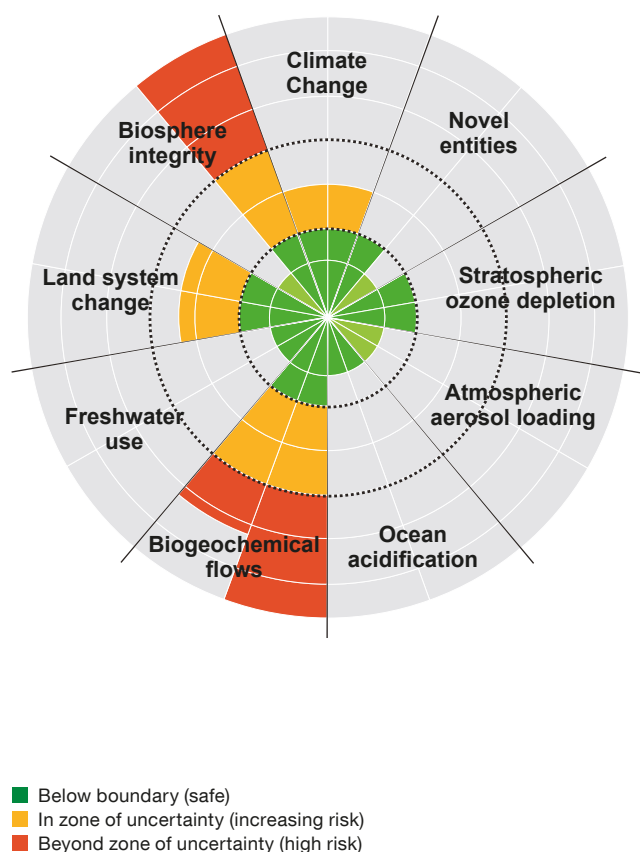
For example, scientists working for the Intergovernmental Panel on Climate Change have shown that there is a real danger of global warming reaching such a tipping point – that if passed, would send the planet into an unstoppable spiral of climate change.<sup>4</sup>

**2** Global Footprint Network: Advancing the Science of Sustainability, Ecological Footprint: <https://www.footprintnetwork.org/our-work/ecological-footprint/>, accessed on 19/02/2019.

**3** Global Footprint Network: Advancing the Science of Sustainability, Ecological Footprint: <https://www.footprintnetwork.org/our-work/ecological-footprint/>, accessed on 19/02/2019.

**4** Intergovernmental Panel on Climate Change (2018), Global Warming of 1.5 °C – Summary for Policy Makers, accessed on 05/04/2019 at: [https://report.ipcc.ch/sr15/pdf/sr15\\_spm\\_final.pdf](https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf)

**Figure 5** The Planetary Boundaries Framework



Source: Stockholm Resilience Centre

**Key:**

1. **Stratospheric ozone depletion:** Depletion of the ozone layer by increased concentrations of ozone depleting chemical substances, mainly CFCs (see page 22).
2. **Biosphere integrity:** Biodiversity loss and extinctions driven by human demand for food, water and natural resources. Further research is underway to improve the availability of reliable data for this boundary.
3. **Novel entities:** Chemical pollution caused by emissions of toxic and long-lived substances such as synthetic organic pollutants, heavy metal compounds and radioactive materials.
4. **Climate change:** The Earth's temperature rises as a result of excessive greenhouse gas (GHG) emissions.
5. **Ocean acidification:** Around a quarter of the CO<sub>2</sub> emitted is ultimately dissolved in the oceans, where it forms carbonic acid, altering ocean chemistry and decreasing the pH level of the surface water.
6. **Freshwater use:** The freshwater cycle is strongly affected by climate change and water is becoming increasingly scarce. Consequences include global scale river flow changes and shifts in vapour flows. Shifts in the hydrological system can be abrupt and irreversible.
7. **Land system change:** Forests are the focus of the boundary for land system change as they play an important role in controlling the climate. Land use change has biodiversity impacts, as well as impacts on water flows and on the biogeochemical cycles of important elements.
8. **Biogeochemical flows:** Nitrogen and phosphorus emissions into the atmosphere and the oceans.
9. **Atmospheric aerosol loading:** Aerosols are fine solid particles or liquid droplets suspended in air. Through their interaction with water vapour, aerosols affect cloud formation and our climate.

### The Planetary Boundaries Framework

This concept focuses on Earth's system processes. It presents a set of nine planetary boundaries within which humanity can operate safely. Crossing the boundaries, on the other hand, increases the risk of large-scale abrupt or irreversible environmental change.

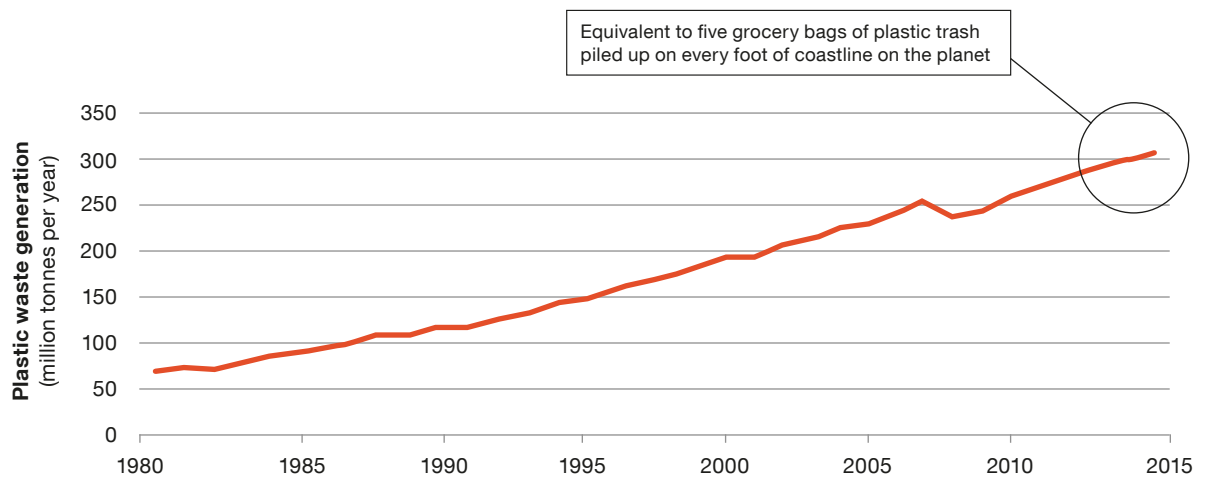
Source: Stockholm Resilience Centre

Similar to the Global Footprint Methodology, the Planetary Boundaries Framework, has defined nine environmental 'boundaries' of Earth system processes that are essential to the stability and resilience of the Earth. We are currently operating outside of the safe zone of four out of the total nine boundaries<sup>5</sup> (see Figure 5 for more details). Transgressing one or more of the planetary boundaries creates a risk of triggering non-linear, abrupt environmental change that can affect large-scale systems, even up to a planetary scale.

According to the scientists behind this research, more than half of the planet's ecosystem services that support human life have been degraded or are used unsustainably. The global interconnectedness brought about by technological advances and international trade flows, means that there are now virtually no ecosystems worldwide that are not impacted by human activity in one way or another.

<sup>5</sup> Will Steffen et al. (2015), Planetary Boundaries: Guiding human development on a changing planet, Science, Vol. 347, Issue 6223

**Figure 6** Plastic waste generation has steadily increased over the past decades



Source: Our World in Data



As we all need these ecosystems in order to thrive and survive environmental degradation is becoming a monumental problem for all of us.<sup>6</sup>

Waste and pollution are the main factors leading to this environmental degradation. As an example of the problem of waste, plastic waste generation is still on the rise (see Figure 6). It is estimated that by 2025 the ocean could contain one ton of plastic for every three tons of finfish.<sup>7</sup> In a business-as-usual scenario there would be more plastic than fish by 2050.<sup>8</sup>

There is evidence that some of this plastic enters the ocean's food chain, and thus the human food chain as well. In fact, the average person consumes about 50,000 pieces of plastic per year and inhales an equal amount.<sup>9</sup>

<sup>6</sup> Stockholm Resilience Centre, Reconnect to the biosphere, accessed on 15/05/2019: <https://www.stockholmresilience.org/research/research-news/2015-02-19-reconnect-to-the-biosphere.html>

<sup>7</sup> Ocean Conservancy and McKinsey Center for Business and Environment (2015), Stemming the Tide.

<sup>8</sup> Ellen MacArthur Foundation (2017), The New Plastics Economy: Rethinking the future of plastics & catalysing action.

<sup>9</sup> Cox, Covernton, Davies, Dower, Juanes and Dudas (2019), Human Consumption of Microplastics.

## Environmental degradation and resource scarcity

The first and most fundamental problem caused by the linear production model is thus **accelerating environmental degradation** resulting from current human economic activity. Given that half of the global population is now middle class or wealthier (see *Figure 7*),<sup>10</sup> the pressure on our planet's resources and ecosystems will be even greater in the future - unless we find a radically different model to satisfy our consumption needs.

The second problem caused by the linear production model is the fact that consuming more resources than the Earth can provide will inevitably lead to shortages of some resources.

**Resource scarcity** can occur for several reasons.

**Figure 7** Half the global population is now middle class or wealthier (2018)



Source: World Data Lab

We distinguish between three types of scarcity.

*Physical scarcity* is about the availability and depletion of stocks – is there enough? As resources become increasingly hard to access, the associated costs and energy needed for extraction increases. As a result, the CO<sub>2</sub> emissions generated per kilo of raw material extracted also rise. This then aggravates the first problem – that of accelerating environmental degradation.

*Economic scarcity* refers to the relationship between supply and demand – is it economically viable to extract the resource at the current price? It also relates to whether the allocation is efficient, as geographical imbalances may lead to too much or too little of a resource being available at a certain place at a certain time.

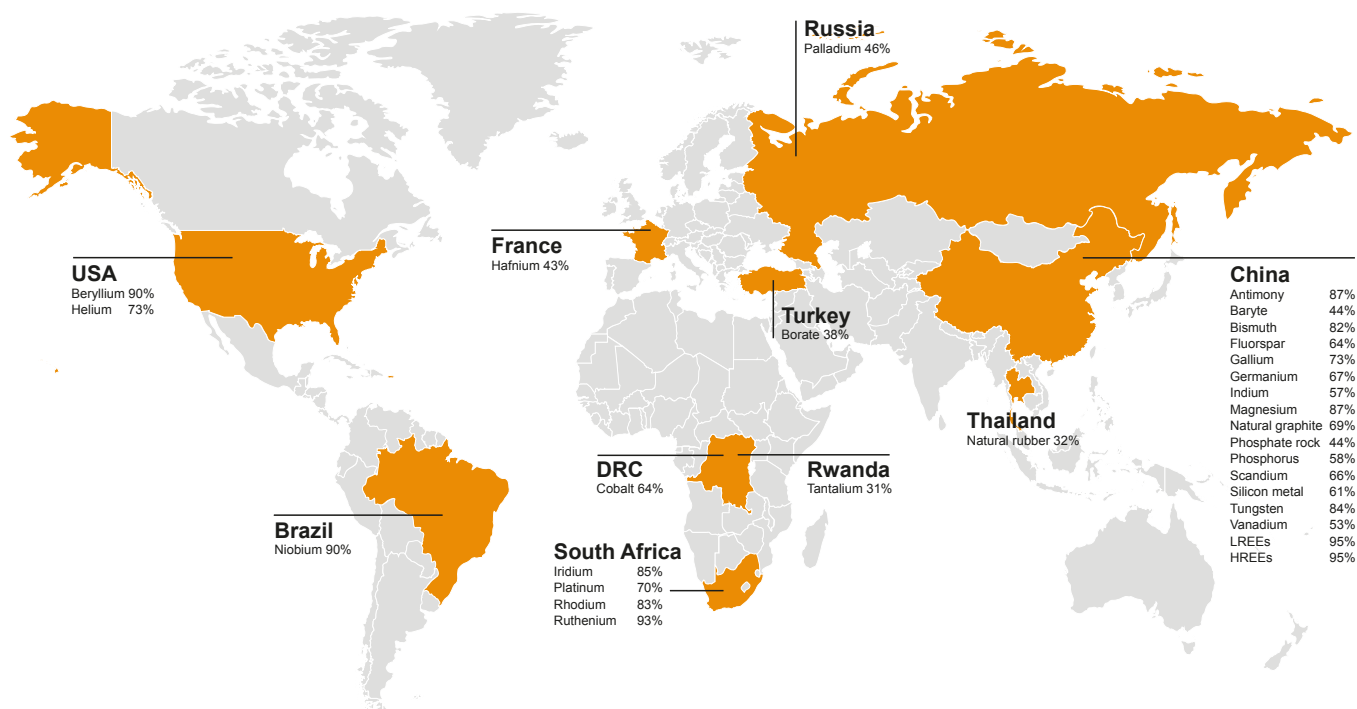
Lastly, *geopolitical scarcity* describes dependencies and risks – who controls the availability of the resource? *Figure 8* shows some of the geographical imbalances in the global markets for critical raw materials.

The three types of scarcity are closely interlinked. The price of a resource will determine the viability of extraction. But a high price also increases the risk of conflict around who controls the resource.

Coupled with poor international governance structures, resource scarcity can thus increase the risk of uprisings and even armed conflict. In turn, armed conflict makes extraction more difficult, which leads to even greater scarcity.

<sup>10</sup> The Brookings Institution (2018), A global tipping point: Half the world is now middle class or wealthier accessed on 04/06/2019: <https://www.brookings.edu/blog/future-development/2018/09/27/a-global-tipping-point-half-the-world-is-now-middle-class-or-wealthier/>

**Figure 8** Some countries have a dominant position in terms of supply of critical raw materials (average 2010-2014)



Source: European Commission

### Conflict minerals

Trade in certain minerals that are in high demand and scarce on the global market are at risk of being used to finance armed groups, fuel forced labour and other human rights abuses, and support corruption and money laundering.

These 'conflict minerals' include tin, tungsten, tantalum and gold and are mined in countries or regions that are either suffering from armed conflict, such as a civil war, or are weakened by post-conflict dynamics. In many cases there are also weak governance structures around mining those minerals.

### Relevant regulations

Recent regulation also recognises the problem of conflict minerals. The US Dodd-Frank Act has been leading the way in setting due diligence requirements for minerals sourced from the Democratic Republic of Congo (DRC) or adjoining countries since 2013. The rule requires companies to report publicly on their due diligence and to have their reports independently audited.

New European Regulation will come into force in 2021 reflecting the increasing need to regulate responsible sourcing of conflict minerals (in all regions of the world).

### Voluntary business standards

In addition to government regulation, there are numerous responsible sourcing and due diligence frameworks in the minerals market, where NGOs, metal exchanges and companies cooperate to implement relevant standards. Many metal exchanges perform due diligence on the sourcing of minerals traded on their platforms. The London Bullion Market Association (LBMA), for example, sets out due diligence requirements for some metals such as gold. This means, if an organisation wants to trade gold on the LBMA, it needs to adhere to the LBMA due diligence rules.

Source: Business & Human Rights Resource Centre, the European Commission and PwC

# The economics of it all

## Negative externalities and public goods

Waste and pollution leading to environmental degradation are what economists call **negative externalities**, or external costs. A negative externality occurs when an economic activity has a negative effect on an unrelated third party. In any production process, the cost of producing a certain good includes the private costs incurred by the producer, and the external costs, such as environmental degradation, which are passed on to society.

### Pollution is a negative externality



If a company operates according to a traditional linear management model, the presence of a negative externality will not influence its decision about whether or not to pollute - because the producer is not directly affected by the associated external cost of its production decisions. This means that, in a linear system, companies have an incentive to produce more than is socially and environmentally optimal, which leads to excessive negative externalities.

### Glossary of economic terms

**Externality** = The effect of an economic activity on an unrelated third party.

**Economic good** = A good or service that has a benefit (utility) to a user or to society.

**Market failure** = A situation in which the allocation of goods and services by a free market is not efficient, often leading to a net social welfare loss.

**Public good** = A good that is not delivered by the free market. It is defined as a good that is non-rivalry and non-exclusive.

Positive externalities are the other side of the coin. These are production choices that have a positive effect on an unrelated third party or on society. An example would be a company that invests in new production equipment that reduces its greenhouse gas emissions.

The reduction in greenhouse gas emissions is desirable from a societal point of view, but the investment is expensive for the company and does not necessarily lead to more output. Companies therefore lack a direct incentive, in the form of cost savings or increased income, to make investments of this kind. From a welfare economics point of view, this is why firms tend to invest little in cleaner technologies.

The incentive for companies to pollute more than is socially and environmentally optimal becomes particularly problematic when we take into account the fact that society considers a clean environment to be a universal right that should be provided free of charge. In economic terms this is called a **public good**.

## Clean water is a public good



Public goods are non-rivalry and non-exclusive in the sense that the enjoyment of a clean environment by one person does not happen at the expense of another person - it is impossible to exclude one person from enjoying a clean environment if it is available. These characteristics make people generally unwilling to pay for public goods, and the unwillingness of consumers to pay for public goods, means that companies have no incentive to provide them.

This is why, ultimately, free market dynamics will lead to an under-provision of public goods. Again, this points to the fact that our current linear economic model will produce undesirable effects that lead to environmental degradation.

## People are becoming concerned

Today we have reached a point at which the effects of our production choices have become more apparent. Public sentiment is shifting and citizens are increasingly demanding that something be done about the problems caused by linear production and consumption models.

Growing concern about environmental damage and its consequences have resulted in agreements such as the COP21 Paris Agreement, through which governments from across the world have committed to working to limit global temperature rises to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C.<sup>11</sup>


By committing to this, as well as other national and international agreements related to the environment, governments have effectively defined a clean and 'liveable' environment as a public good.

## School children striking against climate change



Today, the International Environmental Agreements Database Project lists over 3,750 agreements covering areas ranging from the atmosphere and biodiversity through to chemicals, hazardous substances, waste, land conventions and water. This means that the number of things that we define as public goods has exponentially increased over the past decades as governments are taking public concerns about environmental degradation increasingly seriously.

<sup>11</sup> Intergovernmental Panel on Climate Change (2018), Global Warming of 1.5 °C – Summary for Policy Makers, accessed on 05/04/2019 at: [https://report.ipcc.ch/sr15/pdf/sr15\\_spm\\_final.pdf](https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf)

The image is a full-page background photograph. The foreground is a vast, flat, light-brown landscape, likely a cleared forest floor or a dry riverbed, covered with hundreds of dark, weathered tree stumps of various sizes. Some stumps have exposed roots. In the middle ground, there is a thin, winding line of water. The background is a dense, lush green forest that stretches to the horizon under a clear blue sky. A semi-transparent orange rectangular box is overlaid on the left side of the image, containing white text.

Even though resources are running out at an unprecedented rate, there is no reason to assume that the global markets for raw materials would not be able to solve this through adequate price increases. The problem is that the price adjustment is likely to be too slow to avoid an ecological disaster.

# How do we solve the problem?

## Market dynamics and incentives for change

From an economics point of view, resource scarcity is a lesser problem than environmental degradation – it is one that can be solved by the free market. In a free market economy scarcity will lead to higher prices for raw material and energy inputs, which in turn will force companies to improve their resource efficiency, ultimately leading to less pollution.

Higher prices will also create incentives for collection and re-use, which creates markets for second hand materials. This can be seen with materials such as glass, paper and many metals, where recycled materials compete effectively with those made from virgin inputs.

This is why, even though resources are running out at an unprecedented rate, there is no reason to assume that the global markets for raw materials would not be able to solve this through adequate price increases.

The problem is, however, that the price adjustment is likely to be too slow to avoid an ecological disaster. This leads to some questioning of the inherent characteristics of our current model. Why is this model so ill-equipped to deal with these problems?

## Responding effectively

In short the answer to the above question is that negative externalities and the underprovision of public goods are textbook examples of **market failures**. In the presence of a market failure, free markets will not produce efficient or socially optimal outcomes, which is why governments need to step in to regulate activities that otherwise lead to excessive negative externalities.

The previous chapter showed how no commercial actor has the incentive to supply a public good. This means that the responsibility to safeguard the environment lies with the government – although governments will need to work together with private actors in order to achieve their goals.

In order to promote the transition to a circular economy, governments can shape regulation in a

way that internalises the external costs of production (the negative externalities) and effectively safeguard a clean environment as a public good. When seeking to internalise the external costs, governments set regulations in line with the polluter pays principle. This means setting a price on pollution.

Taxes or levies on polluting activities are one way for governments to make companies assume the external costs of their production activities.<sup>12</sup> Similarly, cap-and-trade schemes put a price on pollution by capping emissions at a certain level (which decreases over time) and then allowing companies to trade permits to emit specific quantities of a specific pollutant per time period.

The increased marginal costs from taxes or levies will incentivise companies to pollute less. The EU Emissions Trading System (EU ETS) is an example of how a supra-national institution has put a price on greenhouse gas emissions through a cap-and-trade scheme.<sup>13</sup>

Extended Producer Responsibility (EPR) is another increasingly popular approach to making the polluter pay. It makes producers responsible for the treatment and/or disposal of post-consumer products (financially by paying for or physically by collecting, treating and disposing of the products). EPR measures incentivise the reduction of waste at its source. Today many governments have EPR policies in place and the trend is towards an extension of EPR to new product groups and waste streams, such as electrical appliances and electronics.<sup>14</sup>

If governments are able to set the price of pollution at the right level through any of these measures, regulation has the potential to increase or even maximise social welfare. Making the polluter pay aligns private profit maximisation with the broader welfare goals of society.

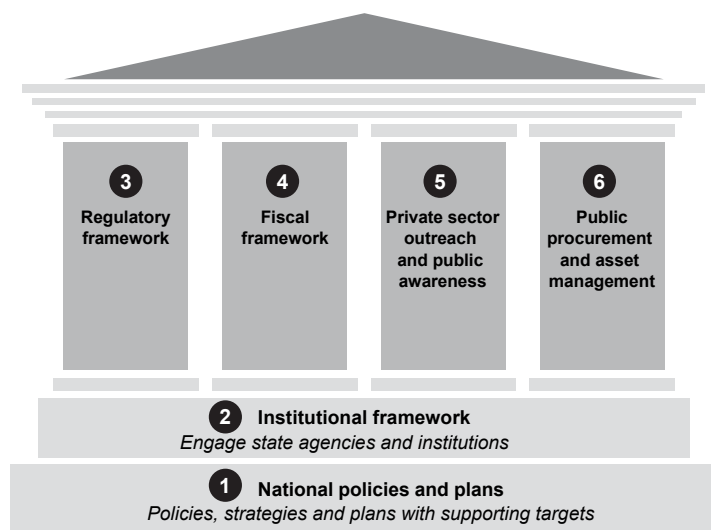
Similarly, in order to incentivise circular production models, governments should seek to incentivise activities that create positive externalities. For instance, innovative ideas that reduce the negative impact on the environment could be subsidised. Supportive funds for circular design and subsidy policies for bio-based fuels and inputs are examples of regulatory tools that incentivise positive

<sup>12</sup> Groothuis (2014), New era. New plan. Fiscal reforms for an inclusive, circular economy. Case study the Netherlands.

<sup>13</sup> Whether the EU ETS sets the price of CO<sub>2</sub> at an adequate level is a subject of debate, but in principle, this scheme would have the potential to significantly reduce CO<sub>2</sub> emissions by European companies.

<sup>14</sup> OECD (2001), Extended Producer Responsibility - A Guidance Manual for Governments.

**Figure 9** The pillars for governments to build a framework for the circular economy



Source: PwC

externalities – and that have the potential to change business practices.

Governments can also protect the environment through regulation that restricts certain activities. For example, many countries have adopted laws that ban the dumping of waste in landfills. The new EU Directive on Single-Use Plastics is a recent example of regulation that will target, and in some cases ban, the ten single-use plastic products most often found on Europe's beaches and in its seas. Similarly, governments in Kenya and Rwanda – to name just two countries – have placed bans on plastic bags.

In summary, by incentivising the types of economic activity that help nature's ecosystems rather than deplete them, national and supra-national legislation has the power to protect the environment and accelerate the transition to a circular economy. Government leadership will be needed in order

to push change initially, but peer pressure will increasingly provide an incentive for citizens and companies – circular models will become the 'new normal'.

### Creating markets for second-hand products and materials

For a circular economy model to work, markets for second-hand products and materials must exist. A challenge today is that not all second-hand materials are price competitive. The price of virgin input materials may be too low and the markets for recycled materials may be too small.

Fragmented collection and recovery methods, coupled with volatile raw material input prices, hamper the creation of second-hand markets. One example is plastics<sup>15</sup>, where current global recycling rates are 14-18 percent. In the current environment of low oil prices, many of the plastic items we use every day can be made far cheaper from petroleum, than from recovered plastics.

Materials that have successfully managed to break the vicious cycle of low demand and low supply have typically done so once volumes reached a high enough level to create economies of scale. In Europe over 70 percent of glass<sup>16</sup> and paper<sup>17</sup> is recycled and around half of the demand for copper is met by recycled material.<sup>18</sup>

We expect market forces to drive similar developments in particular for electronics, electrical devices and fashion/textiles, in the near future. In fact, the second-hand clothing market has been growing 21 times faster than retail clothing market over the past three years<sup>19</sup> and is expected to be larger than fast fashion by 2028.

While market creation is often thought of as needing systems-level change, entrepreneurs can help by changing their sourcing and design practices and looking for ways of turning waste streams into new input materials.

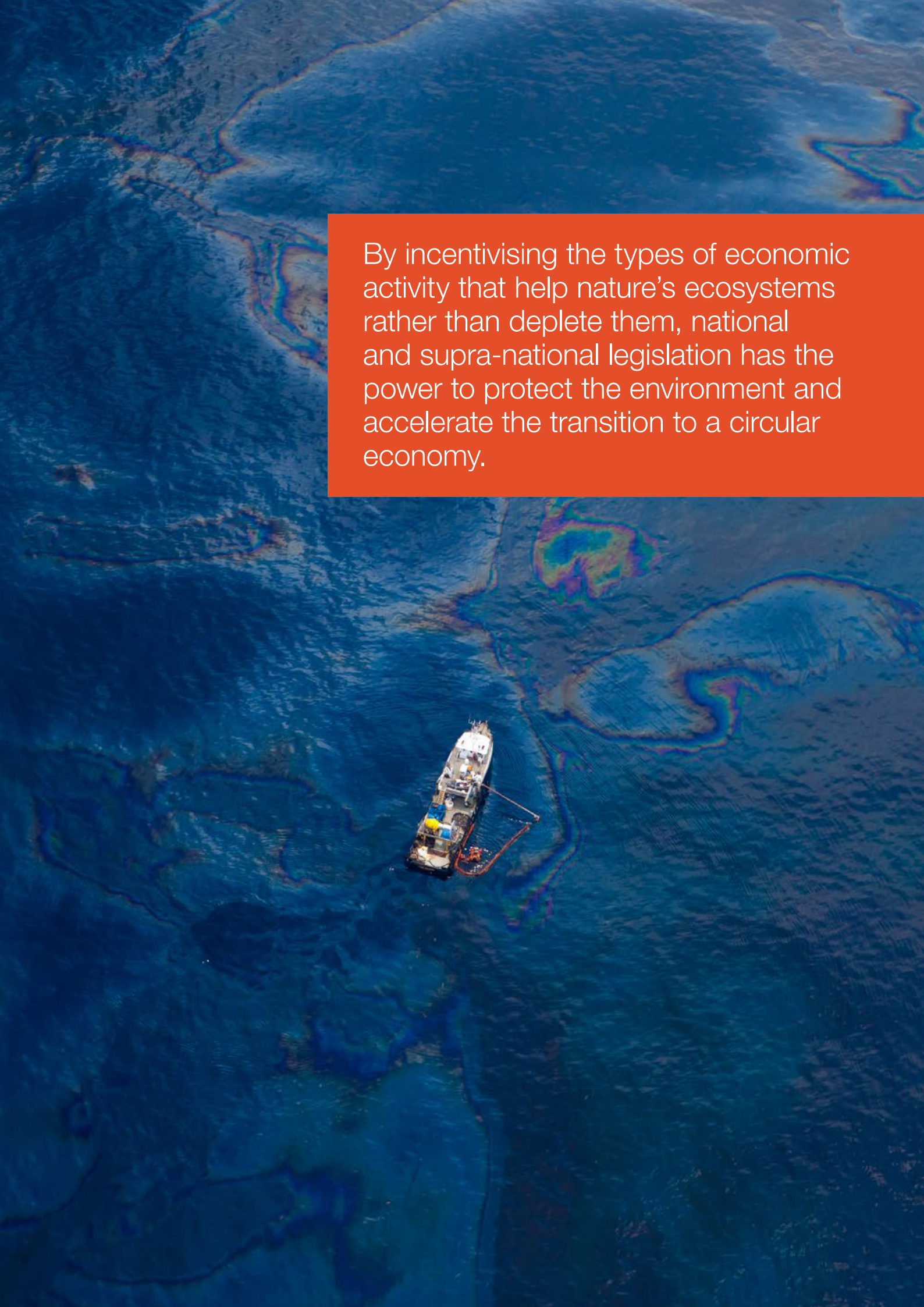
<sup>15</sup> OECD (2018), Improving Plastics Management: Trends, policy responses, and the role of international co-operation and trade: OECD Environment Policy Paper no. 12, accessed on 04/06/2019: <https://www.oecd.org/environment/waste/policy-highlights-improving-plastics-management.pdf>

<sup>16</sup> The European Container Glass Federation (2015), Press release: Glass recycling hits 73% in the EU: <https://feve.org/wp-content/uploads/2016/04/Press-Release-EU.pdf>

<sup>17</sup> Confederation of European Paper Industries (2018), Key Statistics 2017

<sup>18</sup> European Copper Institute (2018), Copper Trends and the Circular Economy, accessed on 04/06/2019: <https://copperalliance.eu/copper-trends-circular-economy/>

<sup>19</sup> The Fashion Network (2019), Secondhand apparel market to overtake fast fashion in next 10 years, accessed on 04/07/2019: <https://uk.fashionnetwork.com/news/Secondhand-apparel-market-to-overtake-fast-fashion-in-next-10-years,1081132.html#.XSXfvuiTI2w>

An aerial photograph showing a large-scale oil spill cleanup operation. A white ship with blue and yellow markings is positioned in the center, pulling a long orange skimmer boom that stretches across the water. The water is dark blue with large, irregular patches of oil slicks that exhibit iridescent colors like purple, green, and yellow. The text is overlaid on a solid orange rectangular background in the upper right quadrant.

By incentivising the types of economic activity that help nature's ecosystems rather than deplete them, national and supra-national legislation has the power to protect the environment and accelerate the transition to a circular economy.

# Many successes, but still just the beginning

## Why we still need circularity

Taxes, levies and subsidies, coupled with regulations limiting or banning certain activities or products are all effective regulatory solutions to the challenges we have identified, but there are still challenges ahead. Broadly speaking, there are three categories of solutions for protecting the environment:

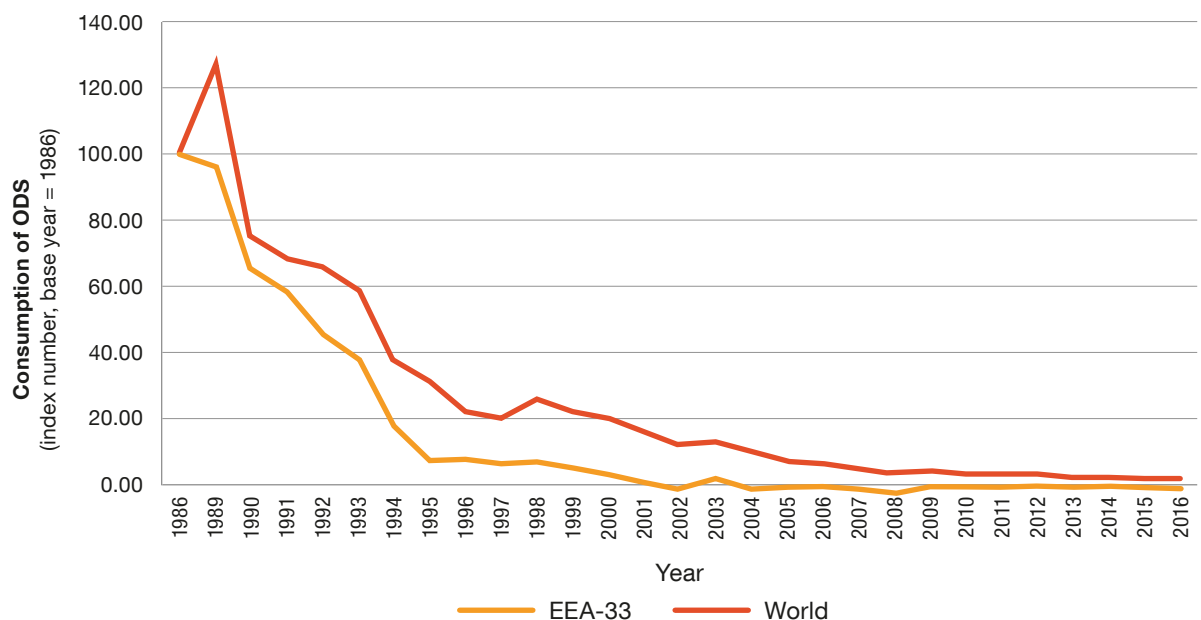
- (1) **stopping** certain activities, or the use of certain products, and finding substitutes or new technological solutions;
- (2) where technological solutions or substitutes do not exist, or are not sufficient, **efficiency improvements** should lead to decoupling of resource use and economic growth; and
- (3) where neither stopping certain activities or generating efficiency improvements is enough, processes would need to **go fully circular** by closing all loops and eliminating all negative externalities in order to avoid an ecological collapse.

To some extent the world has already stepped up its game in terms of protecting the environment by banning certain activities or decoupling them from economic growth. Over the past few decades, multiple initiatives at national and international levels have managed to significantly reduce, and in some cases eliminate, certain forms of pollution.

In the 1980's, the discovery of the damaging effects that chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halocarbon gases and other related chemicals have on the ozone layer led to the Montreal Protocol which phased out ozone depleting substances (ODS) and replaced them with non-damaging alternatives. By 2002 CFCs were fully eliminated in Europe and is now almost completely eliminated worldwide (see Figure 10).

Likewise, emissions of both sulphur dioxides (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>) which both cause acid rain have decreased substantially in line with global commitments to various international agreements on this topic.<sup>20</sup>

**Figure 10** The Montreal Protocol has near eliminated the consumption of ozone depleting substances (ODS) since 1986



Source: European Environment Agency

<sup>20</sup> Some main examples are the UNECE Convention on Long Range Transboundary Air Pollution and European Union sulphur and nitrogen protocols.

This shows that bans on, or international agreements to limit, certain substances have worked. Companies have shifted their production to use alternatives to CFCs. For SO<sub>2</sub> and NO<sub>x</sub> emissions, improved energy efficiency in energy intensive industries, coupled with cleaner energy production technologies, as well as cleaner cars in the transportation sector have had a significant effect.

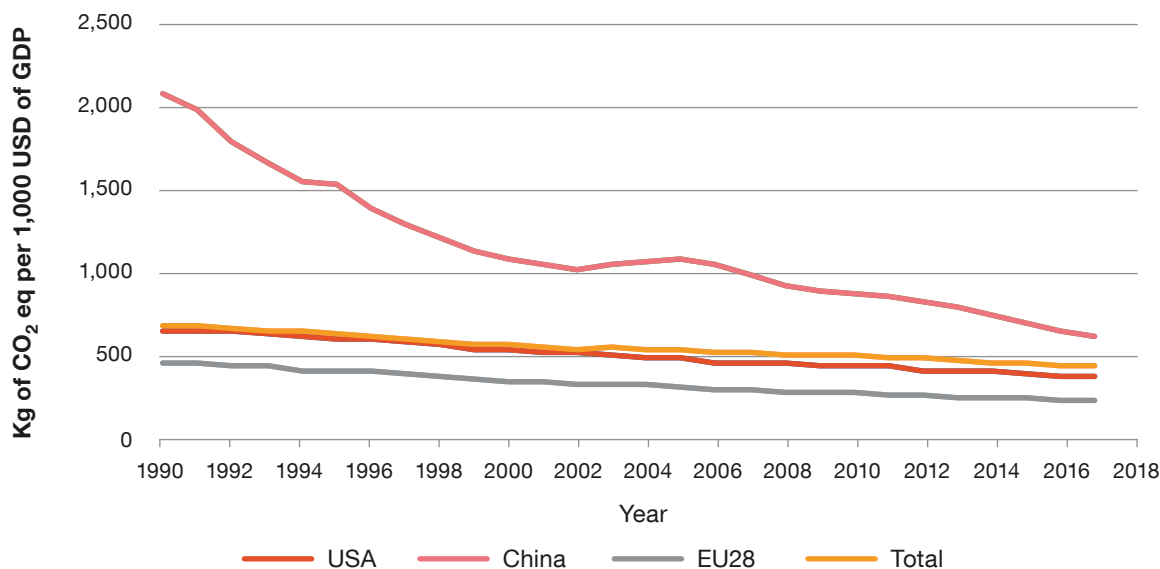
As production techniques have become more efficient, greenhouse gas (GHG) emissions per dollar GDP have declined (see Figure 11). The falling cost of renewable inputs is another significant factor in this development and one which is expected to continue this downward trend. Electricity from renewables is expected to become consistently cheaper than that generated from fossil fuels by 2020. All the renewable power generation technologies that are now in commercial use are expected to fall within the same cost range as fossil-based technologies, with most of them at the lower end or undercutting fossil fuels.<sup>21</sup>

However, these developments should be no reason for complacency. It is important to remember that the reduction of greenhouse gases per dollar GDP is a relative measure and that absolute CO<sub>2</sub> emissions (taken as a proxy for greenhouse gas emissions<sup>22</sup>) are still on the rise globally (see Figure 12), as is plastic waste generation (see Figure 6, page 13) and many other environmentally harmful activities.

The successes of the past few decades should provide a starting point, and motivation, for further progress, and not act as an excuse for not doing more. The ‘pollution curve’ may have been bent back, as more countries worldwide enter the post-industrial era, but we have a long way to go before reaching a truly regenerative zero-pollution society.

Because of the fully regenerative characteristics of a circular model, circularity provides the ultimate response to developing sustainable business practices. In a system where loops are closed, waste and pollution are designed out of the system, and negative externalities are eliminated.

**Figure 11** GHG emissions (measured as CO<sub>2</sub> equivalent) per dollar GDP has decreased over the past decades



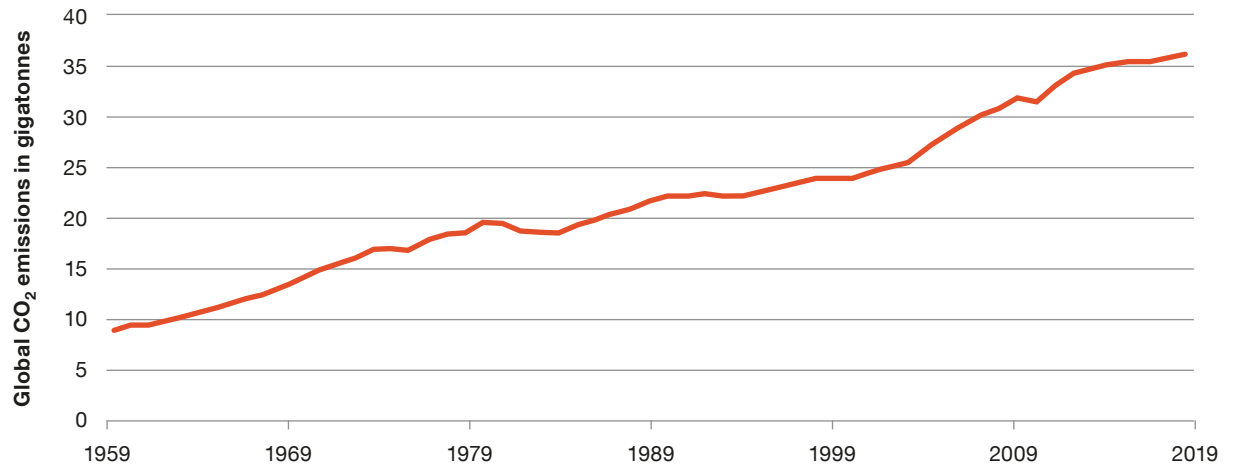
Source: PBL Netherlands Environmental Assessment Agency

Note: GDP is measured on a purchasing power parity (PPP) basis (PPP = 2011 prices)

<sup>21</sup> IRENA (2017), Renewable Power Generation Costs in 2017.

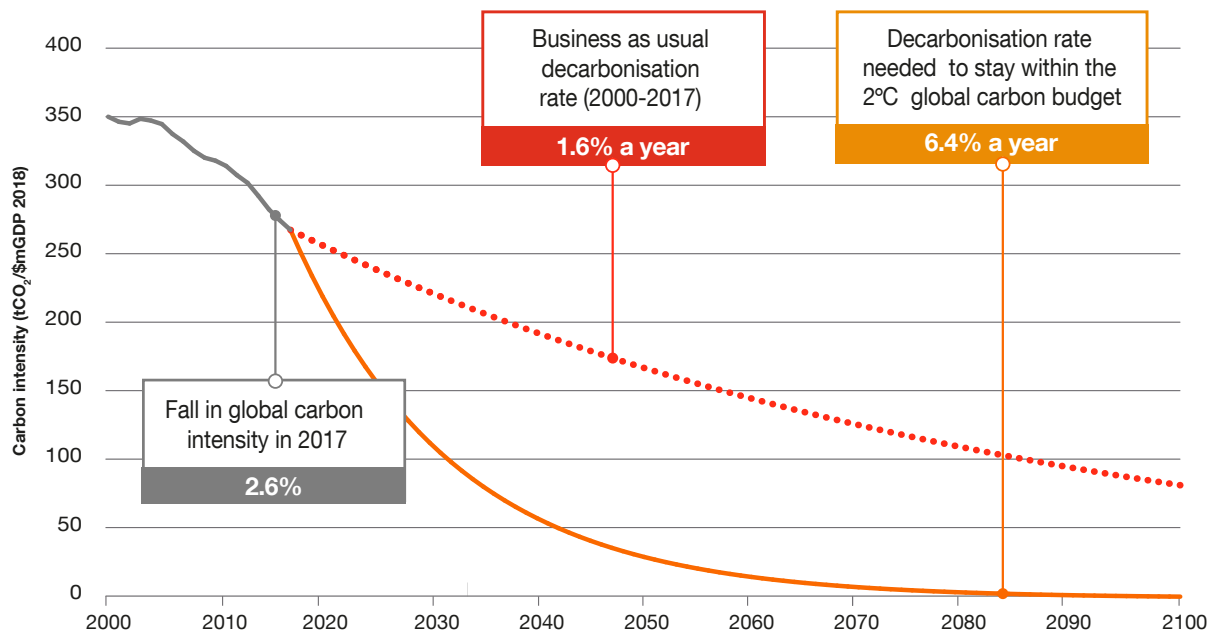
<sup>22</sup> CO<sub>2</sub> is used as a proxy for GHG emissions due to the lack of historical data for the latter. CO<sub>2</sub> make up the bulk of GHG emissions.

**Figure 12** Global CO<sub>2</sub> emissions are still increasing



Source: The Global Carbon Project

**Figure 13** The decarbonisation rate will need to accelerate if we are to meet our 2°C target (transition pathways from PwC's Low Carbon Economy Index 2018)



Sources: BP, Energy Information Agency, World Bank, IMF, UNFCCC, National Government Agencies, PwC data and analysis.  
Note: GDP is measured on a purchasing power parity (PPP) basis.



In a circular economy prices reflect real costs, including the costs of negative externalities in a fully transparent system. Companies get the adequate price signals to be able to make production choices that will not produce the negative side-effects of depleting natural resources or escalating climate change.

A circular economy is therefore more than just a move towards waste reduction and increased recycling. It is a paradigm shift – a new way of thinking about economic activity - that is needed to completely reshape our current economic model at a global level.

#### **Circular Economy as a strategy to mitigate climate change**

The latest United Nations Environment Programme (UNEP) emissions gap assessment shows that the original level of ambition of climate mitigation globally would need to be roughly tripled in order to achieve the 2°C scenario, and increased around fivefold to achieve the 1.5°C scenario.<sup>23</sup> The Nationally Determined Contributions agreed in the 2015 Paris Agreement are simply not sufficient. Given that over 50 percent of greenhouse gas emissions are related to extracting and processing materials, fuel and food,<sup>24</sup> going circular can also become a way of filling the gap.

---

<sup>23</sup> UNEP (2018), Emissions Gap Report 2018: <https://www.unenvironment.org/resources/emissions-gap-report-2018> accessed on 04/06/2019.

<sup>24</sup> UNEP (2019), Global Resources Outlook 2019: [https://wedocs.unep.org/bitstream/handle/20.500.11822/27518/GRO\\_2019\\_SPM\\_EN.pdf?sequence=1&isAllowed=y](https://wedocs.unep.org/bitstream/handle/20.500.11822/27518/GRO_2019_SPM_EN.pdf?sequence=1&isAllowed=y) accessed on 20/06/2019.



## Part 2

# The business perspective

# Why? Reasons for companies to go circular

## The benefits of becoming circular

There are many reasons why companies choose to incorporate circularity into their business models. As the concept matures, the benefits of circular models are becoming increasingly evident. Nonetheless, it is important that discussions of the benefits of a circular economy include details about the value creation for companies that position themselves as circular pioneers. It will only be possible to make meaningful progress towards a circular economy if companies are motivated to transform their business models.

## Increase resilience against external shocks

The first part of this report highlighted two main problems caused by the linear production model: **accelerating environmental degradation** and **resource scarcity**. These have far-reaching implications for companies' supply chain activities.

Resource scarcity means fluctuations in raw material prices, as well as uncertainty in the availability and flow of raw materials, which can lead to even higher prices. Maintaining a linear production model would lead to obvious challenges for companies because they rely on a steady flow of input materials – and on stable prices for those materials.

For this reason, volatility in resource costs is one of the drivers for the shift towards a circular economy. This volatility introduces risks and reduces the quality and certainty of supply, which would both impact the bottom line. Circular value streams offer an alternative.

Resource scarcity is one reason why Danone, for example, prefers bio-based rather than fossil-based plastics for its dairy product packaging.<sup>25</sup> Supply risk factors also play an important role in Apple's ambition to end its reliance on mined resources by only using recycled materials such as aluminium, copper, tin and tungsten in its devices.<sup>26</sup> These examples show how adopting a circular approach makes a company's supply chain more resilient while also cutting costs.

**Climate change** is another side-effect caused by the linear model. It presents several risks to the availability of raw materials and energy. While nature has always disrupted business, companies will face more floods, wildfires and storms in the future than they have in the past – and these events are also expected to be more intense. There is reason for concern because climate risks could reduce a company's value by an average of 2-3 percent, with some sectors such as utilities or oil and gas standing to lose 4-4.5 percent on average.<sup>27</sup>

By going circular companies can do their bit to limit global warming and mitigate climate change and increase their own resilience.

## Make your brand more attractive

Industrial and consumer markets are increasingly rewarding those companies with business models that support **sustainability** – and punishing those that do not. Consumers are seeking more sustainable brands, with green considerations playing a stronger role in decision-making.

According to PwC's recent Global Consumer Insights Survey, 29 percent of respondents said they buy brands that promote sustainable practices. In particular millennials are making purchasing decisions based on sustainable and environmentally packaged brands and products.<sup>28</sup> Brands with a high sense of purpose have experienced a more than double brand valuation increase over the past decade, compared to the median growth rate.<sup>29</sup>

This trend is confirmed by the rising number of eco-friendly or sustainable-minded start-up companies that achieve successful maturity. Tony's Chocolonely, a company that was set up in 2007 as a niche provider of 'slave-free' chocolate, is now the number one seller of chocolate in the Netherlands in terms of revenue.<sup>30</sup>

---

<sup>25</sup> Danone (2016), Packaging Policy, Co-build the circular economy of packaging by sourcing sustainable materials and creating a second life for all plastics.

<sup>26</sup> Apple (2019), Material Impact Profiles, Which materials to prioritize for a 100 percent recycled and renewable supply chain.

<sup>27</sup> Schroeder (2018), How will physical risks of climate change affect companies?: <https://www.schroders.com/en/insights/economics/how-will-physical-risks-of-climate-change-affect-companies/>

<sup>28</sup> PwC (2019), Global Consumer Insights Survey 2019: It's time for a consumer-centred metric: introducing 'return on experience'.

<sup>29</sup> Kantar Consulting (2018), Purpose 2020: Inspiring Purpose-Led Growth.

<sup>30</sup> Tony's Chocolonely (2018), Annual Report 2017/ 2018.



Similarly, Alpro's range of plant-based drinks, yoghurts, cream alternatives and desserts now has the largest growth in market share in the 'dairy' category in Europe.<sup>31</sup> And, of course, Unilever's acquisition of Ben & Jerry's in 2000 is a well-known example of a sustainable start-up being acquired by larger company after reaching maturity.<sup>32</sup>

While some companies may only communicate about sustainability to avoid reputational damage (known as 'greenwashing'), rising expectations for **transparency** are forcing companies to live up to their words. Increased media focus on negative environmental or social impacts is leading to new levels of consumer awareness, protests and boycotts, as well as government pressure on some companies.

For example, a TV report in France in early 2019 showing Amazon employees destroying unsold or returned items that were in perfect condition,

prompted action from the French government as well as a mass boycott by consumers.

For companies operating in industrial markets, the pressure to ensure environmentally and socially responsible practices is generated through increasingly integrated **supply chains**. In the modern world, many companies find that their business model is so interconnected with those of other companies that they are unable to act independently.

For this reason, companies pass their expectations and ambitions for sustainability on to their suppliers, who pass it to their suppliers and so on. This process is making sustainability an increasingly important focus of business-to-business interactions. A strong focus on sustainability can enable companies in the business-to-business segment to reach a broader range of potential customers.

---

<sup>31</sup> De Tijd (2019), Groeimelk, article on 20 February 2019: <https://www.tijd.be/dossier/rekenmeester/groeimelk/10099633.html>, accessed on 01/07/2019.

<sup>32</sup> Unilever, Onze merken: <https://www.unilever.nl/merken/food-and-drink/ben-en-jerrys.html>, accessed on 01/07/2019.

## Preempt regulatory pressures down the line

**Resource scarcity** and **accelerating environmental degradation** has prompted authorities to impose tighter environmental standards on producers and consumers to reduce resource consumption. National and international developments show that governments have effectively defined a clean and livable environment as a public good and are prepared to regulate to protect it (see page 17).

Embracing circular principles can enable companies to avoid being caught off-guard by new regulatory measures – and empower them to capitalise on opportunities.









## Become more digitally enabled

The introduction to this study mentioned how the first industrial revolution introduced the notion of waste. Currently we are witnessing the fourth industrial revolution where technologies will flourish and create new business and business models thanks to digitalisation. This development has the potential to eliminate waste altogether and is playing a game-changing role in enabling a circular economy. Digitalisation is the catalyst through which technological breakthroughs will push our **productivity** to new levels, **increase welfare** and make us **more sustainable**.

PwC has identified eight essential technologies that will have the biggest impact on businesses across industries over the next three to five years (see Figure 14).<sup>33</sup> There are several points of contact where these technologies can help businesses transition to a circular economy. Each technology can help one or more of the circular strategies presented in the introduction to this report (see Figure 15, page 30).

Figure 14 Overview of PwC's essential eight technologies








Source: PwC

 <b>Artificial Intelligence (AI)</b> <p><b>Technology:</b> software algorithms that are automating complex decision-making tasks to mimic human thought processes and senses</p> <p><b>Benefits:</b> able to learn, understand, reason, plan and act when fed with data</p>	 <b>Internet of Things (IoT)</b> <p><b>Technology:</b> ecosystem of sensors, embedded computers, and “smart” devices</p> <p><b>Benefits:</b> able to communicate among themselves and with private/public cloud services in order to collect, analyse and present data about the physical world</p>	 <b>Additive Manufacturing/3-D Printing</b> <p><b>Technology:</b> creating three-dimensional objects based on digital models by “printing” successive layers of material</p> <p><b>Benefits:</b> various materials can be used, e.g. wood, glass, living cell for bio-printing; minimise waste</p>	 <b>Robotics</b> <p><b>Technology:</b> machines with enhanced sensing, control and intelligence used to automate, augment or assist human activities</p> <p><b>Benefits:</b> increase efficiency and productivity</p>
 <b>Blockchain</b> <p><b>Technology:</b> digital ledger that uses software algorithms to record and confirm transactions with reliability and anonymity</p> <p><b>Benefits:</b> increase traceability, transparency, efficiency, enhance security</p>	 <b>Drones</b> <p><b>Technology:</b> unmanned aerial vehicles</p> <p><b>Benefits:</b> extremely versatile due to great variation in their capacity, size, abilities and functions</p>	 <b>Virtual Reality (VR)</b> <p><b>Technology:</b> implies a complete immersion experience, which is 100% computer-generated</p> <p><b>Benefits:</b> innovations can be presented without actually producing them</p>	 <b>Augmented Reality (AR)</b> <p><b>Technology:</b> offers a real world experience with computer-generated overlays</p> <p><b>Benefits:</b> mixture of real and computer world</p>

<sup>33</sup> PwC (2019), The Essential Eight: your guide to the emerging technologies revolutionising business now: <https://www.pwc.com/gx/en/issues/technology/essential-eight-technologies.html>

**Figure 15** The Essential Eight Technologies can help implement the ten circular strategies

Source: PwC analysis

CE initiatives										
Prioritise renewable inputs	①	Circular sourcing	✓				✓			
	②	Sustainable design	✓		✓				✓	
	③	Resource efficiency	✓		✓	✓	✓	✓		
Maximise product use	④	Product as a service		✓						
	⑤	Sharing/virtualising		✓					✓	✓
	⑥	Usage optimisation/maintenance		✓	✓			✓	✓	✓
	⑦	Reuse/redistribution	✓							
Recover by-products and waste	⑧	Refurbishing/remanufacture	✓	✓	✓	✓	✓			
	⑨	Industrial symbiosis								
	⑩	Recycling from manufacturing					✓			
		Recycling from consumption	✓	✓		✓	✓			



1) **Artificial Intelligence (AI)** will be the pervasive technology of the fourth industrial revolution and has perhaps the biggest potential to support a circular economy. Firstly, AI can increase productivity, which is an essential part of a circular economy. AI can also help make systems more efficient by optimising the use of resources like energy or water.

AI speeds up the process of learning and understanding, which enables faster scientific discovery. This can be applied to finding new solutions in areas such as climate change mitigation, or developing technologies that support the transition to a circular economy.

At the end of the product life cycle, the interplay between AI and robotics can get products or components ready to be reused. For example, Apple's robot Daisy takes old iPhones apart and separates their components to extract valuable materials. Over 99 percent of the cobalt from the batteries can be reused to produce new batteries.



2) In industry, the **Internet of Things (IoT)** allows manufacturers to control and analyse performance, and to collect data in order to increase productivity. It also supports remanufacturing and enables parts to be harvested.

IoT can also provide the foundation for sharing platforms or product-as-a-service models. Renault, for example, sells its electric cars without batteries. Instead, buyers lease the battery and pay a monthly fee based on their consumption. Sensors send information about the status of the battery to the manufacturer. When the battery can no longer be used in the car, it is used to store renewable energy instead of being discarded as waste.



3) **Additive manufacturing / 3D printing** can help improve both the (sustainable) design and the longevity of a product, while also minimising the amount of resources needed.

Feetz, for example, is a company that offers customised 3D-printed shoes that are produced without water – and that are made from recycled material that is also recyclable. When a customer no longer wants to wear the shoes, they send them back to Feetz. The material is then recycled to create a new pair of 3D-printed shoes.

The use of 3D printing for spare parts improves the ability to repair a product and extends the life cycle. It also affects product design because the future maintenance of 3D-printed parts can be built into the design process.



4) Advances in **robotics** allow manufacturers to employ robots in an increasing number of applications, thereby eliminating human error that can lead to waste. By applying robotics to the production process, companies can increase yield and reduce waste, as well as extending a product's life by increasing quality.



5) **Blockchain** can help overcome market failures related to information asymmetry. While transparency over a product and its materials is key to enabling products to be recycled, stakeholders in the value chain may hold back information to guard their competitive advantage.

To overcome this obstacle, the start-up Circularise has developed a blockchain-based platform that enables all stakeholders (product manufacturers, end users and recyclers) to communicate about products without sharing sensitive information. Through 'smart questioning', stakeholders can ask questions about products and materials, and receive reliable answers.

The blockchain technology gives all stakeholders in the value chain the required transparency over materials, and enhances the sorting and recycling process.



6) Using **drones** to deliver small packages could cut carbon emissions compared to regular truck deliveries – depending on the size of the drone and the source of the electricity that powers it. Drones can also support precision-farming and predictive maintenance of infrastructure.



7- 8) Both **augmented reality (AR)** and **virtual reality (VR)** can help repair processes that in turn enables products to be used for longer. In the case of AR, non-technical staff can be guided remotely by colleagues with technical expertise to be able to repair and/or replace spare parts of vehicles or machinery in places that are hard to access.

Additionally, the virtual experience provided by both AR and VR can enable a deeper understanding of problems or circumstances which are otherwise hard to grasp. This in turn can unlock the empathy needed to drive a change in behaviour.<sup>34</sup>

New technologies are constantly emerging and reaching maturity. Over the next few years, these technologies will enable businesses to move closer to adopting a circular approach.

<sup>34</sup> PwC (2019), SDG Dome brings Sustainable Development Goals closer to home: <https://www.pwc.nl/en/insights-and-publications/themes/sustainability/sdg-dome-brings-sustainable-development-goals-closer-to-home.html>, accessed on 03/07/2019.



The successes of the past decades should provide a starting point, and motivation, for further progress, and not as an excuse to not do more. The ‘pollution curve’ may have been bent back, as more countries worldwide enter the post-industrial era, but we have a long way to go to reach a truly regenerative, zero pollution, society.

# What? Circular principles and strategies

## The ten circular strategies in practise

The matrix below provides the definition of each of the ten circular strategies described in the introduction to this report (see *Figure 2, page 8*).

PwC has identified a number of cases that illustrate these principles and their corresponding strategies, with one company often applying more than one strategy to its operations.

**Figure 16** Definitions of circular strategies

Source: PwC

CE initiatives			Definitions
Prioritise renewable inputs	①	Circular sourcing	Replace finite resources / materials with renewable, bio-based, or recycled materials in the production process
	②	Sustainable design	Design products - and select raw materials - such that they can be effectively disassembled, reused, repaired and up-cycled
	③	Resource efficiency	Optimise usage of raw materials / resources – minimise waste – in the production process
Maximise product use	④	Product as a service	Provide a service in areas that were traditionally sold as products; increases the product lifecycle through repurposing at the end of usage
	⑤	Sharing/ virtualising	Share durable assets such as cars, rooms, appliances, and digitise products to increase their lifetime (e.g., books, music, shopping, autonomous vehicles etc.)
	⑥	Usage optimisation/ maintenance	Increase performance / efficiency of a product and prolong life through maintenance
	⑦	Reuse/ redistribution	Purchase and sell second-hand and previously owned products to increase product lifecycle
Recover by-products and waste	⑧	Refurbishing/ remanufacture	Remanufacture products or components for a new usage, instead of down-recycling
	⑨	Industrial symbiosis Recycling from manufacturing	Waste or by-products from manufacturing become the inputs for another product
	⑩	Recycling from consumption	Recycle discarded materials after the end of consumption



## Bio-lutions

### Strategy 1 and 2

#### Packaging and tableware made from agricultural residues

Bio-lutions has developed a patented mechanical process for creating disposable tableware and packaging from agricultural residues. The residues are turned into self-binding fibres that do not require any additives or chemicals. They are then moulded and pressed to create the tableware and packaging. The products can be returned to the natural cycle through composting or be recycled after use.

In order to re-engineer the mechanical process of fibre production to include by-products that occur when crops are harvested, Bio-lutions partnered with Zelfo, a company that focuses on engineering lignocellulosic natural fibres.

Bio-lutions also partners with VIKASANA, an NGO that gathers the raw materials from smallholder farmers.

Bio-lutions has raised €8.3 million from investors like Delivery Hero and the DEG (Deutsche Investitions- und Entwicklungsgesellschaft) in 2019.<sup>35</sup>

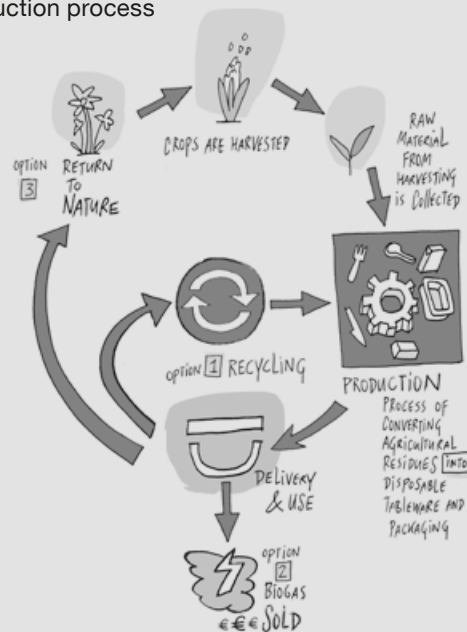
#### Success factors

- R&D partnerships: Developing the process was made possible by sharing expertise and resources.
- Cost efficiency: Bio-lutions keeps its technology as compact as possible and eliminates transport routes by sourcing raw materials locally.

#### Business Benefits

- Price competitive input material from agricultural residues.
- Abundant supply ensures a secure supply chain.
- Patented process gives competitive advantage.

Figure 17: Bio-lutions circular production process



Source: Bio-lutions

Illustrations on pages 34-43: Norbert Vermeer/ De Congres Tekenaar.

<sup>35</sup> Bio-lutions (2019), About us: <https://www.bio-lutions.com/about-us/>, accessed on 27/06/2019.



## Adidas Futurecraft.loop

### Strategy 1, 2 and 10

#### Using 100 percent recyclable material

Adidas' Futurecraft.loop project has developed a 100 percent recyclable performance running shoe. It is specifically designed with recycling in mind as it is made from one single material and no glue is used. When the shoes are disposed of, the material is cleaned and made into pellets before being melted down to form a material that can be used to make a new pair of shoes. This stands in stark contrast to traditional shoe designs that involve complex mixtures of materials and adhesives.

Adidas worked together with recycling specialists and material developers to create the shoe. The first generation of Futurecraft.loop shoes is being rolled out as a pilot.

A wider release is planned for the first half of 2021. The Futurecraft.loop shoe is a first step in a wider strategy which aims to use only recycled polyester in all products by 2024.

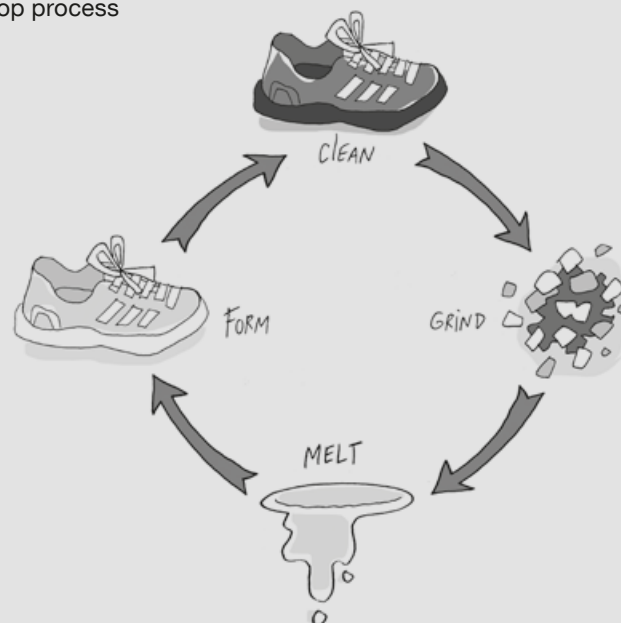
#### Success factors

- Research and testing: Adidas overcame technical challenges through cross-industry collaboration with recycling experts.
- Step-by-step approach: Piloting and testing before a broader roll-out.

#### Business Benefits

- Adidas has positioned itself as a purpose-driven company attracting customer groups that can help generate new revenue streams.
- The Futurecraft.loop joins a line of other Adidas Futurecraft products, including a shoe made from plastic ocean waste, further helping the brand positioning.<sup>36</sup>

Figure 18: Futurecraft.loop process



Source: Adidas

<sup>36</sup> Forbes (2018), The Power Of Purpose: How Adidas Will Make \$1 Billion Helping Solve The Problem Of Ocean Plastic: <https://www.forbes.com/sites/afdelaziz/2018/10/29/the-power-of-purpose-how-adidas-will-make-1-billion-helping-solve-the-problem-of-ocean-plastic/#57e00acfd215>, accessed on 27/06/2019.



## General Electric

### Strategy 2 and 3

#### Using 3D printing for resource efficiency

General Electric (GE) is one of the pioneers in additive manufacturing. Printing layer-by-layer uses less input material and gives the possibility to print only the required parts.

GE has a set of high-end machinery and also offers 3D printing services to meet other companies' needs, including companies in the aerospace, automotive, medical and dental industries.

GE expects the additive manufacturing industry to grow from \$7 billion today to \$80 billion in a decade,<sup>37</sup> driven by manufacturers' demand for increased efficiency.

For example, Boeing expects to save between \$2 million and \$3 million per airplane by using 3D printing to produce parts for its 787s.<sup>38</sup>

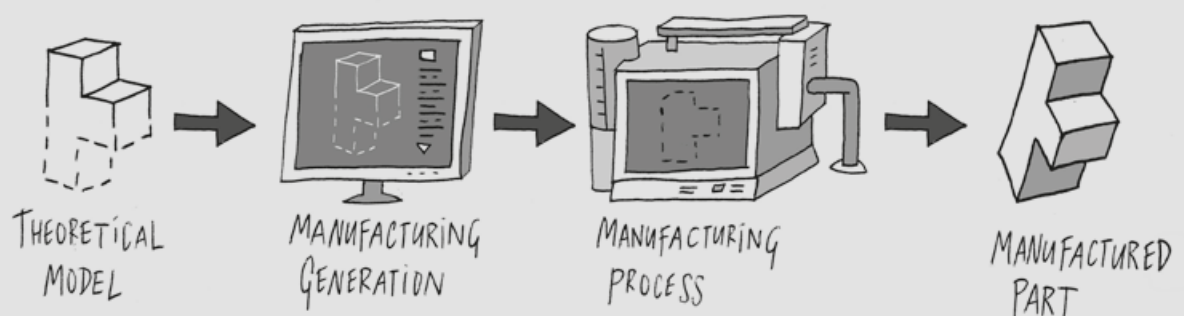
#### Success factors

- First-mover advantage: GE gained a competitive advantage as a pioneer in the industry.
- Acquisitions: GE gained external competencies from acquisitions of start-ups such as Morris Technologies and Concept Laser.
- Investing in R&D: GE's has a large Additive Technology Center in Ohio with over 90 3D printers and 300 designers, machinists and engineers.<sup>39</sup>

#### Business Benefits

- Decreased own manufacturing costs as both material costs and energy is saved.
- Creating a new business by offering its solutions to other companies. GE is now one of the world's largest 3D service company.

Figure 19: GE's additive manufacturing model



Source: General Electric Additive Manufacturing Machines & Materials

<sup>37</sup> GE Reports (2018), The Blade Runners: This Factory Is 3D Printing Turbine Parts For The World's Largest Jet Engine: <https://www.ge.com/reports/future-manufacturing-take-look-inside-factory-3d-printing-jet-engine-parts/>, accessed on 27/06/2019.

<sup>38</sup> GE Additive (2019), Aviation and aerospace industry: <https://www.ge.com/additive/additive-manufacturing/industries/aviation-aerospace>, accessed on 27/06/2019.

<sup>39</sup> GE Reports (2018), The 3D-Printed Age: Why This Futuristic Ohio Factory Is Proving Mark Twain Wrong: <https://www.ge.com/reports/3d-printed-age-futuristic-ohio-factory-proving-mark-twain-wrong/>, accessed on 27/06/2019.



## Y:closet

### Strategy 4 and 6 Offering fashion, not clothes

Y:closet is a Chinese fashion sharing platform that allows users to rent clothes and accessories, including luxury brands, through various subscription plans. Clothes are selected online by the member, shipped and then worn before being returned and washed by Y:closet.

As rental firms make higher profits the more times they can rent out a garment, a shift to renting also means a shift to products that are better made and sustains being worn for longer.

Y: closet has more than 15 million registered users<sup>40</sup> as it has responded to changes in consumer behaviour in China where customers want the latest styles, and increasingly do not want to be seen wearing the same outfit twice. Investors are increasingly aware of this and for example Alibaba has invested in Y:closet.

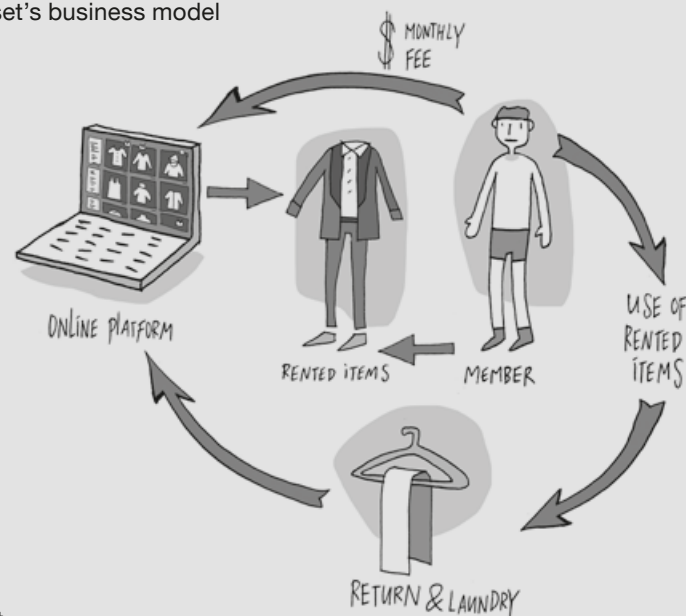
#### Success factors

- Strategic partnerships: Collaboration with luxury brands and industrial laundry services, as well as with two Alibaba e-commerce platforms.

#### Business Benefits

- Being a pioneer in sustainable fashion through a product-as-a-service business model.

Figure 20: Y:closet's business model



Source: Y:Closet

<sup>40</sup> China Daily (2018), Alibaba invests in clothes sharing platform Yclocet, <http://www.chinadaily.com.cn/a/201809/18/WS-5ba06197a31033b4f4656a27.html>, accessed on 23/07/2019



## BlaBlaCar

### Strategy 5

#### Travelling together and sharing costs

BlaBlaCar is one of the largest global online marketplace for carpooling. It combines a travel search engine with a social network: drivers who plan a car trip can offer available seats to other members of the online community as digitalisation provides easy connectivity between drivers and riders.

In recent years, BlaBlaCar has also established partnerships including an agreement with Axa to provide insurance options to its users, and with Opel to offer long-term rentals. It also offers an application for daily carpooling, called BlaBlaLines.

BlaBlaCar was launched in France in 2004 and now operates in more than 22 countries and has more than 70 million users.<sup>41</sup>

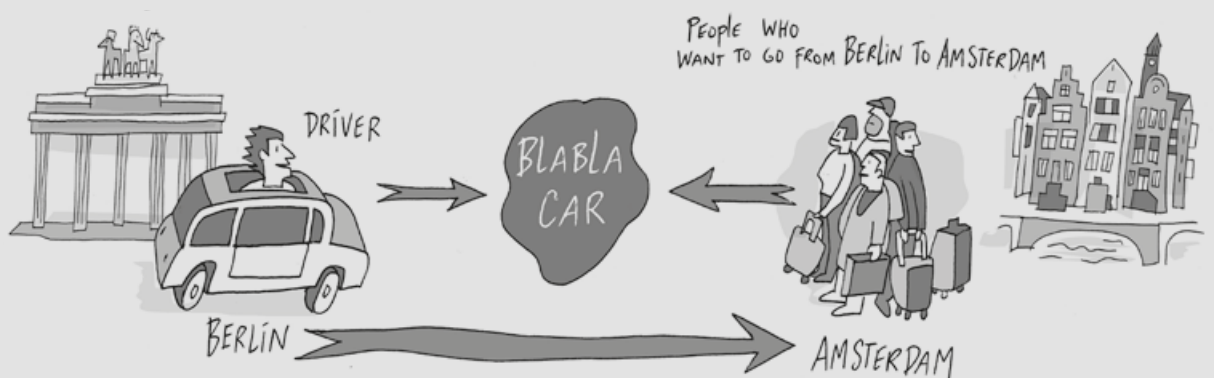
#### Success factors

- User experience: All users have a profile that connects suitable drivers and passengers based on their age, taste in music and other interests.

#### Business Benefits

- As the number of users is continuously growing, so does the revenue.

Figure 21: BlaBla car connects drivers and riders<sup>42</sup>



Source: BlaBlaCar

<sup>41</sup> World Economic Forum (2019), BlaBlaCar: <http://reports.weforum.org/digital-transformation/blablacar-2/>, accessed on 27/06/2019.

<sup>42</sup> BlaBlaCar (2019), Le BIPE Environmental Study 2019: <https://blog.blablacar.com/newsroom/news-list/zeroemptyseats>, accessed on 27/06/2019.



## INFRABEL

### Strategy 6

#### A new era in maintenance

Infrabel is a state-owned company responsible for Belgium's rail infrastructure. Infrabel has invested heavily in automated and predictive maintenance processes, and uses large-scale application of data analytics in maintenance. It is becoming increasingly data-driven in its decision-making. Optimising maintenance has provided cost savings of more than 50,000 hours/year from freeing up technicians' time.<sup>43</sup>

Infrabel has developed innovative monitoring tools, including measurement trains for inspecting tracks, railway ties and overhead lines, as well as sensors for detecting overheating, semi-automatic vehicles that check sign-post visibility, and metres that detect drifts in power consumption.

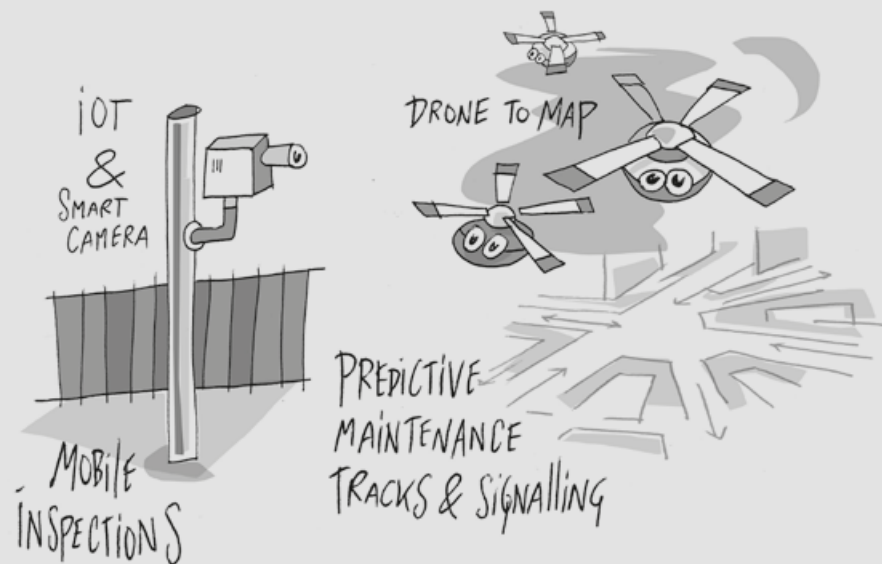
#### Success factors

- Digitalisation: Infrabel collects data to enable smart, efficient and targeted maintenance with lower costs.
- Big data: The use of big data and IT-applications creates a safer and more reliable rail network.

#### Business Benefits

- Data driven decision-making increases quality and decreases maintenance costs.

Figure 22: Infrabel's use of IoT for maintenance



Source: Infrabel

<sup>43</sup> Infrabel (2019), Predictive maintenance: <https://www.infrabel.be/en/digital-days/stand-06>, accessed on 27/06/2019.



## eBay Classifieds Group

### Strategy 7

#### Enabling accessible online trading

eBay Classifieds Group is a pioneer in peer-to-peer trading platforms. Between 2004 and 2008, eBay acquired several online trading platforms including dba (Denmark), 2dehands (Belgium), Marktplaats (the Netherlands) and Gumtree (the UK) and is one of the largest groupings of peer-to-peer marketplaces in the world.

eBay classifieds revenue has grown from \$180 million in 2014 to \$263 million in 2018.<sup>44</sup> Today, it is investing in AI and machine learning to enhance frictionless trade on its platforms.

#### Success factors

- First-mover advantage: Early acquisitions made eBay a pioneer in peer-to-peer trading platforms.
- New revenue streams: eBay invested in peer-to-peer trading to create new revenue streams.

#### Business Benefits

- eBay is a frontrunner in a growing market of second-hand trade.

Figure 23: eBay Classified Group's platforms connects buyers and sellers of second-hand items



Source: eBay Classified Group

<sup>44</sup> Statista (2019): eBay's classifieds revenue from 4th quarter 2014 to 1st quarter 2019: <https://www.statista.com/statistics/541159/ebays-quarterly-classifieds-revenue/>, accessed on 27/06/2019.



## Encory GmbH

### Strategy 8

#### Closing value chains and creating after-sale solutions

Encory GmbH is a joint venture from BMW and the recycling company Alba that offers logistics and consultancy solutions for processing and marketing used automotive parts. Encory handles the entire process from logistics through to reconditioning automotive parts or disposing of them if necessary.

Encory uses IT solutions to ensure transparent after-sales service and to optimise its logistics. This makes it possible to efficiently remanufacture products that are otherwise expensive or difficult to handle. Materials that were previously disposed of can be reused with no additional input materials required.

Encory also owns a returns platform that has 1,800 daily users, enabling around 260,000 daily transactions. There are currently 30 countries connected to Encory's reverse logistics solution, with more rollouts scheduled by 2020.<sup>45</sup>

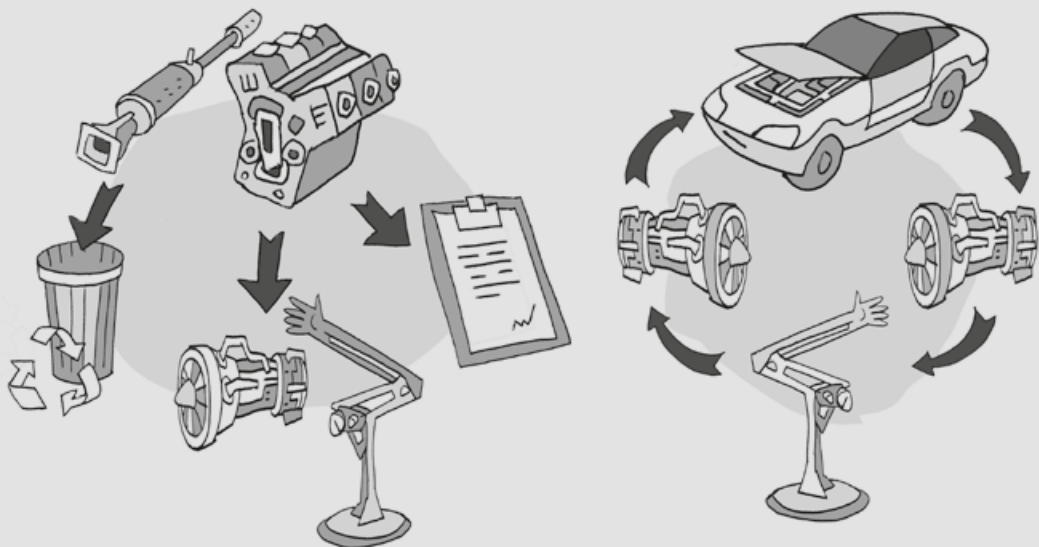
#### Success factors

- Knowledge-sharing: BMW and Alba each share their networks and expertise with Encory.
- Leveraging ICT: Encory uses IT-based solutions to enable a reverse supply chain.

#### Business Benefits

- Remanufacturing savings of 85 percent of raw material and 55 percent of energy costs.<sup>46</sup>
- The parts trade is based on BMW's quality standards.

Figure 24: Encory reconditions automotive parts



Source: Encory GmbH

<sup>45</sup> Encory (2019), Facts & Figures: <https://encory.com/#a-facts-and-figures>, accessed on 27/06/2019.

<sup>46</sup> BMW Group (2019); Circular Economy @BMW Group: <https://www.bmwgroup.com/en/responsibility/sustainable-stories/popup-folder/circular-economy.html>, accessed on 27/06/2019.



## Kalundborg Symbiosis

### Strategy 9

#### An industrial symbiosis that creates value for all participants

Kalundborg is a city in Denmark hosting the world's first centre for industrial symbiosis. Companies in this cluster swap waste and by-products to cut costs and CO<sub>2</sub> emissions. The project includes Denmark's largest oil refinery, run by Equinor, as well as the pharmaceutical company Novo Nordisk, the enzyme producer Novozymes, and Ørsted.

Cross-industry collaboration ensures that all participants benefit from the exchange of knowledge, materials, information and assets.

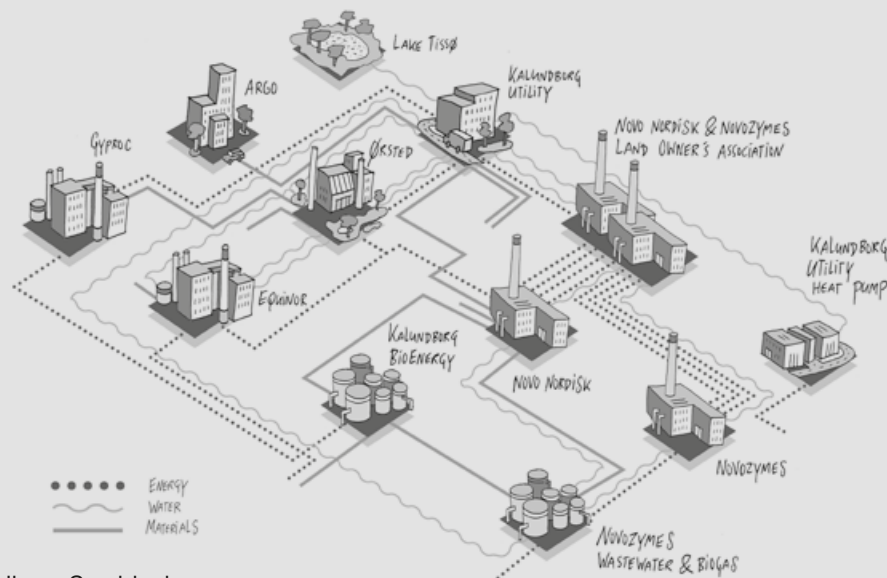
#### Success factors

- Open collaboration: Ensuring that all participants benefit from the project.

#### Business Benefits

- Estimated cost savings between \$72 million to \$87 million per year.<sup>44</sup>
- Emission cuts from the product exchanges is estimated at 270,000 tonnes CO<sub>2</sub> per year.<sup>45</sup>

Figure 25: Overview of Kalundborg industrial symbiosis project



Source: Kalundborg Symbiosis

<sup>44</sup> Reuters (2015), RPT-Small Danish town sees the big picture with profitable emissions cuts: <https://af.reuters.com/article/africaTech/idAFL8N14735R20151221>, accessed on 27/06/2019.

<sup>45</sup> Reuters (2015), RPT-Small Danish town sees the big picture with profitable emissions cuts: <https://af.reuters.com/article/africaTech/idAFL8N14735R20151221>, accessed on 27/06/2019.



## Werner & Mertz

### Strategy 1, 2 and 10

#### Circular packaging based on recycled material

Werner & Mertz is a manufacturer of washing, care and cleaning agents, and has positioned itself at the forefront of research and development in recycling within the retail and consumer sector. The company set up the Recyclat initiative together with project partners Der Grüne Punkt,<sup>46</sup> packaging manufacturer Alpha, sorting technology specialist Unisensor, Rewe Group and the German Nature And Biodiversity Conservation Union (NABU). The initiative has enabled 80 percent recycled materials, gathered from the standard household waste, to be used in the Frosch brand PET packaging.

Werner & Mertz now focuses on creating packaging that is fully recyclable and made from one single material in order to make it more suitable for sorting

and processing and has announced plans to build a new production site together with Alpha.<sup>47</sup>

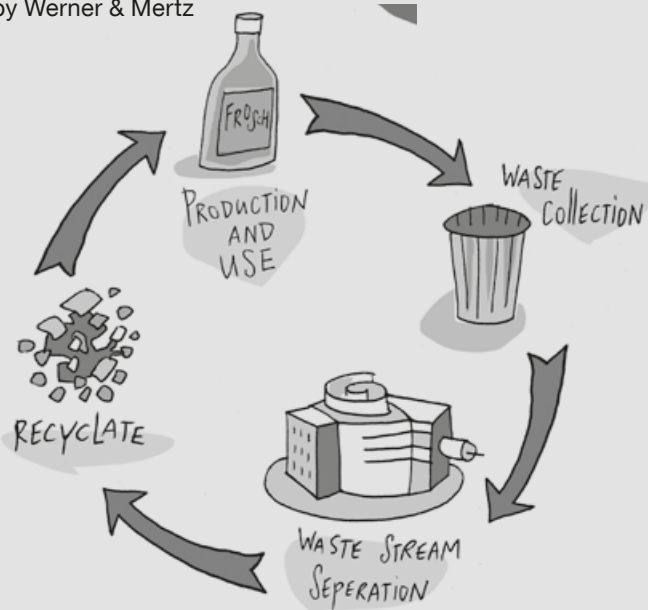
#### Success factors

- Brand recognition: Bottles from Werner & Mertz are widely regarded as environmentally friendly by consumers, which creates high levels of customer loyalty.
- Partnerships: Werner & Mertz worked closely with recyclers and packaging experts in an open innovation process.

#### Business Benefits

- The use of waste as the input material for new products is cost-effective.
- The production process requires two-thirds less energy, saving both costs and emissions.
- Compliance with environmental standards for sustainable packaging.

Figure 26: Circular packaging by Werner & Mertz



Source: Werner & Mertz

<sup>46</sup> Der Grüne Punkt's Duales System Deutschland GmbH (DSD) was set up in the 1990's in order to liberate industrial firms and retailers from their individual take-back and recovery obligations under the German Packaging Ordinance. It established a second (dual) disposal system alongside the public-sector waste disposal service.

<sup>47</sup> Neue Verpackung (2019), Neues Gebäude von Werner & Mertz – und Alpha zieht mit ein, <https://www.neue-verpackung.de/64349/neues-gebäude-von-werner-mertz-und-alpha-zieht-mit-ein/>, accessed on 27/06/2019.

# How? Accepting challenges, setting goals and measuring progress

## Taking action

Many companies understand the concept of circularity but struggle to apply it to their business. This may simply be because it can be intimidating to move away from old ways of working and core business activities often take priority over long-term considerations. Fully integrated circular business models extend value creation beyond the scope of short-term financial value. They focus on value creation in a larger sense, taking customer, environmental and societal value into account.

A circular transition starts with a robust strategy. Implementing this strategy will lead to transformation of business models and internal processes. This is followed by the development of a management and reporting processes in order to follow up on the effectiveness of the strategy (see Figure 32, page 51).

**1** Formulating a circular **strategy** ultimately means rethinking business models and changing corporate strategy. This is a circular revolution that will affect all areas of every industry and company.

A circular strategy requires that business leaders take a long-term perspective and fight short-termism which has dominated how we view business activities to date. Circularity will require investment which will deliver return if it is based on a medium or long-term

vision. This requires a forward-looking approach but will be worthwhile in order to secure revenue in the long-term.<sup>48</sup>

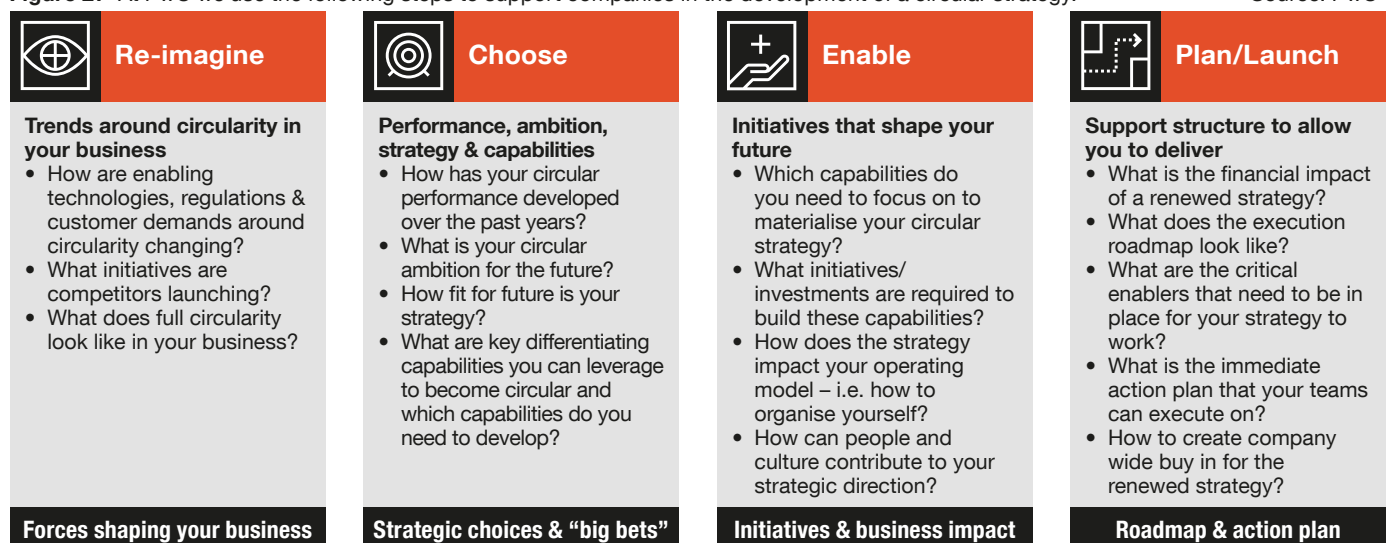
To develop a circular strategy (see figure 27) at PwC we typically start with a **re-imagination** process through which we envision what a circular business model could mean for your company. Then we help you **choose** a direction based on your baseline performance and readiness to go circular. From there, we move to full strategy development and identify the company specific capabilities that will **enable** your circular transition. Finally, we help you **plan and launch** your circular transformation.

If you are a company that has already taken the first steps towards circularity, we are also able to help with parts of this four step process. For example we can help evaluate and re-calibrate your circular strategy to seek out the adjustments that will enable you to meet your targets.

**2** Working circularly will change companies vertically and horizontally. From management boards to shop floors, from sourcing to production. From our work with clients we find that for a circular transition to be successful, everything needs to be considered from a circular perspective. It is a true **transformation** process – internally as well as in collaboration with customers, suppliers and other stakeholders.

**Figure 27** At PwC we use the following steps to support companies in the development of a circular strategy.

Source: PwC



<sup>48</sup> Andrew S. Winston (2014), The Big Pivot: Radically Practical Strategies for a Hotter, Scarcer, and More Open World.

Like any transition, a circular pivot will require changes to the way the system is organised and the way people behave. It will also entail new technologies that will need to be adjusted over time to ensure optimal outcomes. New collaborations will be established to facilitate the transition with new supply chains bringing together companies and organisations that have not previously been working together.

**3** Finally, companies will need to monitor their steps towards circularity through adequate **management and reporting** processes. This includes defining concrete indicators to measure progress (see page 46). From previous research and the development of PwC’s Total Impact Measurement and Management,<sup>49</sup> there is evidence that ‘what gets measured, gets managed’.<sup>50</sup> This is why establishing management and reporting processes is paramount to further refining a circular strategy.

### Deciding direction and setting goals

Companies are at different stages of maturity when it comes to integrating circularity into their business operations. Many companies have started working on being more sustainable in organisational silos rather than through an integrated approach.

There are three levels of circular maturity: the circular novice, the advanced intermediate and the fully integrated circular champion (see Figure 28). Moving from one level to the next needs clearly defined steps and priorities. Companies that embrace circularity embark on a

journey that starts with small steps but often ends in a transformation of their whole business model.<sup>51</sup>

**Novice:** Typically, a company begins its circular journey by weaving a circular narrative into its current operations without yet having made circularity part of its broader strategy or processes.

**Intermediate:** At the next stage, companies begin integrating circular thinking into their sustainability strategy. Companies in this category tend to focus on environmental impacts, such as greenhouse gas emissions, recycling rates, eliminating waste sent to landfill or addressing the company’s impact on biodiversity. This typically starts with pilot projects that tackle the end of the product life cycle.

**Circular Champion:** A few frontrunners have reevaluated their corporate strategy to base it on circular principles. They focus on circular value creation and preserving value through new products and services and new earnings models. Our experience shows that for companies that have not yet engaged with circular concepts, analysing the value chain and product portfolio is key to identifying the biggest potential opportunities.

Moreover, circular economy novices should focus on starting with one project and then expanding it when it becomes successful. By applying a combination of circular strategies, a company can successfully close several loops and decrease value leakage over the lifecycle of a material.

**Figure 28** Moving through the stages of becoming circular

	Novice	Intermediate	Circular Champion
Circular strategy ambition and focus of operations	<ul style="list-style-type: none"> <li>• Circularity is not part of overall company strategy, but there is a narrative on circularity built around current operations.</li> </ul>	<ul style="list-style-type: none"> <li>• Circularity is a part of the company’s sustainability strategy.</li> <li>• Focus on environmental impacts, such as GHG emissions, recycling rates or biodiversity impact.</li> </ul>	<ul style="list-style-type: none"> <li>• Circularity is part of the corporate strategy.</li> <li>• Focus on circular value creation, innovation and creating new revenue streams, products and services.</li> </ul>

Source: WBCSD

<sup>49</sup> Access the PwC Impact Explorer: <https://www.pwc.com/gx/en/services/sustainability/total-impact-measurement-management.html>

<sup>50</sup> PwC (2015), Implementing integrated reporting.

<sup>51</sup> WBCSD (2018), Circular Metrics Landscape Analysis.

## Measuring progress

After companies begin implementing effective circular approaches into their business models, it is important to be able to measure success. Until now, there has been a struggle to identify standard indicators that accurately estimate the impact of a certain circular approach as this varies widely across industries (see *Figure 29*). To some extent the challenge with existing metrics mainly relates to the fact that they do not yet reflect a fully circular mindset.

It is clear that no one single indicator can capture all of the various aspects of circularity, but metrics for materials, energy and water tend to make it onto the long-list of what is measured. For the production industry, progress is often measured in terms of the circularity of the products and is determined by looking at the life cycle of the products.

Generally speaking, metrics can be divided into three main categories:

- 1) **Operational efficiency:** Metrics covering resource efficiency (e.g. reduction in energy consumption) and resource savings (e.g. reduction of plastic use), mostly driven by efforts to decrease operational costs.

- 2) **Sustainability performance:** Metrics covering sustainability topics (e.g. CO<sub>2</sub> emissions), often based on reporting standards such as the Global Reporting Initiative (GRI) or Carbon Disclosure Project (CDP) that aim to facilitate comparisons.
- 3) **Value creation:** Metrics covering circular value, such as the percentage of revenue attributed to products with a profile that includes circularity (e.g. products made using recycled material).

While metrics in the first two categories are common, few companies publish KPIs from the third category. This can be explained by the fact that circularity metrics in this category are not yet as well developed as those in the first two categories which are derived from reporting standards or linked to specific targets.

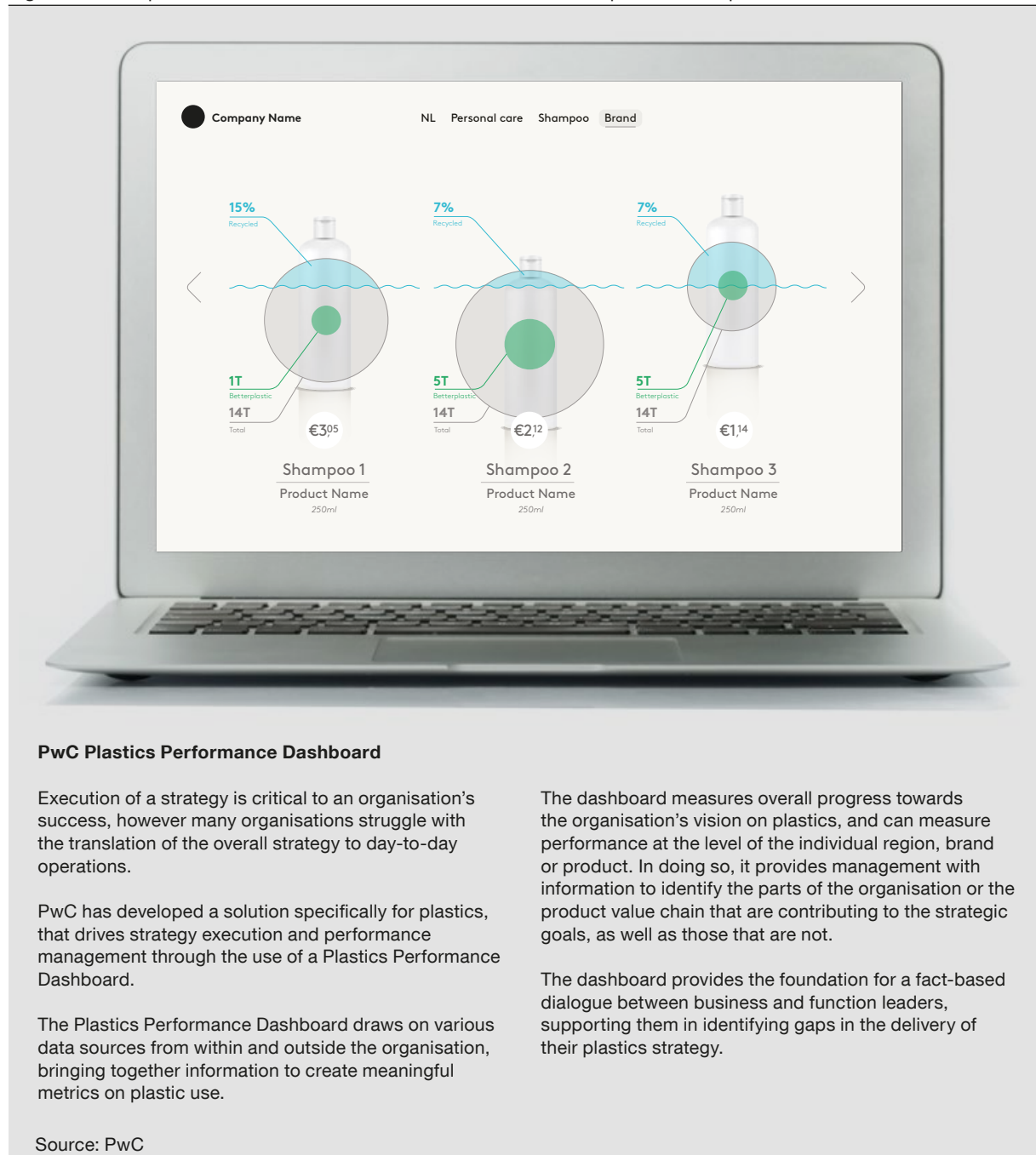
Nonetheless, the benefit of one integrated approach should not be underestimated. Developing one common framework would allow exceptionally circular businesses to distinguish themselves from the competition and would help investors make more informed decisions. This in turn would be an important factor in enabling circular businesses to develop.

**Figure 29** Suggested priority areas for a selected number of industries

Sector	Priority (examples)
Agriculture	Improving of soil fertility
Healthcare	Reduction of hazardous waste
Construction	Reduction of virgin materials
Waste Management	Minimising down-cycling
Financial Services	Increasing the circularity of the portfolio
Mining	Leveraging urban mining
Manufacturing	Closing the materials loop
Transport & Logistics	Maximising use and lifetime

Source: Research conducted by PwC for WBCSD

**Figure 30** Example of PwC's Plastics Performance Dashboard used for personal care products





## Part 3

# Bringing it all together

# The way forward

The moment to embrace a new and fully circular way of thinking is now. Citizens and companies alike are seeking to radically change the way our economic model operates today.

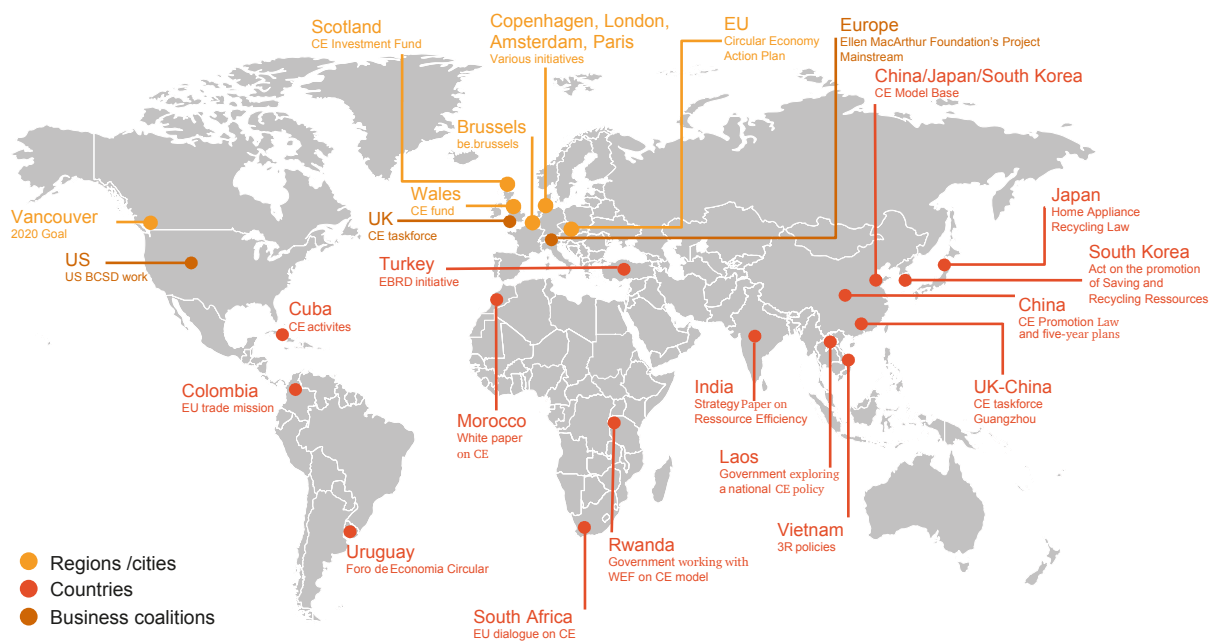
By generating a sense of urgency, governments can create incentives for companies to develop new business models that are resource-efficient, eco-friendly and sustainable. Businesses that manage to radically innovate to create new business models will become the winners of tomorrow as circularity becomes the 'new normal'. *Figure 31* shows the plethora of circular initiatives worldwide.

Also for companies that want to contribute to reaching the United Nations' Sustainable Development Goals

(SDGs), adopting a circular approach makes sense. A circular business model is one of the main tools that companies can use to meet SDG 12: Responsible Consumption and Production, and circularity has clear benefits to helping to meet many of the other goals too.

One thing is certain and that is that our current linear economic model is unsustainable, and will have to change. It needs to do so sooner rather than later, as the problems caused by the linear production model will be increasingly difficult to solve if we wait too long. In order to secure revenue in the long-term, companies need to act now to change the way they do business and make a pivot to circularity.

**Figure 31** There are many initiatives for a circular economy worldwide



Source: Chatham House



## Part 4

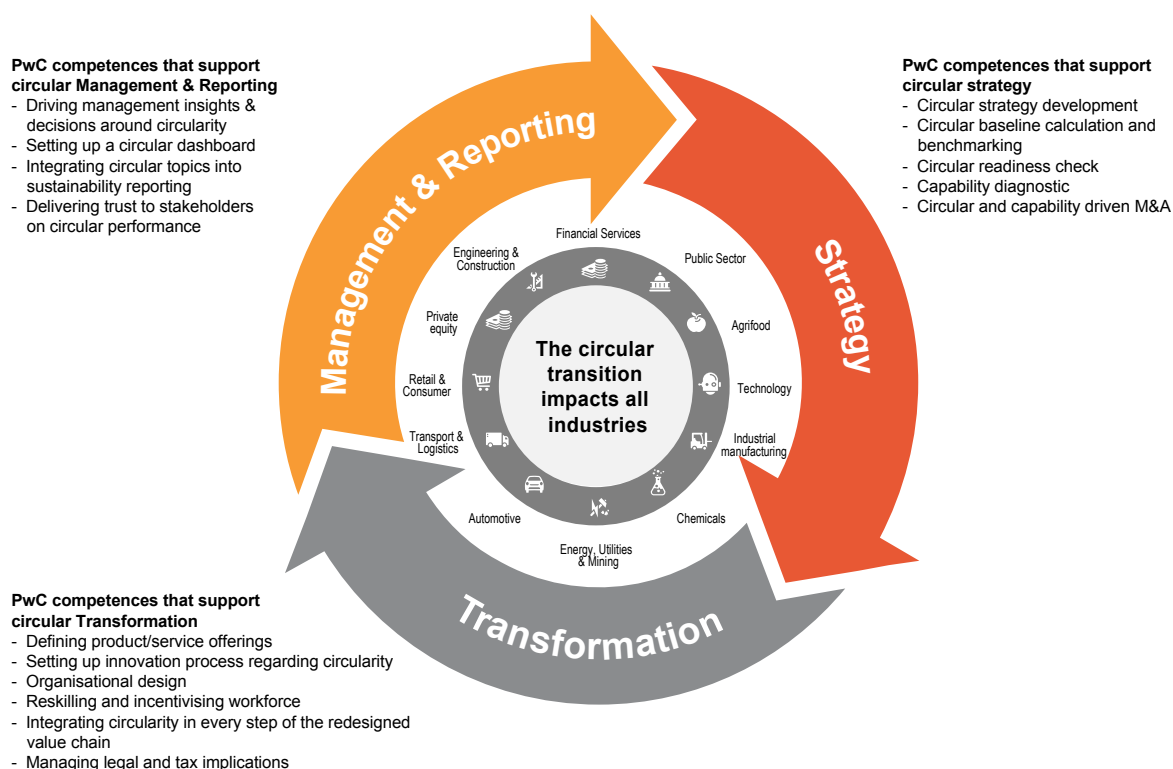
# How we can help

# PwC's circular service offerings

Circularity demands a new way of thinking which starts with a robust strategy, followed by a circular transformation process and the development of an effective management and reporting processes (see page 44-46 for more details).

PwC's team of experts can help you navigate through the process of becoming circular, from setting the vision and making strategic choices to launch and execution, followed by a holistic impact assessment.

**Figure 32** PwC's circular service offerings



# Contacts

## The Netherlands



**Jan Willem Velthuijsen**  
*Chief Economist,  
PwC Europe*  
T: +31 88 792 75 58  
M: +31 6 2248 3293  
E: jan.willem.velthuijsen@pwc.com



**Jan-Willem van den Beukel**  
*Circular Economy Lead,  
PwC Netherlands*  
T: +31 (0)88 792 46 58  
M: +31 (0)6 10 53 83 70  
E-mail: jan-willem.van.den.beukel@pwc.com

## Belgium



**Marc Daelman**  
*Partner,  
PwC Belgium*  
T: +32 2 7107159  
M: +32 477 500038  
E: marc.daelman@pwc.com

## Austria



**Birgit Haberl-Arkhurst**  
*Manager Sustainability Services  
PwC Austria*  
T: +43 1 501 88  
M: +43 699 1630 2988  
E: birgit.haberl@pwc.com

## Germany



**Hendrik Fink**  
*Partner Sustainability Services,  
PwC Germany*  
T: +498957905535  
M: +4916090145391  
E: hendrik.fink@pwc.com



**Pia Schnüeck**  
*Senior Manager Sustainability Services,  
PwC Germany*  
T: +492119812154  
M: +491715677225  
E: pia.schnueck@pwc.com

## Switzerland



**Stephan Hirschi**  
*Director Sustainability & Climate Change,  
PwC Switzerland*  
T: +41 58 792 2789  
M: +41 79 687 1778  
E: stephan.hirschi@ch.pwc.com

## Lead author



**Erika Carlsson**  
*Researcher, Chief Economist Office  
PwC Netherlands*  
T: +31(0)88 792 28 50  
M: +31 (0)6 31 77 72 92  
E: erika.carlsson@pwc.com

We would like to thank our authors, reviewers and lay out team for their contribution to this report: Maarten Hopman, Sarah Maria Stachelscheid, Thijs Ijsbrandij, Thomas Wolf, Stefanie Raimund, Denise Solmaz and Richard Volbeda.

