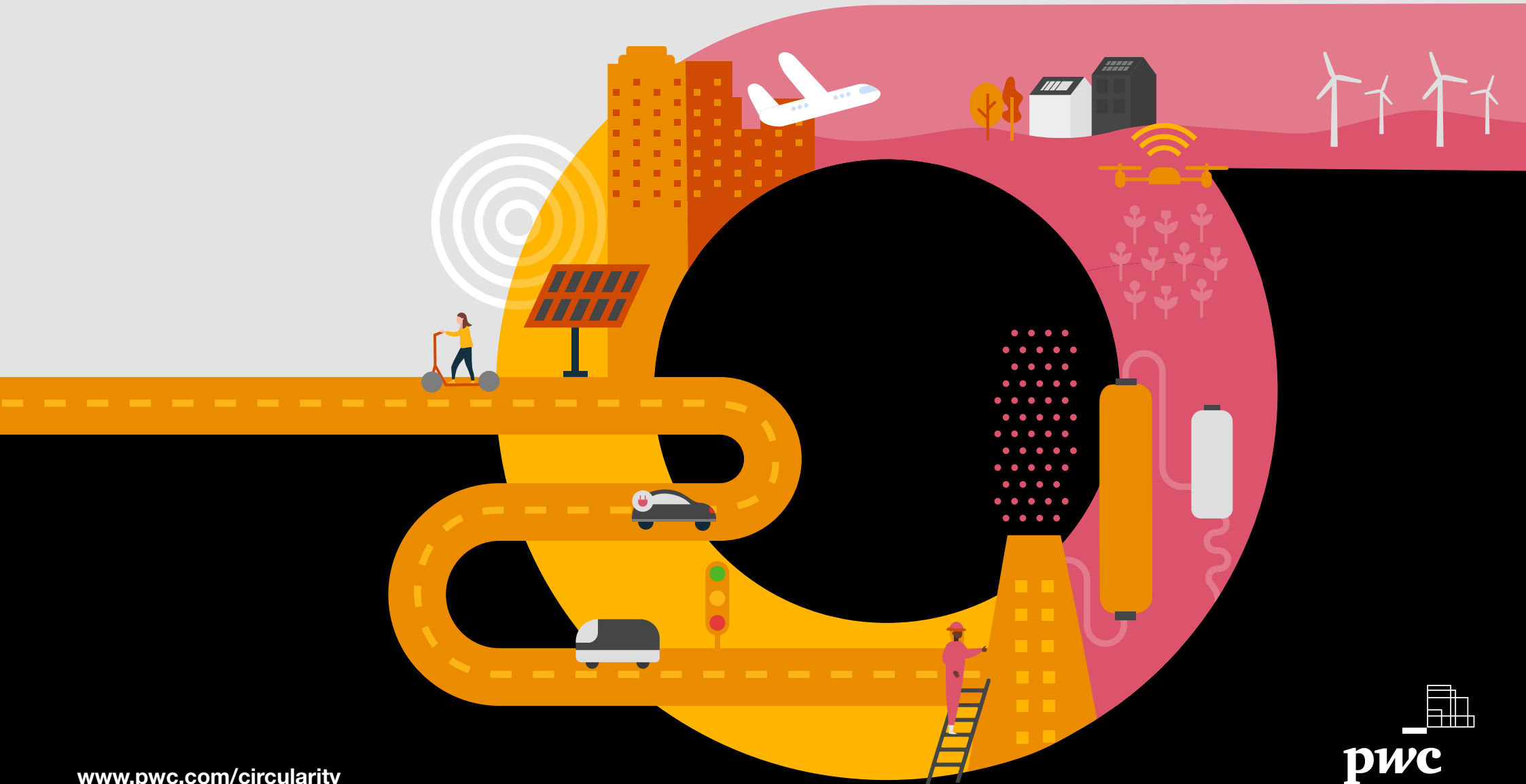


Taking on tomorrow

The rise of circularity in energy, utilities and resources



Contents

Introduction	3
Addressing tomorrow's challenges today	5
• The rise of renewables	7
• Increased recycling and resilience	9
• From resource drain to resource gain	11
• Enabling circularity	12
• Value-adding supply chain partnerships	15
• Rethinking the business model	18
Deciding on your circularity journey	20



Introduction

The novel coronavirus pandemic has accelerated a host of transformative trends, such as remote working, automation and digitisation. COVID-19 delivered a powerful lesson in the dangers of straight-line thinking. We can no longer assume that what happened in the past will continue to happen in the future. The pandemic reminded humanity of its vulnerability and shattered business-as-usual thinking.

Even before the spread of the pandemic, concerns about climate change and a range of global risks had already been putting pressure on previously held assumptions about the viability of linear economic and business models. As a result, linear strategies—based on ‘take, make, dispose’ volume rather than value relationships—had been coming into question. Instead of continuing with these one-way approaches, an increasing number of companies and governments are turning to circular economic models, which rely on the reuse, recovery, repurposing and recycling of materials and resources.

In this report, we examine how companies in the energy, utilities and resources (EU&R) sectors can gain by addressing today’s challenges through the lens of circular economic principles. Not all players in these sectors can aim for complete circularity, of course. But integrating circular thinking into core strategies can produce powerful new perspectives and levers for efficiency and value creation. Just as companies need not be fully digital to benefit from digital investments, companies don’t have to pursue a goal of total circularity to benefit from circular thinking and investments.

Circularity is an ambitious journey, comprising small but significant steps that can deliver big rewards. As circularity gains momentum, companies will find that they must navigate complex interdependencies. The growing use of renewables and energy storage has the potential to introduce new challenges for recycling and waste processing. Companies that reconfigure their operations with an eye towards resolving such tensions will find they—and the world—have much to gain.



IN FOCUS

Pressing the reset button

Before the spread of COVID-19, we identified five urgent global issues that were fundamentally changing the way millions of people live and work: asymmetry, disruption, age, polarisation and trust (our ADAPT framework).¹ These issues are key in framing strategic change and readjustment.

It was clear then that the pressures arising from the ADAPT issues would forge a completely different world by 2025 and that organisations would have to reconfigure themselves to maintain their viability. The global pandemic has now accelerated the need for change, and circularity offers a way of pressing the reset button to address many of the challenges.

Disruption: circularity addresses the disruptive threat of climate change and pressure on resources by developing a more sustainable economic model.

Asymmetry and polarisation: as communities and nations fracture, circularity emphasises interdependence and mutual benefit.

Trust: as trust in institutions erodes, circularity offers an opportunity to develop more transparent supply chains and demonstrate environmentally and socially responsible practices.



¹ PwC, ADAPT: Outlining five urgent global issues facing the world today and their implications, 2020: <https://www.pwc.com/gx/en/issues/adapt.html>.

Addressing tomorrow's challenges today

What is the circular economy? As our colleagues laid out in a 2019 report, *The road to circularity*,² the circular economy is a move away from the current take, make, dispose linear economic model and towards a more efficient and sustainable one. Circular thinking decouples economic activity from the consumption of materials and energy by creating closed-loop cycles in which waste is minimised or even eliminated, and in which resources, including carbon, are reused. It does so by using resources efficiently, prioritising renewable inputs, maximising a product's lifetime, and capturing and repurposing what was previously regarded as waste.

Many aspects of circularity address the challenges brought on by the current overlapping crises. These challenges include the needs to rationalise operations, to construct more localised supply chains and to build resilience. Addressing them with circularity as a guiding principle yields the benefit of new business models that can add value and provide a competitive advantage. Circularity also ensures that strategies address the intensifying challenges brought on by climate change and mitigate the risk of future crises. Most importantly, a circular economic model spurs companies to move away from the orthodoxies of the past and embrace the future today.

Some companies in the EU&R sectors have much to gain from developing fully fledged circular business models. For others, particularly oil and gas and other extractive industries that are based on a traditionally linear model, only some elements of circularity will be immediately relevant. But across the board, circularity principles provide an effective way to explore answers and find new sources of value.

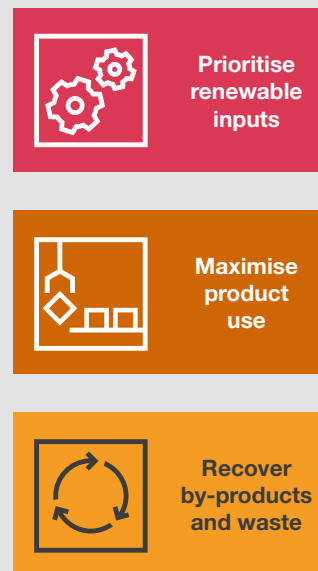
² PwC, *The road to circularity*, 2019: <https://www.pwc.nl/en/assets/documents/pwc-the-road-to-circularity-en.pdf>.



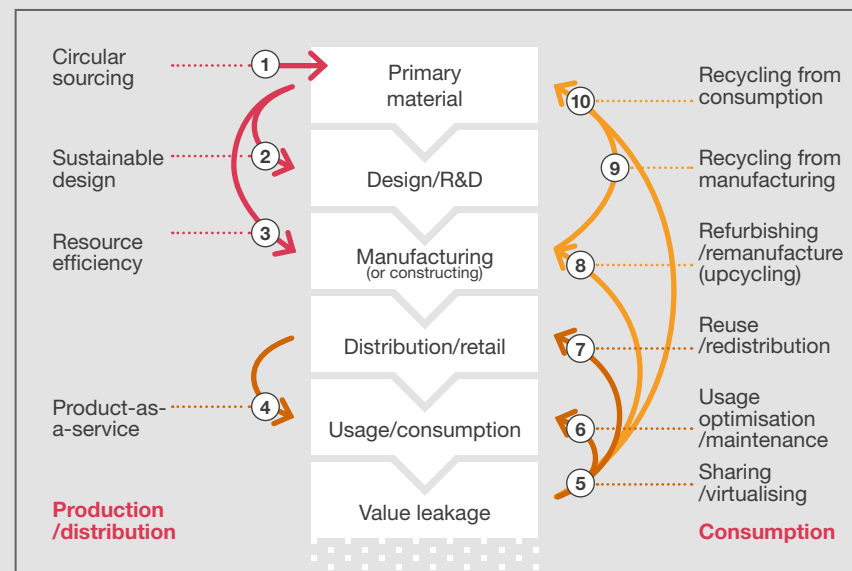
IN FOCUS

Circularity principles and strategies

Three principles...



...and ten corresponding strategies



Circularity can be centred on three overarching principles, which define ten corresponding strategies. The diagram, at left, illustrates the continual flow of resources in both the production/distribution phase and the consumption phase.

- Circularity in production/distribution 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, reusing, repairing, remanufacturing and recycling.
- The end of a product's life represents value leakage when important by-products are not collected for productive use. The circular economy stops value leakage due to discarding products and materials after use.



The rise of renewables

Circularity provides a strategic and effective way to identify both cost-saving and value-creation opportunities. In many instances across the EU&R ecosystem, shifting to renewable energy as an input is a first step. As technologies evolve, the adoption of emissions-free power is becoming more and more widespread.

This switch to renewable energy is a key element of circularity, and an increasing number of companies are seeking to reduce costs, increase sustainability and deliver long-term strategic value by making the change. Many factors drive the adoption of renewable energy, and economics is also becoming less of a barrier in some locations—in the power-generation sector, but for end users, too.

Examples of companies that are moving towards renewables span continents and sectors:

- Mining giants Fortescue and Rio Tinto, which have tended to rely on natural gas or diesel to power their operations, have announced substantial investments in solar power and battery technology for their iron-ore mining operations in Western Australia. Fortescue's addition of 150 megawatts (MW) of solar photovoltaic capacity to its existing 60MW, alongside large-scale battery storage in the Pilbara region, will ultimately enable it to meet 25%–30% of its stationary energy requirements from solar generation.³
- Nearby, Rio Tinto is incorporating a 34MW solar plant and lithium-ion battery energy storage to its Koodaideri project, which will supply all of the project's

electricity needs during peak solar power generation.⁴ The Koodaideri investment is part of a US\$1bn, five-year programme to reach climate change targets and a company objective of net zero emissions from operations by 2050.

- Global resources company BHP, as part of its 2050 net zero goal, has entered into renewable-power purchase agreements (PPAs) that will enable its Escondida and Spence copper mines in Chile to move to 100% renewable energy by the mid-2020s.⁵
- Similarly, in 2019, Shell opened a 27MW solar power plant at its Moerdijk chemicals site in the Netherlands.⁶ In the US, Johnson Matthey's refinery and chemicals plant at West Deptford, New Jersey, sources 17% of its electricity from an adjacent solar plant.⁷

3 Fortescue, *June 2020 Quarterly Production Report* analyst call, 30 July 2020: [https://www.fmgil.com.au/docs/default-source/announcements/investor-and-analyst-call-transcript-\(june-2020-quarterly-production-report\).pdf?sfvrsn=299b584_8](https://www.fmgil.com.au/docs/default-source/announcements/investor-and-analyst-call-transcript-(june-2020-quarterly-production-report).pdf?sfvrsn=299b584_8).

4 Rio Tinto, news release, 16 Feb. 2020: <https://www.riotinto.com/news/releases/2020/Rio-Tinto-to-build-first-solar-plant-in-Western-Australia-to-power-iron-ore-mine>.

5 BHP, *Climate Change Report 2020*, Feb. 2020: <https://www.bhp.com/investor-centre/climate-change-2020>.

6 Shell, news release, 14 Mar. 2019: <https://www.shell.com/business-customers/chemicals/media-releases/2019-media-releases/shell-moerdijk-solar-farm.html>.

7 Johnson Matthey, *Annual Report and Accounts*, 2018: <https://matthey.com/en/investors/report-archive/annual-report-2018>.



IN FOCUS

Solar and battery technology: Reducing material and carbon footprints

Without a commitment to better recycling, the uptake of renewable energy will be accompanied by ever larger material footprints. Solar panel and battery technology present challenges as well as opportunities. In 2016, the International Renewable Energy Agency (IRENA) estimated there was about 250,000 metric tonnes of solar panel waste in the world at the end of that year. By the 2050s, yearly waste amounts (5.5m–6m tonnes) could almost equal the mass contained in new installations (6.7m tonnes).

IRENA's analysis indicates that many technical barriers must be overcome before closed-loop circularity is possible for solar panels. But raw materials can already be treated and recycled at a rate of 65%–70% by mass. By 2030, solar panel raw material recovery could represent a value creation opportunity worth US\$450m.⁸

The expanded use of battery technology lies at the heart of strategies for renewable energy storage and the decarbonisation of transport. But battery production itself has a significant carbon footprint. The CO₂ footprint of producing a fully electric vehicle (EV), for example, is higher than that of manufacturing a vehicle with an internal combustion engine. The lower direct and indirect emissions during the EV's use, though, lead to an overall CO₂ footprint advantage over its life cycle.

As is the case with many other products and technologies, circularity in the global battery chain needs to be seen in the context of the end market and assessed with the cross-sector benefits for transport and power generation taken into account.

The World Economic Forum (WEF) and the Global Battery Alliance (GBA) emphasise the importance of such cross-sector coupling.⁹ But they also acknowledge wider concerns about the global battery value chain. For example, the extraction of the raw materials needed for batteries has been linked to dangerous working conditions, child labour, poverty, and other social and environmental concerns. As a result, the WEF and GBA's circularity vision also encompasses eliminating human rights violations and ensuring safe working conditions across the value chain, as well as improving the repurposing and recycling of materials.

Audi and Umicore are among the companies aiming to put this vision into practice with a strategic research collaboration. Together, they have embarked on a closed-cycle pilot project, having already demonstrated that more than 90% of the cobalt and nickel in the high-voltage batteries of the Audi e-tron all-electric SUV can be recovered and used in new battery cells.¹⁰

8 The International Renewable Energy Agency and the International Energy Agency Photovoltaic Power Systems Programme, *End-of-Life Management: Solar Photovoltaic Panels*, 2016: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_IEAPVPS_End-of-Life_Solar_PV_Panels_2016.pdf.

9 Global Battery Alliance and World Economic Forum, *A Vision for a Sustainable Battery Value Chain in 2030*, 19 Sept. 2019: <https://www.weforum.org/reports/a-vision-for-a-sustainable-battery-value-chain-in-2030>.

10 Audi and Umicore, news release, 17 Dec. 2019: <https://www.umicore.com/en/media/press/battery-recycling-audi-and-umicore-start-closed-loop-for-cobalt-and-nickel>.



Increased recycling and resilience

Replacing fossil fuel generation is just one way to apply circularity principles to a company's value chain. Complete circularity creates systems in which all materials enter into a continual cycle, thus decoupling economic activity from the consumption of finite resources. Mining and other extractive resource activities can never be completely closed-loop. But much can be done to create reuse cycles in the end markets for resources, most notably in metals and petrochemicals.

Aluminium, steel and copper, for example, are almost 100% recyclable. Indeed, producing aluminium from recycled products requires only 5% of the energy needed to produce primary metal. In the US, around two-thirds of steel production comes from a considerable supply of domestic scrap, compared with 56% in the EU.¹¹ In China, the largest scrap consumer in the world, its use is

increasing, although the percentage of steel production coming from scrap remains less than in the US and Europe.

Mini-mills use electric arc furnaces to melt, refine and alloy scrap steel in smaller, lower-cost operations that are independent of traditional supplies of iron ore and coke. Scrap-based production tends to cost less than primary production, so the key constraint is the availability of scrap. The global scrap collection rate is currently around 85%, with rates by end use varying from as low as 50% for structural reinforcement steel to as high as 97% for industrial equipment.¹² Clearly, there is significant scope for improving scrap collection, recovery, separation and sorting, and recycling rates.

Recycling also provides an opportunity for building greater resilience by localising and shortening supply chains—an ambition high on the agenda in light of COVID-19. In 2017, in the US, domestic recycling of scrap exports alone could have displaced 36% of direct steel imports, enabling local sourcing and reducing the US trade deficit by US\$5.5bn.

Smaller micro-mills introduce the possibility of reducing costs and increasing circularity further by using renewable energy to make steel. In summer 2020, Nucor opened a US\$250m micro-mill in Sedalia, Missouri. It is the first US steel plant to operate on wind energy, supplied under a 75MW power purchase agreement with local utility Evergy. In Colorado, a recycled-steel plant run by Evraz is transitioning from coal to solar in a partnership with Xcel Energy and a solar developer half-owned by BP.

¹¹ Eurofer, *Circular economy*, 27 Mar. 2020: <https://www.eurofer.eu/issues/environment/circular-economy>.

¹² International Energy Agency, *Iron and Steel*, June 2020: <https://www.iea.org/reports/iron-and-steel>.



IN FOCUS

The metals industry's reliance on fossil fuels remains high. Three-quarters of the steel industry's worldwide energy demand is provided by coal.¹³ And the production process creates significant emissions of greenhouse and other gases. Among the many innovation efforts underway to work towards zero-emission production is the Hybrit initiative, a collaboration by Swedish steelmaker SSAB, iron-ore producer LKAB and energy company Vattenfall. Hybrit technology aims to replace coking coal with fossil fuel-free electricity and hydrogen. The result would be the world's first fossil-free steelmaking technology, with virtually no carbon footprint. SSAB says it expects to offer the first fossil-free steel products on the market in 2026. The company also expects its US scrap-based, electric arc furnace operations to be powered completely by renewable energy by 2022.¹⁴ In Germany, steelmaker Salzgitter is harnessing wind power and adding hydrogen to the energy mix in its SALCOS (Salzgitter low CO₂ steelmaking) initiative.¹⁵

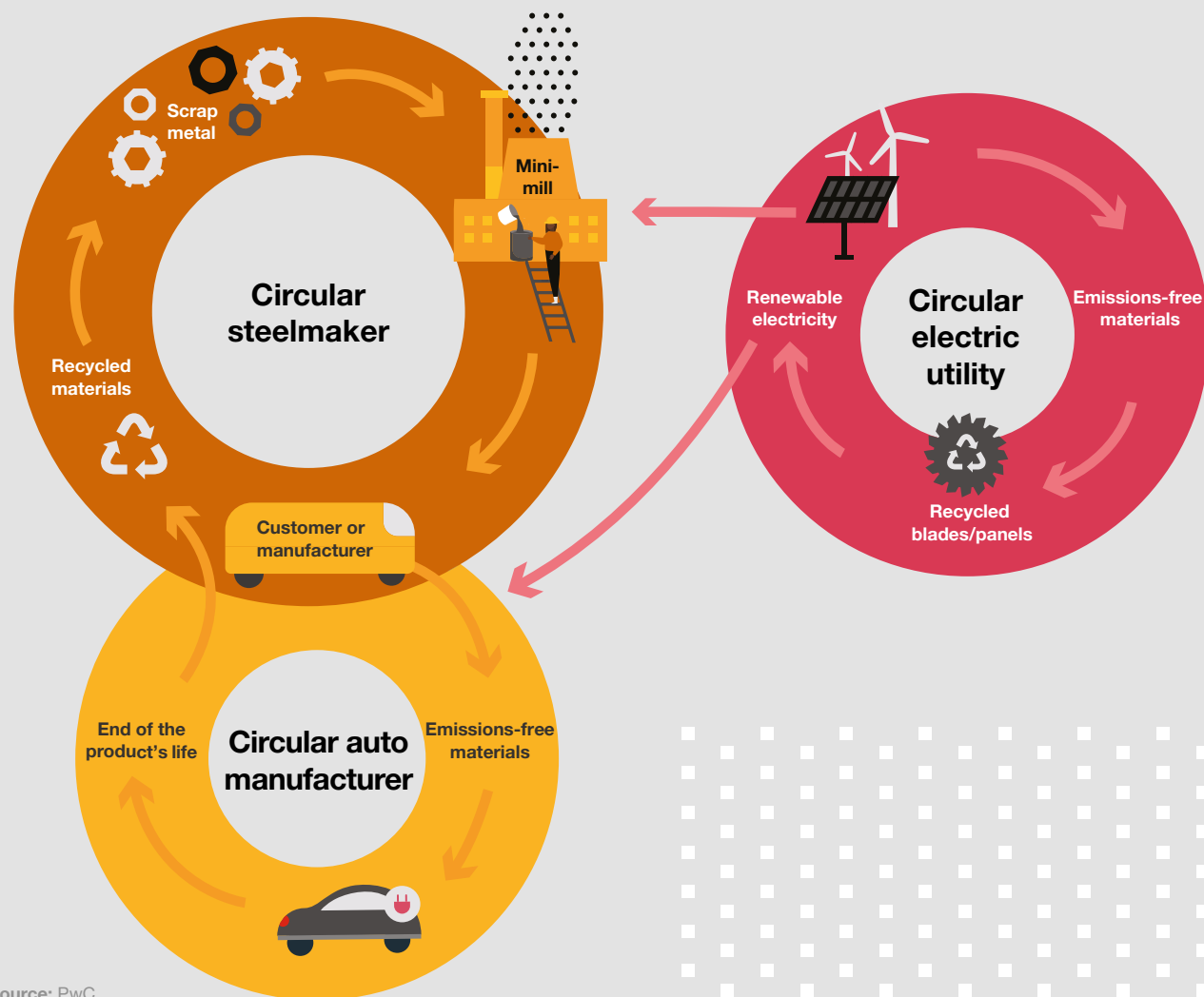
¹³ International Energy Agency, *Iron and Steel*, June 2020: <https://www.iea.org/reports/iron-and-steel>.

¹⁴ SSAB, news release, 14 Nov. 2019: <https://www.ssab.us/news/2019/11/ssab-to-be-first-to-market-with-fossilfree-steel>.

¹⁵ Radtke, Katrin, "SALCOS Project: A Steel Giant Wants to Become Greener," Windfair, 19 May 2020: <https://w3.windfair.net/wind-energy/news/34553-salcos-steel-production-hydrogen-green-wind-farm-integrated-system-fraunhofer-research-salzgitter-ag-germany-project-vestas-turbine>.

A circularity ecosystem

By working together, a steelmaker, a utility and an auto manufacturer can construct circular supply relationships.



Source: PwC

From resource drain to resource gain

Across the board, companies are examining their use of resources with a fresh eye and striving to derisk business models. Circularity provides a useful lens to consider strategic options, ensuring that resources are used with more care and, wherever possible, treated as assets that have cradle-to-cradle value.

The chemicals sector is already responding to an increased public and government focus on issues such as single-use plastics and recycling. In January 2019, more than 25 companies formed the nonprofit Alliance to End Plastic Waste.¹⁶ In a survey conducted just before the COVID-19 pandemic, sustainability and the circular economy headed the list of initiatives that chemicals company CEOs said they would prioritise and invest in over the next 12 months, with 58% expecting to focus on these areas.¹⁷

BASF has long used its *Verbund* philosophy of adding value through the efficient use of resources to incorporate circularity principles into its operations. In the *Verbund* approach, by-products of one process are used as starting materials for another process to save raw materials and energy, minimise emissions, cut logistics costs, and realise synergies. BASF says it achieves annual worldwide savings of more than €1bn through this approach¹⁸—around half of that coming from wastewater, steam and electricity cost savings.¹⁹

In 2019, Shell announced that it had successfully manufactured high-end chemicals using a liquid feedstock made from plastic waste. The technique, known as pyrolysis, advances Shell's ambition to use 1m tonnes of plastic waste a year in its global chemicals plants by 2025. It is working with companies that collect and transform

plastic waste to scale this solution to industrial and profitable quantities across its chemicals plants in Asia, Europe and North America.²⁰

In a partnership between Netherlands-based Fuenix Ecogy Group and Dow, Fuenix will supply the feedstock for the production of new polymers at Dow's facilities in the Netherlands. The agreement also contributes to Dow's commitment to incorporate at least 100,000 tonnes of recycled plastics in its product offerings sold in the EU by 2025.

Like many other circularity initiatives, these efforts will depend in part on incentivising circularity in the waste ecosystem. Regulation may be required to price the cost of negative externalities, such as waste pollution, into market systems and taxation regimes.

¹⁶ The following companies are the founding members of the alliance: BASF, Berry Global, Braskem, Chevron Phillips Chemical Co. LLC, Clariant, Covestro, Dow, DSM, ExxonMobil, Formosa Plastics Corp. USA, Henkel, LyondellBasell, Mitsubishi Chemical Holdings, Mitsui Chemicals, Nova Chemicals, OxyChem, PolyOne, Procter & Gamble, Reliance Industries, SABIC, Sasol, Suez, Shell, SCG Chemicals, Sumitomo Chemical, Total, Veolia and Versalis (Eni).

¹⁷ PwC, *Chemicals trends 2020: Winning strategies for an era of sustainable value chains*, 2020: <https://www.pwc.com/gx/en/ceo-agenda/ceosurvey/2020/trends/chemicals.html>.

¹⁸ BASF website, "Who we are," accessed in Oct. 2020: <https://www.basf.com/us/en/who-we-are/strategy/verbund/production-verbund.html>.

¹⁹ BASF website, "BASF Verbund," accessed in Oct. 2020: <https://www.basf.com/global/en/investors/calendar-and-publications/factbook/basf-group/verbund.html>.

²⁰ Shell, news release, 21 Nov. 2019: <https://apnews.com/press-release/pr-prnewswire/ccf24d88c21572f5d1d3d55af68e32b6>.



Enabling circularity

Momentum for greater circularity and sustainability is likely to be maximised by a combination of the push of regulation and the pull of new markets. And as conditions evolve, companies will find growth opportunities by becoming enablers of sustainability and circularity. The utilities industry has emerged as a key player in supplying renewable energy to industrial operations. And the chemicals industry has a significant role to play in contributing to energy efficiency and greenhouse gas reduction in other sectors, improving the sustainability of downstream energy chains.

In the energy sector, chemical products are used in solar generation and in lighter and longer thermoplastic blades for wind turbines that offer the promise of greater wind power stability and efficiency.

In transportation, the use of lightweight plastics could be key to improvements in the fuel efficiency of vehicles and the development of electric vehicles. Reducing the fleet weight of passenger cars from a current 1,380kg to 1,000kg by 2050 could reduce emissions from those vehicles by 40%, according to a study by the International Transport Forum.²¹ DuPont, which is implementing more than 100 circular economy projects, is one of a number of companies active in developing materials to reduce vehicle weight. Through its transportation and advanced polymers division, it is working with auto industry collaborators to replace metal parts with materials based on high-performance polymers.

Decarbonisation will be a major challenge for the chemicals sector. An analysis by the International Energy Agency points out that petrochemicals are rapidly becoming the largest driver of global oil consumption. They are set to account for more than one-third of the growth in oil demand to 2030 and nearly half to 2050, ahead of trucking, aviation and shipping.²²

Much of the chemicals industry's oil consumption goes into feedstocks, and hence is locked into final products such as plastics and released only when the products are burnt or decompose. That's one of the reasons for the increasing amount of attention that chemicals CEOs are paying to renewable or green feedstocks and to waste and recycling strategies.

21 International Transport Forum, *Lightening Up: How Less Heavy Vehicles Can Help Cut CO₂ Emissions*, 2017: <https://www.itf-oecd.org/sites/default/files/docs/less-heavy-vehicles-cut-co2-emissions.pdf>.

22 The Organisation for Economic Co-operation and Development and the International Energy Agency, *The Future of Petrochemicals*, 2018: <https://www.iea.org/reports/the-future-of-petrochemicals>.

As part of its annual reporting, for example, BASF publishes the proportion of its raw materials that come from renewable resources.²³ And it has committed itself to decoupling organic growth from greenhouse gas emissions. Its goal is to grow faster than the market in the period to 2030 while keeping its emissions flat at 2018 levels.²⁴ In Brazil, biopolymer producer Braskem is making green plastic from sugarcane; the plastic is 100% recyclable and used by an increasing number of customers worldwide.²⁵

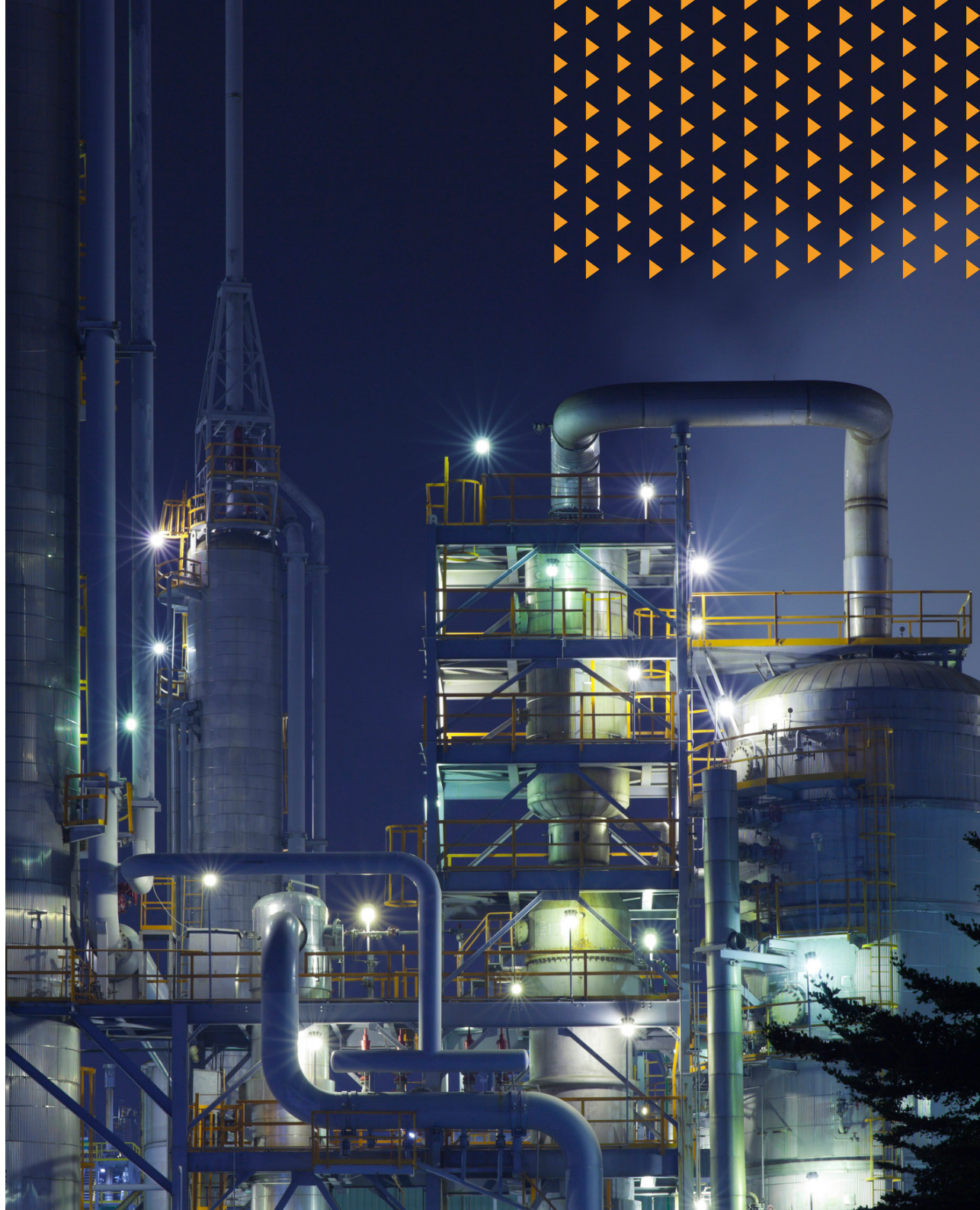
Resource competition for food, land, water and energy is increasing the focus on bioplastics. The Bioplastic Feedstock Alliance (BFA)—formed by some of the world’s leading consumer brands, including Lego, Coca-Cola, Ford and McDonald’s—is a multi-stakeholder forum focused on advancing knowledge of bioplastics. The BFA notes that “recent advances in technology and agricultural production make it possible to envision a future where renewable carbon from plants replaces fossil carbon in the production of new materials.”²⁶ This more circular future ‘bioeconomy’ will require careful decision-making and responsible sourcing to avoid adverse social and environmental issues arising from increases in agricultural and forestry inputs.

²³ BASF, *Economic, environmental and social performance*, 2019.

²⁴ BASF, news release, 20 Nov. 2018: <https://www.basf.com/global/en/media/news-releases/2018/11/p-18-374.html>.

²⁵ Braskem, news release, 26 May 2020: <https://www.braskem.com.br/europe/news-detail/braskems-bioplastic-recognized-at-un-event-as-one-of-brazils-most-transformational-cases-in-sustainable-development>.

²⁶ Bioplastic Feedstock Alliance, 2020: <https://bioplasticfeedstockalliance.org/who-we-are>.





IN FOCUS

Fossil fuels: Adding circularity to linear operational models

Industries with operational models centred on the extraction and use of fossil fuels are, of course, inherently linear. Companies in such industries, though, can introduce elements of circularity into some parts of their operations and are already applying technological advancements to reduce the impact of fossil fuel use.

Various initiatives are underway, for example, to explore the potential for reusing offshore oilfields and assets after drilling operations are discontinued. In the North Sea alone, around 475 installations, 10,000km of pipelines, 15 onshore terminals and 5,000 wells will eventually need to be decommissioned. Norwegian company DNO is exploring how platforms can be repurposed to support offshore wind projects.²⁷ In the Mediterranean, Italian energy company Eni is developing a dual-use wave turbine that could be employed to convert decommissioned oil platforms into renewable-energy islands.²⁸

Maersk Drilling has joined a new CO₂ storage consortium formed by INEOS Oil & Gas Denmark and Wintershall Dea, with the intent of using discontinued offshore oil and gas fields to permanently store approximately 3.5m tonnes of CO₂ per year by 2030.²⁹ The initiative is part of the company's plans to develop carbon-neutral or even carbon-negative drilling. Those plans include an investment in carbon-negative technology being developed by Clean Energy Systems.³⁰ In the US, Occidental Petroleum is experimenting with ways to capture greenhouse gases that would otherwise be released into the atmosphere from factories and power plants. These gases are being used for enhanced oil recovery; they are injected into aging oilfields in a bid to push out the remaining barrels. Instead of getting released into the environment, the CO₂ is left underground.

Occidental is also an investor in Net Power, which is testing novel Allam Cycle technology to produce low-carbon gas power generation. Natural gas is burned with pure oxygen instead of air to generate electricity without emitting any CO₂. This process also avoids generating nitrogen oxides, the main atmospheric and health contaminant emitted from gas plants. The company began testing a small installation in 2018 and hopes to develop a full-size commercial plant by 2022.³¹ California-based Clean Energy Systems is also developing oxy-fuel technology that is capable of zero emissions. It says its process can result in a 20% increase in power production compared with a conventional plant using the same quantity of fuel.³²

27 Thomas, Allister, "Updated: Potential first for UK in plans to reuse offshore platforms for wind farms," *Energy Voice*, 27 Aug. 2019: <https://www.energyvoice.com/oilandgas/north-sea/206114/dno-in-talks-to-reuse-uk-north-sea-platforms-to-support-wind-farms>.

28 Ibbetson, Connor, "Engineers convert old oil rigs into wave energy sites," *New Civil Engineer*, 3 Apr. 2019: <https://www.newcivilengineer.com/latest/engineers-convert-old-oil-rigs-into-wave-energy-sites-03-04-2019>.

29 Staff, "Consortium aiming to re-purpose Danish North Sea fields for CO₂ storage," *Offshore*, 17 June 2020: <https://www.offshore-mag.com/home/article/14178029/consortium-aiming-to-repurpose-danish-north-sea-fields-for-carbon-dioxide-storage>.

30 Staff, "Maersk Drilling pursuing net-negative emissions technology," *Offshore*, 29 July 2020: <https://www.offshore-mag.com/drilling-completion/article/14180573/maersk-drilling-pursuing-netnegative-carbon-dioxide-emissions-technology>.

31 Net Power website, accessed in Oct. 2020: <https://netpower.com>.

Patel, Sonal, "300-MW Natural Gas Allam Cycle Power Plant Targeted for 2022," *Power magazine*, 27 Nov. 2019: <https://www.powermag.com/300-mw-natural-gas-allam-cycle-power-plant-targeted-for-2022>.

32 Clean Energy Systems website, "Zero Emissions Power Generation," accessed in Oct. 2020: <http://www.cleanenergysystems.com/zero-emission-power-generation>.





Value-adding supply chain partnerships

Most companies developed linear supply chains for delivery, not recovery and reuse. But it is not just reuse and recovery that are more difficult with linear supply chains; synergies and relationships are also more challenging to develop and grow. By contrast, circular supply chains add value by enhancing feedback, collaboration and a mutual exploration of sustainable growth opportunities throughout the value chain. By positioning themselves as collaborative partners to their customers, suppliers and other companies and sectors, circularity adopters can develop innovative approaches to transform their target markets. Procurement, for example, in a linear model has traditionally been a cost centre. Circular procurement, on the other hand, treats suppliers as partners in creating further value beyond one-off transactions. In this circular approach, procurement ‘dematerialises,’ turning products into services that can be leased, reused, sold back or shared.

Partnerships in chemicals

Chemical leasing is a well-established alternative approach in which profit doesn’t depend on volume. Economic success instead depends on the service that is linked with the chemicals, so chemical consumption becomes a cost rather than a revenue factor. Business partners benefit from the joint development of resource-efficient, innovative solutions and fair profit-sharing.

One such successful partnership is the long-term service commitment that Opel shares with PPG Industries, which supplies paints, coatings and speciality materials. A large team of PPG specialists embedded at an Opel plant in Poland manages the painting process and handles the relationship with about 50 of Opel’s second-tier paint suppliers. The result has been a 30% reduction in wastewater sludge measured by weight and 70% less chloride concentrated in wastewater. The accuracy of the painting job on cars has nearly doubled from 50% on the

first pass to 95%. The painting process now consumes 30% fewer resources.³³

Partnerships in hydrogen

Perhaps the most exciting emerging example of a cross-industrial circular economy collaboration in EU&R centres on hydrogen, a clean fuel with no direct emissions of harmful pollutants or greenhouse gases. But industrial demand for hydrogen is currently almost entirely supplied by fossil fuels and, as a result, is a major contributor to CO₂ emissions. The vision of a hydrogen-fuelled future is based on producing hydrogen from low-carbon energy sources such as renewable generation (green hydrogen) or from natural gas with CCUS (blue hydrogen).

Hydrogen could play a pivotal role in a sector-coupled circular economy, offering a solution for decarbonising a range of sectors, including transportation, heating, chemicals, and iron and steel. Because hydrogen can

be produced by drawing off excess output from solar and wind generation, it is also a leading contender for providing a storage solution for renewable power output.

Costs are coming down: Bloomberg New Energy Finance calculates that renewable hydrogen could be produced for US\$0.7 to US\$1.6 per kilogram in most parts of the world before 2050, equivalent to natural gas priced at US\$6 to US\$12/MMBTU. That makes it competitive with current natural gas prices in Brazil, China, India, Germany and Scandinavia on an energy-equivalent basis, and cheaper than producing hydrogen from natural gas or coal with carbon capture and storage.³⁴

Effective collaboration across sectors and government policy support will be key factors for success. The EU has put investment in a hydrogen ecosystem at the heart of its post-COVID-19 economic recovery plan. From 2025 to 2030, it expects hydrogen will be an intrinsic part of an integrated energy system, with at least 40 gigawatts (GW) of renewable hydrogen electrolyzers and the production of up to 10m tonnes of renewable hydrogen in the EU. From 2030 onwards, it expects that renewable hydrogen will be deployed at a large scale across all hard-to-decarbonise sectors.³⁵ In Australia, the national science agency, CSIRO, has announced it will inject AUS\$20m into a partnership with Fortescue Metals Group on hydrogen technologies.³⁶

Companies from the power utilities and chemicals sectors are already collaborating on green hydrogen projects. With EU support, a consortium comprising Nouryon, Gasunie and four other partners is developing a 20MW electrolyser in the Netherlands, which would be the first of its size to be implemented in Europe.³⁷

A US\$5bn production facility for the world's largest green hydrogen project is set to be developed in Saudi Arabia by US company Air Products; Acwa Power, a Saudi power and water company; and Neom, Saudi Arabia's ambitious 'city of the future' project. Air Products will be the exclusive off-taker of an expected 650 tons a day of green ammonia, which will be transported around the world to be dissociated to produce green hydrogen for the transportation market.³⁸

Cross-sector partnerships

Another example of cross-sector coupling is thyssenkrupp's Carbon2Chem initiative. The project by the diversified industrial group and steelmaker seeks to ensure that the waste gases from steelmaking, including CO₂, are used to produce valuable raw materials such as methanol or ammonia. Already around 60% of the top gases at thyssenkrupp are used to generate electricity, but the project is seeking ways of using the rest. Thyssenkrupp is investing around €60m in the project



alongside other partners, creating a cross-industrial circular economy initiative that will reuse CO₂ as a raw material to produce outputs such as ammonia and methanol.

Energy utility company E.ON is collaborating in the Carbon2Chem project by linking thyssenkrupp's hydrogen technology to the power grid through E.ON's virtual power plant.³⁹ The virtual power plant uses so-called power-to-X systems to ensure thyssenkrupp's hydrogen production uses clean power whenever there is a surplus of renewable generation. The principle is that if there is a high demand in the power grid, the plant will shut down hydrogen production so that the energy required for electrolysis is available to the public power supply. Conversely, hydrogen production ramps up if more energy is fed into the grid than can be distributed.

34 BloombergNEF, *Hydrogen Economy Outlook*, 30 Mar. 2020: <https://data.bloomberglp.com/professional/sites/24/BNEF-Hydrogen-Economy-Outlook-Key-Messages-30-Mar-2020.pdf>.

35 European Commission, *A hydrogen strategy for a climate-neutral Europe*, 8 July 2020: https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf.

36 Commonwealth Scientific and Industrial Research Organisation, news release, 22 Nov. 2018: <https://www.csiro.au/en/News/News-releases/2018/hydrogen-partnership-to-benefit-rd-jobs-exports>.

37 Nouryon, Gasunie, et al., news release, 22 Jan. 2020: <https://www.nouryon.com/news-and-events/news-overview/2020/nouryon-led-consortium-wins-eu-backing-for-pioneering-green-hydrogen-project>.

38 Air Products, news release, 7 July 2020: <https://www.airproducts.com/news-center/2020/07/0707-air-products-agreement-for-green-ammonia-production-facility-for-export-to-hydrogen-market>.

39 E.ON, news release, 30 June 2020: <https://www.eon.com/en/ueber-uns/presse/press-releases/2020/2020-06-30-e-on-and-thyssenkrupp-bring-hydrogen-production-on-the-electricity-market.html>.



IN FOCUS

Circularity in a more vulnerable, risk-aware world

A much greater emphasis on circularity is increasingly accepted as vital, not just important in managing pollution and waste problems but integral to limiting climate change. The goal of the Paris Agreement to limit global warming to 1.5°C above pre-industrial levels can only be achieved by a circular economy, according to the Platform for Accelerating the Circular Economy, a public-private collaborative group.⁴⁰ The group estimates that the world economy is currently only 9% circular, and it promotes private and public initiatives to close what it terms the circularity gap.

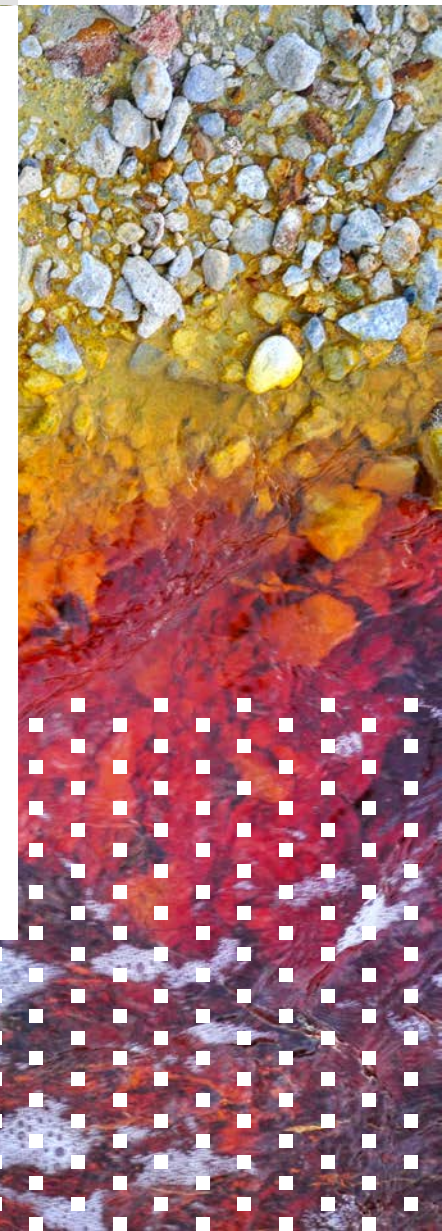
The EU has put circularity at the heart of its environmental and economic policy with the launch in 2020 of the Circular Economy Action Plan. “Today, our economy is still mostly linear, with only 12% of secondary materials and resources being brought back into the economy,” said Frans Timmermans, Executive Vice President for the European Green Deal, in announcing the plan’s adoption. “Many products break down too easily, cannot be reused, repaired or recycled, or are made for single use only. There is a huge potential to be exploited both for businesses and consumers.”

In 2018, the EU signed an agreement with China on furthering the understanding of how circular economic cooperation can be advanced. China has adopted the circular economy as a national policy, starting with the enactment in 2008 of the Circular Economy Promotion Law. It was amended in 2018, and the country’s most recent five-year plan validates the importance of the circular economy both as a national policy and as a key pillar of the Chinese economy.

These moves build on earlier multilateral and individual government initiatives to promote circularity. Extended producer responsibility (EPR) has been on the agenda of the Organisation for Economic Co-operation and Development since 2001 as a way of making producers responsible for the treatment and/or disposal of post-consumer products—financially by paying for it or physically by collecting, treating and disposing of the products. EPR measures incentivise the reduction of waste at its source. Today, the trend is towards an extension of EPR to new product groups and waste streams, such as electrical appliances and electronics.

⁴⁰ Circle Economy, *The Circularity Gap 2019*, 2019: <https://www.circle-economy.com/resources/the-circularity-gap-report-2019>. The report is published as part of the Platform for Accelerating the Circular Economy (PACE).

PACE is a public-private collaboration mechanism and project accelerator dedicated to bringing about the circular economy at speed and scale. It assembles a coalition of more than 50 leaders and is cochaired by the heads of Royal Philips, the Global Environment Facility and UN Environment. It is hosted by the World Economic Forum.





Rethinking the business model

Embedding circularity principles into existing business models can produce significant benefits. Companies can reduce costs, optimise resources and create added value through new product and service ideas and relationships. But, in many cases, circularity is taking companies further—into territory where they are rethinking and transforming their business models, shifting them into new value-chain positions that can make them more resilient and competitive.

Companies that traditionally have been heavily focused on hydrocarbons are using circularity principles as a basis for major strategic shifts in response to decarbonisation. OMV, Austria's largest international energy company, is moving from being a pure oil and gas player to becoming a leading downstream petrochemicals company. Instead of viewing oil as an energy product, OMV will increasingly use oil as a feedstock for making chemical, industrial and consumer products. It is developing ways to recycle post-industrial plastics into synthetic crude oil using a pyrolysis process in its ReOil pilot plant at the Schwechat refinery,

just outside Vienna. The aim is to use plastics that might otherwise go to waste as a feedstock for producing new plastics or as energy for mobility.

Like many other examples, this is not a pure circularity play. Few companies can move from linear business models to completely closed-loop, circular business models in just one transformation. For many, achieving circularity will involve a series of transformations, with more circular positions sitting alongside or gradually replacing linear positions.

This process is beginning to occur in the oil and gas sector, with companies moving away from fossil fuels and into renewables and other positions in the electricity and e-mobility value chain. Shell and BP, for example, have both announced their intention to become net zero—emissions energy businesses by 2050 or sooner. Becoming net zero is likely to include more circularity, but it is unlikely to mean complete circularity. Some industries, such as mining, will always by definition be linear, but their operational footprints will tilt more towards resources that

can contribute to partly and fully circular end markets—for example, copper production for use in batteries.

The megatrends of decarbonisation, decentralisation and digitisation are compelling power utility companies to evolve faster than ever before. And so power companies are at the heart of delivering one of the key operating planks for a circular economy—the provision of renewable energy. Xcel, Evergy, E.ON and many other power utility companies worldwide are key facilitators of this important piece in the circularity jigsaw, enabling territories and individual customers to move towards achieving their 100% carbon-free or 100% renewable-energy ambitions.

But some power utilities see an opportunity to enable wider circularity strategies. The Enel Group, for example, has formed Enel X, which brings the group's advanced energy services together into a single business line that includes an explicit circularity offering. Enel X is positioning itself as a hub to help its customers implement circular economy strategies. Its focus is on five pillars that reflect the most promising foundations for developing

circular economy business models: sustainable inputs, the extension of the useful life of products, shared platforms, products-as-services and end-of-life management.

Companies have good reasons for rethinking their business models in the light of the COVID-19 pandemic. Those in the vanguard of circularity gain a chance to shape the circular world around them. They also ensure that they are ahead of the curve and planning for, rather than having to react to, eventual regulation or public pressure.

The policy impetus behind circularity from governments is growing. Foremost is the EU's Circular Economy Action Plan. The plan is intended to lead to legislation that requires sustainable products, including widening the Ecodesign Directive beyond energy-related products to cover the broadest possible number of products and to make the directive deliver on circularity. Worldwide, a number of circularity initiatives are also underway. In a 2019 report on circularity, we counted 19 such initiatives in countries outside the EU.⁴¹

The Circular Economy Action Plan follows an EU directive on single-use plastics that was adopted in 2018. The directive will target, and in some cases ban, the ten single-use plastic products most often found on Europe's beaches and in its seas. As of 2018, more than 50 nations—including Ecuador, India, Rwanda and China—were taking action to reduce plastic pollution.⁴²

41 PwC, *The road to circularity*, 2019: <https://www.pwc.nl/en/assets/documents/pwc-the-road-to-circularity-en.pdf>.

42 United Nations Environment Programme, *Single-use plastics: A roadmap for sustainability*, 2018: <https://www.unenvironment.org/resources/report/single-use-plastics-roadmap-sustainability>.



IN FOCUS

A collaborative transition

Whether it involves major oil companies on a journey to become major energy companies or multiple players from across industries mapping out future stakes in a hydrogen economy, the growth of more sustainable business models and circularity will present firms with many key strategic decisions.

Companies with legacy models rooted in fossil fuels will face crucial decisions on the portfolio management and phasing of the move from hydrocarbons into new, cleaner energy activity. For the hydrogen economy, there will be technology choices to make, as well as decisions on how to assemble cross-sector value chains, and which of the cross-sector opportunities to focus on.

All companies will face decisions on whom to collaborate with and what investments will deliver the best returns.

Companies will need to identify not just how and where they can achieve the best value but also whom to collaborate with in new value chains that comprise shared and, sometimes, competitive interests.

A circular value chain must be an integrated and interactive ecosystem. Participants will need to focus on cultures and skills that will promote a collaborative system design that recognises there is a community of interest. Such a community will include government and policy actors and careful evaluation of the best way to design goals, standards, incentives, reporting measures and other protocols. A key challenge is how this new ecosystem can encourage innovation and ensure the timely evolution of regulation to enable it.



Deciding on your circularity journey

Companies in the EU&R sectors have the potential to play a huge role in the development of a circular economy. Many of the technological developments that could accelerate circularity are within their sphere of operations. These include innovations in materials composition and efficiency, electrification, hydrogen production, biochemistry and synthetic chemistry, and carbon capture and use.

We see a world ahead in which the old, linear economic model falls further out of favour in the aftermath of the COVID-19 pandemic and as climate concerns intensify. In fact, as the examples we've highlighted in this report demonstrate, such a world is starting to take shape. Leaders striving to embrace circularity can be guided by six steps that underlie many of these recent successes, and are helping companies to build momentum for a more sustainable future.

Six steps companies can take

- 1 Map your circular opportunities.** Examine where your current operational footprint and direction are taking you. Assess your opportunities to deliver circularity, looking deep inside your operations and outside to the surrounding community of suppliers, customers and stakeholders.
- 2 Be clear about your strategy and vision.** Set out your circularity ambition and give it the necessary strategic underpinning, ensuring that it is widely communicated and understood by those who have to deliver it.
- 3 Plan your circular transformation route.** For some companies, it may be small steps. For others, it will require the transformation of their whole business model. Either way, identify the company-specific capabilities that will enable your circular transition.
- 4 Develop circular collaborations and frameworks.** Forge the relationships and alliances that you will need to develop an effective circular ecosystem. Circular ecosystems need to be part of a supportive framework within well-functioning markets and have clear rules, a dedicated infrastructure and a logistical network.
- 5 Measure, review and communicate your progress.** Monitor your circularity steps with adequate management and reporting processes, and use those processes to further refine your circular strategy.
- 6 Move before your competitors, customers and regulators do.** It's better to facilitate your own circular transformation, rather than let others overtake you and find yourself playing catch-up.

Contacts

Key contacts

Jeroen van Hoof

Global Leader, Energy, Utilities & Resources
PwC Netherlands
+31 88 7921328
jeroen.van.hoof@pwc.com

Niloufar Molavi

Global and US Oil & Gas Leader
PwC United States
+1 713 356 6002
niloufar.molavi@pwc.com

Nils Naujok

Global Chemicals Leader
PwC Strategy & Germany
+49 30 88705855
nils.naujok@pwc.com

Jock O'Callaghan

Global Mining & Metals Leader
PwC Australia
+61 3 8603 6137
jock.ocallaghan@pwc.com

Gavin Sanderson

Global Energy, Utilities & Resources
Advisory Leader
PwC UK
+44 7740 157147
gavin.sanderson@pwc.com

Dr. Peter Gassmann

Managing Director, Strategy & Europe,
and PwC's Global ESG Leader
Partner, PwC Germany
+49 69 97167470
peter.gassmann@strategyand.de.pwc.com

Olesya Hatop

Global Energy, Utilities & Resources
Clients & Markets Industry Executive
PwC Germany
+49 211 9814602
olesya.hatop@pwc.com

Territory contacts

Asia-Pacific

Australia

Guy Chandler
+61 7 3257 5796
guy.chandler@pwc.com

China

Lisa B. Wang
+86 106533 2729
binhong.wang@cn.pwc.com

India

Sambitosh Mohapatra
+91 1243306008
sambitosh.mohapatra@pwc.com

Indonesia

Sacha Winzenried
+62 215212901
sacha.winzenried@id.pwc.com

Japan

Norio Katayama
+81 90 5408 1882
norio.katayama@pwc.com

South Korea

Wonseok Yoo
+82 27094718
won-seok.yoo@pwc.com

Europe

Austria

Michael Sponring
+43 1501882935
michael.sponring@pwc.com

Belgium

Marc Daelman
+32 27107159
marc.daelman@pwc.com

Denmark

Claus Dalager
+45 89 32 57 72
claus.dalager@pwc.com

Finland

Kimmo Vilske
+358 407320850
kimmo.vilske@pwc.com

France

Pascale Jean
+33 156571159
pascale.jean@pwc.com

Germany

Folker Trepte
+49 89 5790 5530
folker.trepte@pwc.com

Greece

Evangelos Markopoulos

+30 6942431298

vangellis.markopoulos@pwc.com

Hungary

Ádám Osztovits

+36 14619585

adam.osztovits@pwc.com

Ireland

Kim McClenaghan

+353 7920 6912

kim.a.mcclenaghan@pwc.com

Israel

Eitan Glazer

+972 3 795 4664

eitan.glazer@il.pwc.com

Italy

Alessandro Grandinetti

+39 348 2505073

alessandro.grandinetti@pwc.com

Netherlands

Viviana Kooistra-Voorwald

+31 88 7923353

viviana.voorwald@pwc.com

Dr. Jens Dinkel

Sustainability

+31 6 3987 5134

jens.d.dinkel@pwc.com

Norway

Ole Martinsen

+47 952 61 162

ole.martinsen@pwc.com

Poland

Dorota Debinska-Pokorska

+48 502184883

dorota.debinska-pokorska@pwc.com

Portugal

Joao Ramos

+351 213599296

joao.ramos@pt.pwc.com

Russia

Tatiana Sirotinskaya

+7 4959676318

tatiana.sirotinskaya@ru.pwc.com

Spain

Carlos Fernandez Landa

+34 639 136076

carlos.fernandez.landa@pwc.com

Sweden

Eva Carlsvi

+46 10 212 67 45

eva.carlsvi@pwc.com

Switzerland

Marc Schmidli

+41 58 79221 564

marc.schmidli@ch.pwc.com

Turkey

Murat Colakoglu

+90 2123266434

murat.colakoglu@pwc.com

United Kingdom

Drew Stevenson

+44 7710 002801

drew.stevenson@pwc.com

Middle East and Africa

Middle East

Neil O'Keeffe

+971 56 676 3097

neil.okeeffe@pwc.com

Francophone Africa

Emmanuel Le Bras

+221 77 464 08 77

emmanuel.lebras@pwc.com

The Americas

Argentina/Latin America

Ezequiel Mirazon

+54 48506000

ezequiel.mirazon@ar.pwc.com

Brazil

Ronaldo Valino

+55 21 3232 6139

ronaldo.valino@pwc.com

Canada

Helen Bremner

+1 972 965 1078

bremner.helen@pwc.com

Mexico

Eduardo Reyes Bravo

+52 55 5263 8962

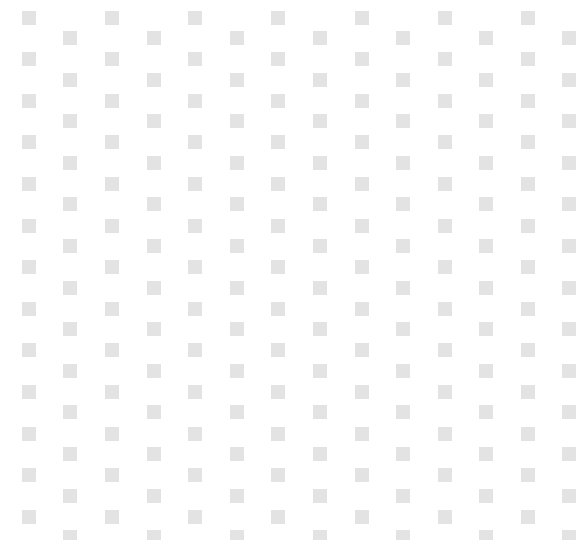
eduardo.reyes.bravo@pwc.com

United States

Michael A. Herman

+1 312 298 4462

michael.a.herman@pwc.com



www.pwc.com/circularity



At PwC, our purpose is to build trust in society and solve important problems. We're a network of firms in 155 countries with over 284,000 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.

© 2020 PwC. All rights reserved. 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 for further details.

This content is for general information purposes only, and should not be used as a substitute for consultation with professional advisers.