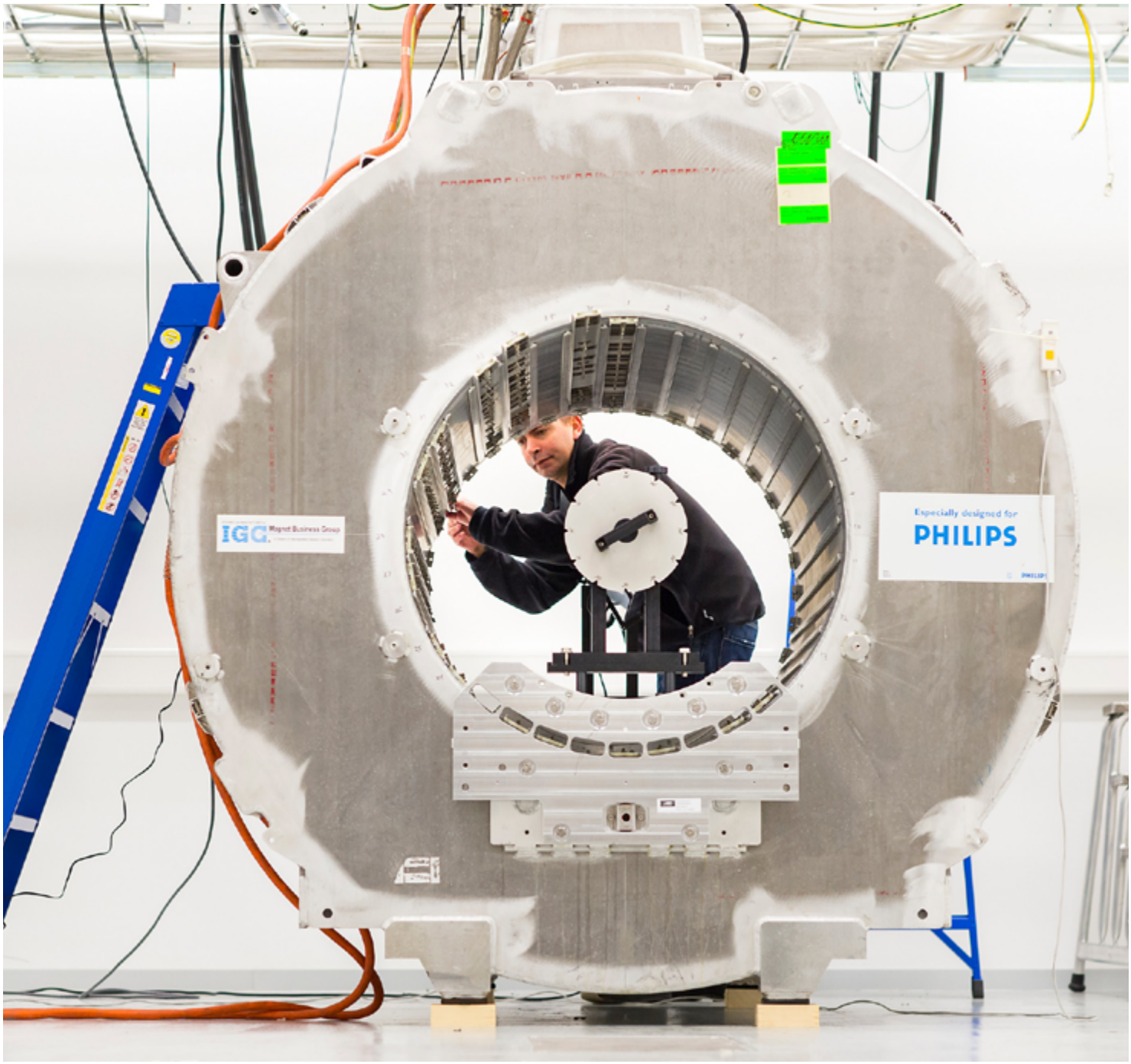
Manufacturing: the future is circular



Netherlands

Photo: Ahrend

Content

“To transition to a circular economy and drive impact, we must scale circular solutions and forge new collaborations, between businesses, governments, researchers, financial institutions, civil society organizations and others.”

Frans van Houten
CEO Philips & PACE

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Chairperson Platform for Accelerating Circular Economy (PACE)

The case for change is clear. In the last decade, we have seen a huge increase in the world’s environmental footprint, with consumption currently running at around 1.7 times the resource capacity of the planet*, and resource use expected to double by 2050 if we continue with business as usual.

We have all seen the harrowing images of plastics accumulating in our oceans, electronic waste polluting our air and soil, and the burning of fossil fuels creating blankets of smog in the world’s most populous cities.

Despite the many challenges we face in turning this around, I am encouraged by recent trends.

People are becoming more mindful of the way they consume. Customers, too, are increasingly asking for concrete solutions that help them become more sustainable. At the same time, rapid advances in digital technology are helping to drive more efficient use of resources as well as effective collaboration and transparency across the value chain.

Why circular manufacturing is part of the solution

Circular economy solutions are the missing link in the climate debate. Doubling the current global circularity rate of 8.6% will cut 39% of emissions and 28% of virgin resource usage (Circularity Gap report 2021, Circle Economy). Changing the way products are made and used can help address 45% of global greenhouse gas emissions, while creating a circular economy offers a $4.5 trillion economic opportunity by helping to avoid waste, stimulate business growth, and create employment opportunities.

Within manufacturing, capital equipment represents a broad group of hardware products as diverse as servers, medical scanners and ships. Their manufacture uses 6 billion tonnes of raw materials globally each year. We can and should lead the way on value retention and take-back.

Collaboration is key

To transition to a circular economy and drive impact, we must scale circular solutions and forge new collaborations, between businesses, governments, researchers, financial institutions, civil society organizations and others. This is why the Capital Equipment Coalition, as part of PACE – the Platform for Accelerating Circular Economy – was started in 2018, when Philips teamed up with partners such as ASML, Cisco, Dell, KPN and others.

At Philips, we are closing the loop on all medical systems equipment that becomes available to us and taking care of responsible repurposing. We can improve more lives, while no longer relying on the use of natural resources.

Focusing on the priorities

We need to prioritize circular design and apply a host of measures that enable this shift. These include increasing the supply of competitively priced recycled materials in order to meet demand. It also requires investing in new technology and significantly scaling up facilities.

There is an important role for research organizations to develop new science-based methodologies and tools to guide new business model design and measure impact. Governments and financial organizations also need to provide an enabling environment to support companies implementing these kinds of circular business models. The incentives must be put in place for both consumers and business-to-business customers to return products through deposit and buy-back schemes, and refurbishment. Finally, it is crucial for businesses to share their success stories and learnings to show the best way forward.

For the circular economy to reach scale, governments and businesses need to invest in collection and sorting facilities – and plan them strategically so they are in the right place and work efficiently. It is important to enable efficient transboundary reverse supply chains, in compliance with the Basel Convention, so that products can be shipped to the places where they can be reused or processed.

Moving ahead together with urgency

For a healthy, sustainable world for all, the transition to a circular economy is essential. That is why we must move ahead with urgency. I am convinced that by working together we can drive systemic change and scale circular innovation.

I hope this report inspires you, with its cases and concrete guidance, to start embedding circular economy practices in your business. I invite all public parties and businesses to join the transition to circular manufacturing.

* Global Footprint Network (2019)

Introduction

At Holland Circular Hotspot we believe that creating a circular economy calls for a profound transformation in the way we work and produce, the way we design, teach, invest and buy. For this reason, we strive to connect the global circular community, by inspiring cross-sectoral collaborations, stimulating the exchange of knowledge and innovations, boosting circular entrepreneurship.

In 2020 we started a series of publications focusing on the sectors with high potential for circular transition inspired by the Dutch transition agendas. With these publications we want to bring our insights to an international level and share best practices with the hope that it will inspire everyone around the world to take action and kick-start circular development.

The Dutch manufacturing industry offers plenty of inspiring and groundbreaking innovations for a circular economy. But it is clear that the International cooperation is crucial to realize and accelerate the circular transition. The manufacturing industry is an international industry with value chains that cover the whole world.

For this publication about the manufacturing industry we teamed up with the ‘Uitvoeringsprogramma Circulaire Maakindustrie- UPCM (Circular Manufacturing Implementation Program) the Dutch program that stimulates the circular transition of the sector. In this program the ministries of Economic Affairs and Climate, sector organizations FME and Koninklijke Metaalunie, RVO, companies and other stakeholders work together.
We aim to provide more in-depth insight in opportunities and challenges and the need for international action and cooperation to achieve a circular transition in this sector.

We will first go into the main ecological constraints and challenges why manufacturing has to become circular and what the expected benefits are. Illustrated by a great number of showcases we will present the main circular strategies and solutions that have been developed by industry. We then present the key projects that the Netherlands will work on in the upcoming years and the international actions we want to take. We conclude with an action perspective on how the transition can be organized.

We would like to thank all the parties that have contributed to this publication, especially all the companies and other parties that shared their showcases. We also want to thank the Netherlands Strategic Platform of UPCM for their input and feedback.

We are very grateful for the preface by Mr. Frans van Houten CEO of Philips and who is an international flagbearer for the promotion of circular entrepreneurship.

Please don’t hesitate to contact Holland Circular Hotspot or UPCM for further information.

Chapter 1

Current state of the manufacturing industry

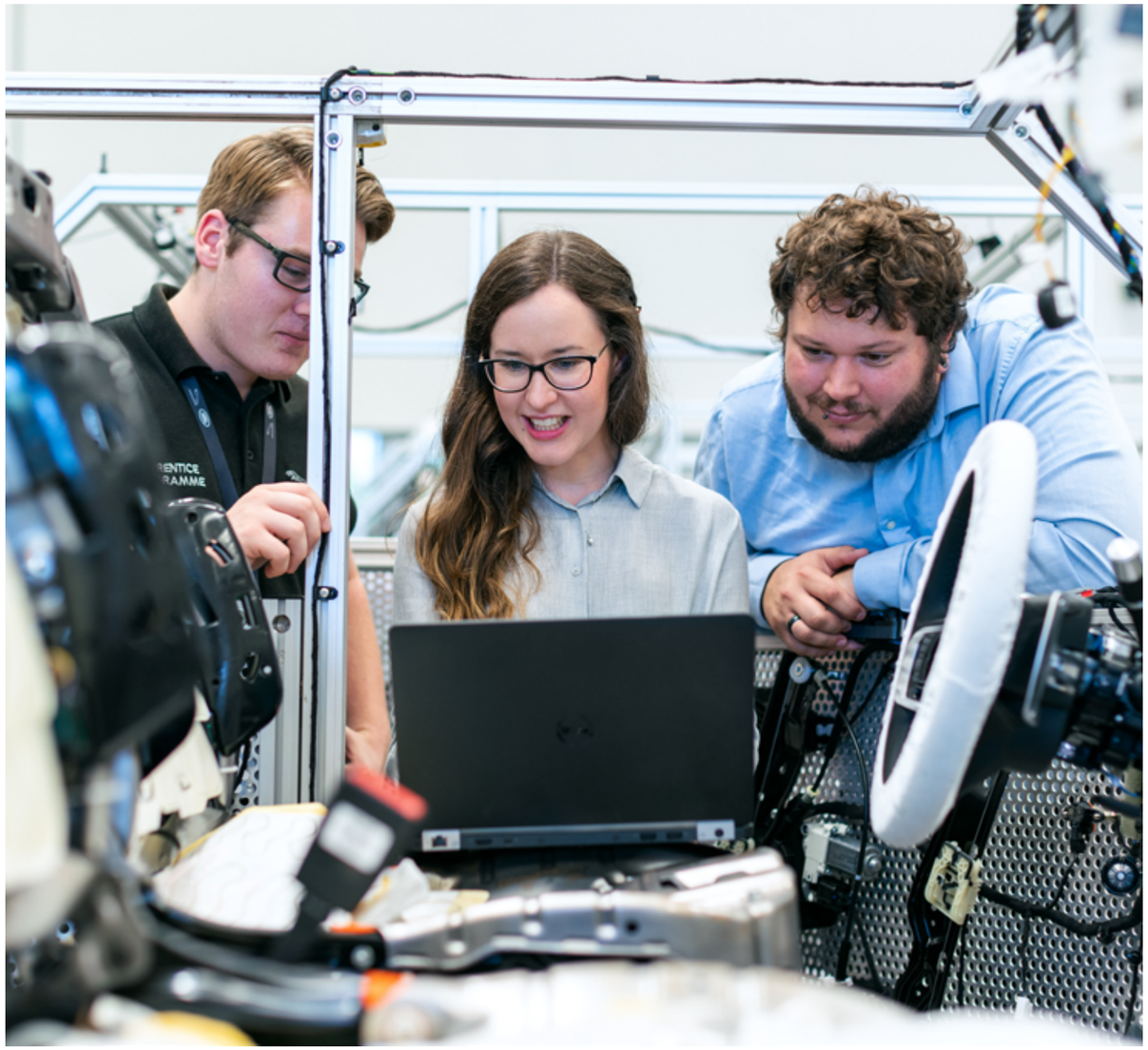
The manufacturing industry is at the heart of a modern, successful economy. As countries develop and their economies flourish, they build up an expanding stock of commodities and materials such as steel, aluminium and plastics. These materials are used to create infrastructure, transportation systems, buildings and factories, and consumer products and their packaging. Materials are the heart of maintaining a high standard of living. A healthy industrial sector is also widely seen as crucial for economic competitiveness and social wellbeing.[1] In the Netherlands, industrial activities represent nearly one fifth of the economy. This figure comprises not only the added value of industry, but also the added value from activities in the supply chain.[2]

This decade is likely to become a decade of transformation for the manufacturing sector and the related global value chains. Whilst the COVID-19 pandemic is a definitive game changer, it is not the single driver for this change. The pandemic comes on top of challenges that result from the new industrial revolution, growing economic nationalism and the sustainability crisis (Table 1).[3]

Table 1 Megatrends shaping the future of international production

Technology/ New Industrial Revolution	Advanced robotics and AI Digitalization in the supply chain Additive manufacturing (3D printing)
Policy and economic governance	More interventionism in national policies More protectionism in trade and investment More regional, bilateral and ad hoc economic cooperation
Sustainability	Sustainability policies and regulations Market-driven changes in products an processes Physical supply chain impacts

Source: Zhan, J., Bolwijn, R., Casella, B. and Santos-Paulino, A., 2020. Global value chain transformation in the decade ahead | VOX, CEPR Policy Portal. [online] Voxeu.org. Available at: <https://voxeu.org/article/global-value-chain-transformation-decade-ahead> [Accessed 24 March 2021].



Of all societal and sustainability challenges that will influence enterprises and their international value chains, it is expected that environmental issues will be the most important driver for change. Countries and regions are increasingly making ambitious commitments to climate action. Sustainability policies, green deals and trade regulations are enforced by governments and spark new political and economic momentum for change.

Environmental challenges for the manufacturing industry arise first of all from the increasing demand for resources and the CO_2 emission involved. This demand is rising due to growth of the global population and better living standards, and – more specifically for critical raw materials- due to the energy transition. In addition, collection and recycling of consumed electric and electronic products leave a lot to be desired, resulting in material losses and environmental[4] and health damage.[5] In the following paragraphs we will explore these environmental challenges further.

Photo: Fairphone

CO_2 impact of resources

In 2020, the International Resource Panel reported that Greenhouse gas (GHG) emissions from the production of solid materials increased from 5 gigatons (Gt) of CO_2-equivalent in 1995 to 11 gigatons in 2015. Their percentage of global emissions grew from 15 percent to 23 percent.[6] The materials with the largest impact were iron and steel (32%), cement, lime and plaster (25%), and plastics and rubber (13%).

Emissions from the production of materials increased from 5 gigatons (Gt) of CO_2-equivalent in 1995 to

11 Gt CO_2 eq in 2015

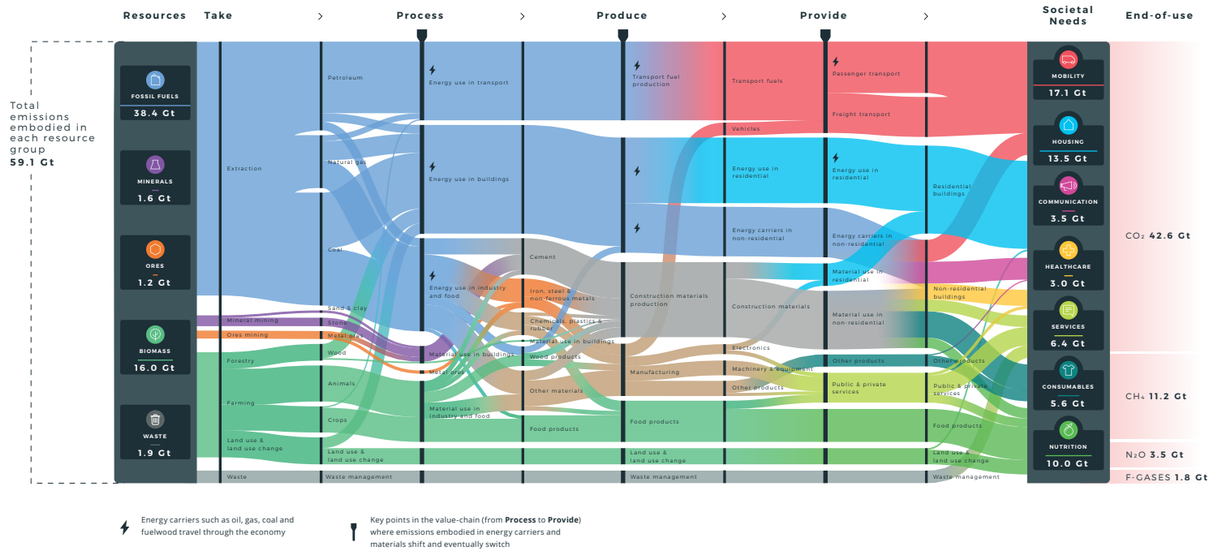
Although this corresponds to the proportion of GHG emissions from agriculture, forestry and land-use change combined, the emissions from material production often get overlooked in the climate debate.

The Global Resources Outlook 2019 points that "if current trends continue from 2015 -2060, natural resources use is expected to grow by 110%, increasing GHG emissions by 43% with catastrophic consequences."[7]

Natural resources use is expected to grow by 110%, increasing GHG emissions by 43%

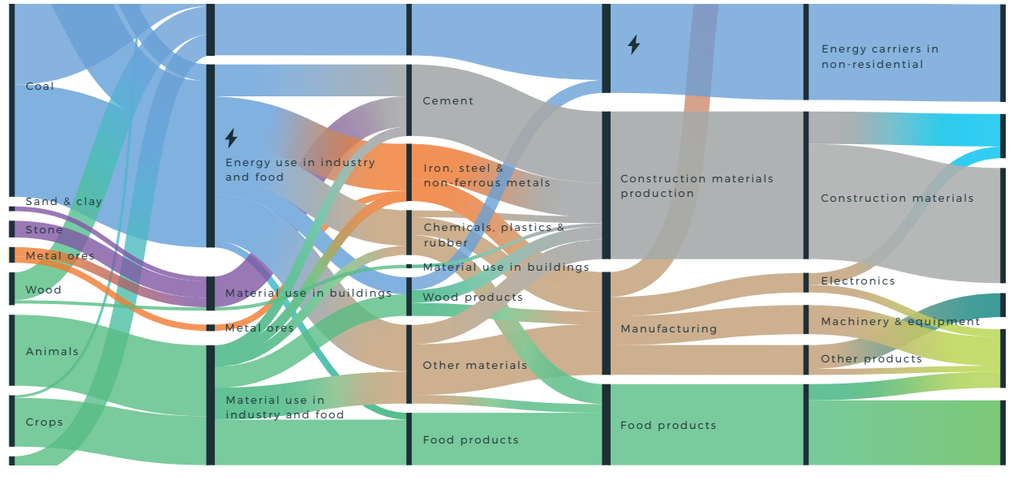
The Emissions X-Ray (figure 1 & 2) in the Circularity Gap Report (2021) shows the significant role of manufacturing in embodiment of GHG-emissions, from materials (and energy) to products.[8] This also indicates that the manufacturing sector is an important player in reducing GHG emissions from resources.

Figure 1: The Emissions X-ray behind global societal needs



Source: Haigh, L., de Wit, M., von Daniels, C., Colloriccho, A. and Hoogzaad, J., 2021. Circularity Gap Report 2021. [Online] Circularity-gap.world. Available at: https://www.circularity-gap.world/2021.

Figure 2: Detail of figure 1: embodiment of energy carriers in products through manufacturing



Pressure on material extraction

The growing demand for electronics, machinery automotive industry, electric transport, aerospace, and sustainable energy technologies is responsible for an increasing use of raw materials. The extraction and production of these resources cause environmental problems and other sustainability issues.

Upscaling of extraction in the very near future is necessary because of the increasing demand for metals and minerals. This is challenged by the fact that opening a new mine is time consuming (10 to 20 years) and requires enormous capital. In addition, raw material extraction is getting more complicated because of declining ore quality.

A source of concern is that many businesses are still unaware of the risks related to resource scarcity and of the solutions circular economy could offer. More awareness has to be raised and new revenue models need to be developed to reduce the reliance of raw materials and reduce environmental impact. Development of new policy is needed to guarantee availability of raw materials and to prevent geo-political conflicts.[9]

Demand for critical materials

The global energy transition requires a rapid implementation of renewable energy technologies.[10] As a result, the extraction and processing of specific Critical Raw Material (CRMs) needed for these technologies has to grow with a factor of 12 by 2050.[11] Calculations showed that additional wind turbines and PV panels needed in the Netherlands alone would require a significant share of the annual global production of some critical materials.[12]

Renewable energy technologies require the global production of specific critical metals to grow at least 12-fold towards 2050

Large-scale transition to electric mobility is another development that will increase demand, while existing products as consumer electronics also require these materials.[13]

An additional challenge is that the mining and production of critical materials is located in a limited number of countries. In order to reduce trade dependency, strategic alliances along the value chain are needed.[14]

Growing waste streams

Globally, 2 billion tons of municipal solid waste is produced a year. Unfortunately, about 33% of this waste is not managed properly creating environmental and health hazards.[15] Municipal solid waste is expected to grow with another 70% to 3.4 billon tons by 2050,[16] following trends in global demand for products and services, population growth, economic growth and consumer behavior.

As electrical and electronic equipment has become an indispensable part of modern life, electronic waste (e-waste) has become the world's fastest-growing domestic waste stream. The Global E-waste Monitor 2020 reported that in 2019, 53.6 (Mt) million metric tons e-waste was generated globally. The stream is expected to grow by 38 percent—74.7 million metric tons— by 2030.[17]

Collection and recycling are being adopted but at a slow pace and much of the waste is not returned to the system. Numerous countries are confronted with inefficiently managed Waste Electrical and Electronic Equipment (WEEE) systems, resulting in a 17 percent rate—9.3 metric tons—. This percentage has increased annually by 0.4 metric tons since 2014. But this quantity is not proportional with the growth of e—waste generated which represents nearly 2 metric tons a year since 2014. This shows that recycling activities are not keeping up with the worldwide growth of e-waste.

Northern Europe proves that higher collection and recycling rates can be achieved. It has the highest percentage in the world regarding formal recycling at 59%[18], due to the early development of e–waste legislation in 2003.

In 2019, the world generated 53.6 million metric tons (Mt) e-waste.

Only 17.4% of this was officially documented as properly collected and recycled

Photo: @Freek van Eijk
Agbogbloshie, Ghana the world largest e-waste recycling dumpsite. The site is home to 80,000 people, many of whom make a living primarily by retrieving and selling copper cable and other metals from e-waste.

Chapter 2

Circular Economy as solution

Defining a circular economy

Circular economy is an alternative approach to the linear economic model and is restorative by intention and design.[19] It is an answer to the global challenges of this century such as climate change and waste generation; replacing the end-of-life concept with restoration, shifting toward the use of renewable energy, requiring fewer virgin resources from the natural system (take), and leaving less emissions and pollution through disposal (waste).[20]

Therefore circularity is an imperative part of a broader transformation of industry towards climate-neutrality and long-term competitiveness. Throughout value chains and production processes, substantial material savings can be realized, generating extra value and open economic opportunities.

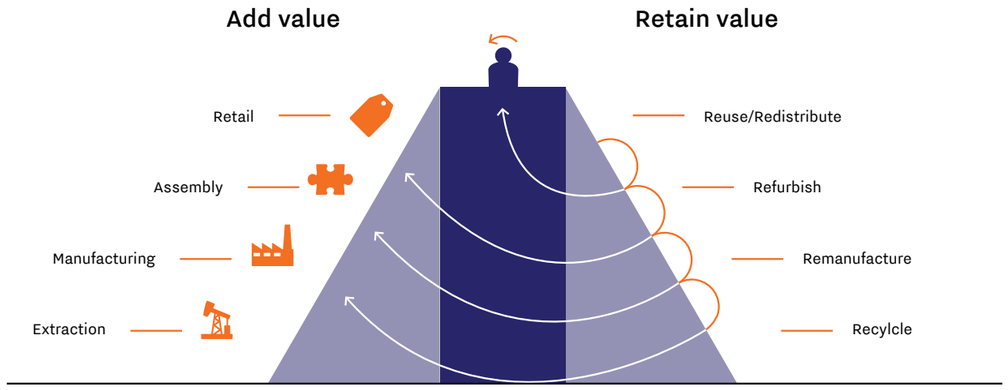
In a circular economy the added value of a product is retained as long as possible, as visualized with 'The Value Hill' (see Figure 4). Circular strategies add value uphill to keep products as long as possible as high as possible on the hill. Products are developed for a long life and are suitable for good maintenance and repair, thus slowing the use of resource loops and prolonging the use phase. Finally, products are cascaded as slowly as possible down, back into the Value Hill where they can serve as useful resources.[21]

The benefits of a circular economy

Materials Economics investigated how a more circular economy would contribute to the reduction of CO_2 emissions in light of the Paris Agreement targets. Including opportunities for the four largest materials (in terms of emissions); steel, plastics, aluminium and cement and the two largest associated use segments for these materials, the research showed a substantial role for circularity. Deep cuts to emissions from heavy industry are possible: as much as 296 million tons CO_2 per year in the EU by 2050 in an ambitious scenario, out of 530 Mt in total. Globally, some 3.6 billion tonnes per year.[22]

The Ellen MacArthur Foundation argued in their 2014 'Towards a Circular Economy'-report, that choosing circular is not merely an operational decision, as well strategically beneficial. Substantial net material savings can be realised and the Ellen MacArthur Foundation calculated that closing cycles would reduce net raw material procurement costs by 19-23%. Annually, this leads to savings of €460 to €550 billion. TNO calculated specifically for the metal industry in the Netherlands that this sector could earn around €575 million annually by focusing more firmly on circularity.[23]

Figure 4: The Value Hill

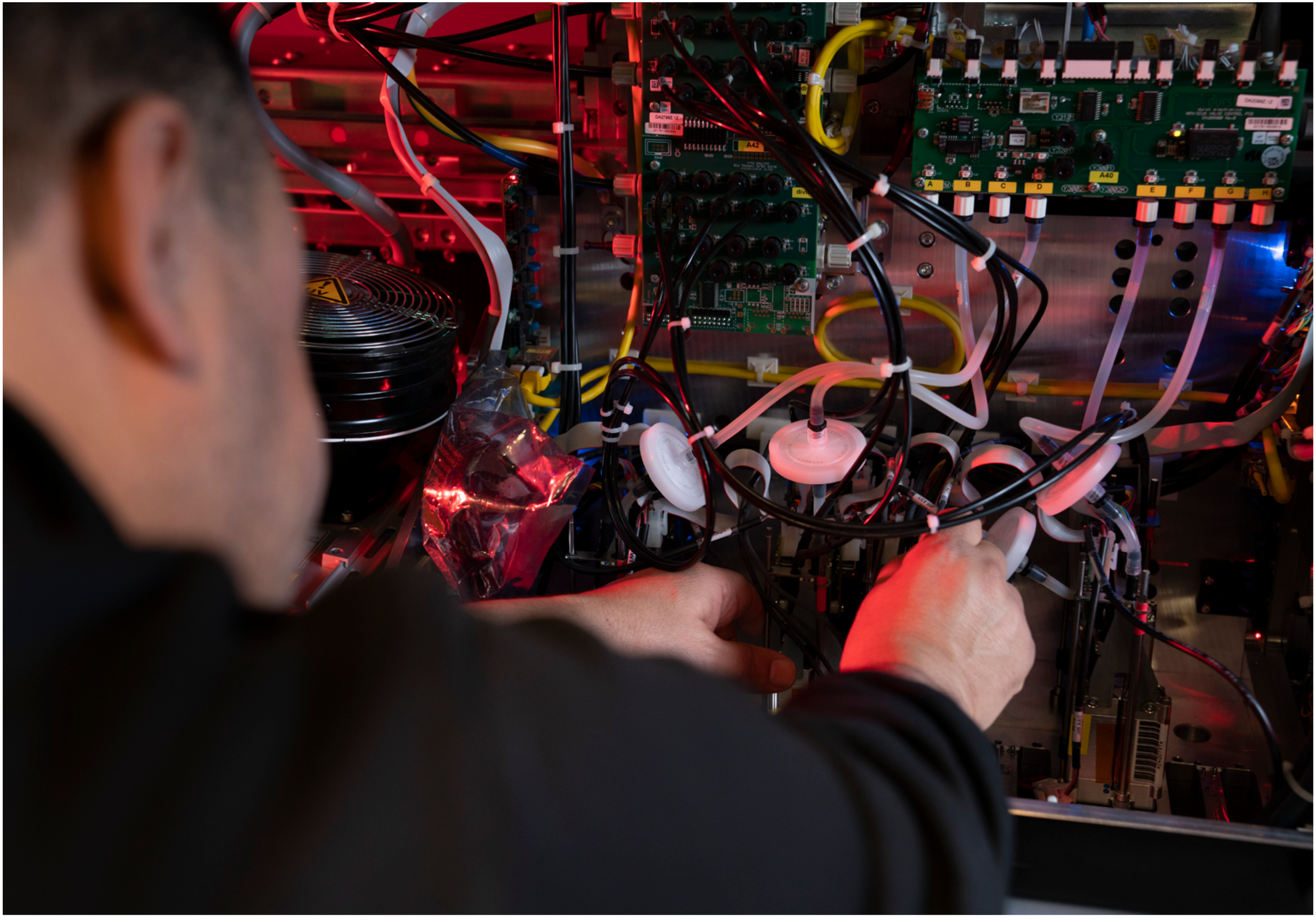


Source: Achterberg, E., Hinfelaar, J. and Bocken, N., 2016. Master circular business with the Value Hill. [online] CIRCO. Available at: https://www.circonl.nl/resources/uploads/2019/11/value-hill-white-paper.pdf

Photo: Circo

Globally, a more circular economy could avoid

3.6 Gt CO_2 per year by 2050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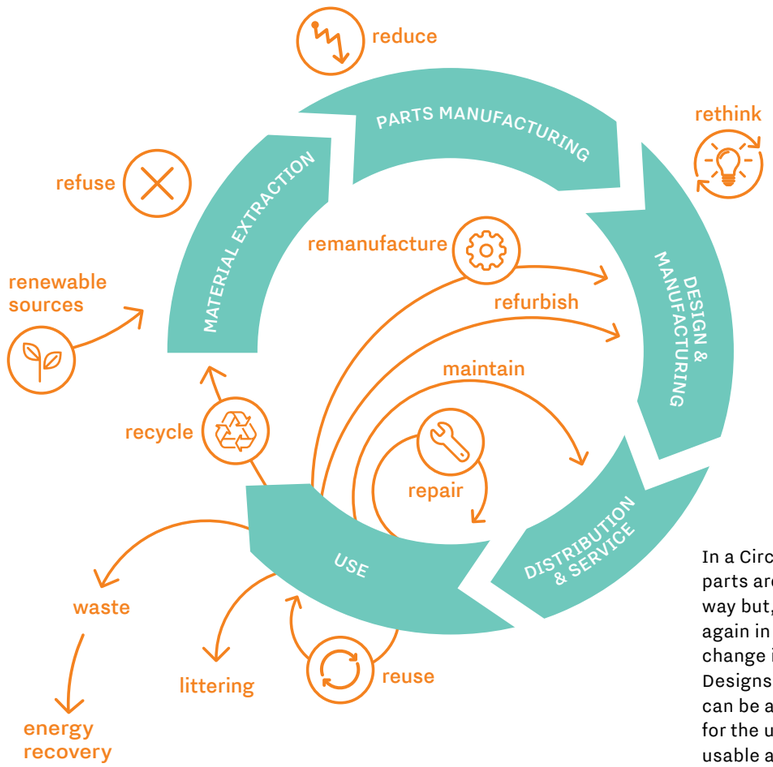
Chapter 3

What is a circular manufacturing industry?



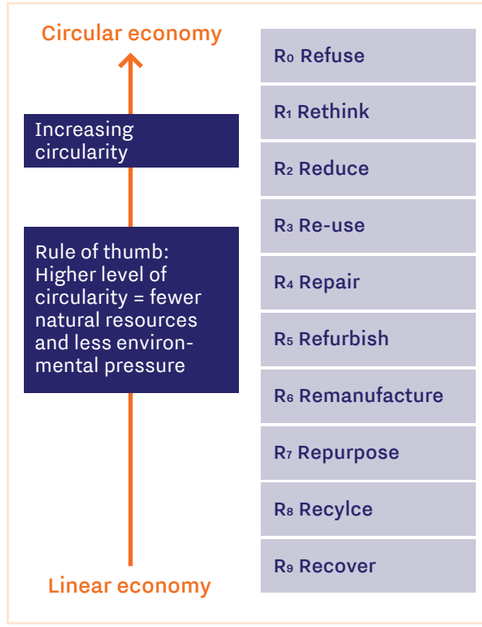
In a Circular Manufacturing Industry, products and parts are not thrown away or recycled in a low-grade way but, after inspection and processing, are used again in a high-quality manner. This means a radical change in the current way of producing and selling. Designs aimed at an optimal lifespan. Products that can be adapted every time, so that they remain relevant for the user. And, if there is no other option, recover usable and valuable materials as pure as possible, so that they can be reused as well.[24]

Photo: Swapfiets

10 R-hierarchy of circularity

For materials to function in a circular economy, the 10 R-hierarchy of circularity can be applied. The R strategies correspond to different levels of value retention of the products,[25] as illustrated in the value hill. Generally, the more value retention can be kept, the higher circularity and reduction of pressure on the environment. The 10 strategies are divided in three groups: Circular Design, Lifetime extension and Recycling.[26]

Figure 5: Levels of Circularity

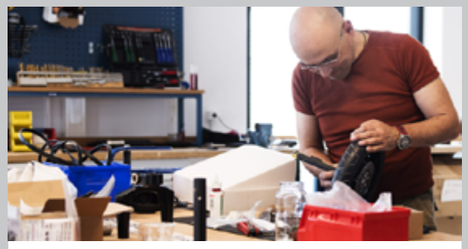


Source: Rood and Kishna (2019), Outline of the Circular Economy. PBL Netherlands Environmental Assessment Agency, The Hague. Available at https://www.pbl.nl/en/publications/outline-of-the-circular-economy

Circular design (R0-R2 Refuse, Rethink, Reduce)

Design sits prominently at the heart of the circular economy. It requires us to redesign everything: products, business models, and the linear systems that have lasted for the past centuries.

Product designers can 'refuse' (R0) the use of specific materials or offer the same function with a different material, or with less material. For instance, digital solutions like Spotify can provide similar value as their hardware counterparts. With the circular strategy 'rethink' (R1), product use is made more intensive e.g., through sharing products, or by making the product multi-functional and easy to change through modular design. At the start of the design phase, there is the possibility of eliminating certain materials and thereby to have an influence on the waste streams after the end of product life. The circular strategy 'reduce' (R2) focuses on the efficiency of manufacturing a product and the reduction of materials in their design, with the common goal of using fewer natural resources and materials.



Designed to last

Bugaboo International is a Dutch design company that develops and produces strollers and other modern parent products. The products are designed for long life, easy repairability and multifunctional use. Wheel broken or torn upholstery? Everything about Bugaboo strollers is replaceable so they last as long as possible and can be adapted to the user's taste. Material choice is optimized for each part based on purpose and expected lifetime. Bugaboo clicks and screws connections as much as possible to avoid that different materials become inseparable.

Creating sustainable working environments

Ahrend is an international leader in office furniture and space solutions. In the last 30 years, sustainability and circularity have played a big part in their corporate strategy. Ahrend uses the 'less is more' approach for its products. It starts with modular design, allowing components to be removed or replaced, which facilitates reuse and saves natural resources. Product value retention is achieved through large scale refurbishment, re-manufacture or re-purpose activities. Ahrend offers 'Furniture as a Service', maintaining ownership of their products and assisting the user with different services.

Photo: KPN

Durable, ethical and smart mobile phone designed to last

Fairphone developed the first ever ethical phone in the world with conflict-free minerals and Fairtrade gold in their supply chain. The company made a breakthrough in modular and repairable design to prolong lifetime and break with the two-year cycle of the average smartphone. Repairs to the smartphone are simple and quick compared to other smart-phones, spare parts are easy to get a hold of and software is relatively future proof. Its display, for example, can be replaced within minutes, for just the fraction of the cost compared to non-modular smartphones. The company had sold more than 250.000 Fairphones since its foundation in 2013 until the present.

Building resilient supply chains for critical raw materials

KPN is one of the 5 most sustainable telecom companies in the world and wants to be close to 100% circular operations by 2025. This is why KPN works on circular design, re-use and recycling, starting with 15 iconic products like the TV-receiver, modem and remote control. Aim is to introduce design criteria and set standards with suppliers. In 2019 KPN started assessing the role of critical raw materials in the supply chain of these key products. Now they develop strategies together with suppliers to mitigate risks and achieve circularity of critical raw materials. Future technology developments are monitored to keep track of changing impacts on supply chain resilience.

Lifetime extension (R3-R7 re-use, repair, refurbish, remanufacture, repurpose)

When a product is in use there are different circular design strategies applicable to extend the lifetime of a) the product, b) structural elements or c) product parts. When the life cycle of a product has come to an end, this does not mean the life span of a components have come to an end.

A circular strategy applicable is 're-use' or 'resell' (R3). With re-use, a product hardly needs any adaptation and provides the same functionality with the same purpose on a different location.

Repair (R4) and maintenance of defective products or components ensure they can be used with their original function. Much of the current circular activities in the Dutch manufacturing industry concern the repair of all kinds of products, such as bicycles and cars. These are mostly craft companies that have been a common part of the economy for years. In recent discussions, these activities are often not recognized at all or recognized not as circular, while they do contribute to the circular economy.[25]

Refurbishment (R5) is most adequate in cases where the overall structure of a large multi-component product is used. This strategy focuses on restoring an 'old' product and brings it up to date. A product consisting of multi-components, is remanufactured (R6) when it is disassembled, checked, cleaned and when necessary, replaced or repaired into a new product with similar or enhanced functionality.

Remanufacturing and refurbishment are key strategies within the circular economy and are expected to play a major role in a resource-efficient manufacturing industry. In addition to its environmental benefits, remanufacturing and refurbishment provide opportunities for the creation of added value, highly skilled jobs and economic growth. In 2015 ERN estimated the size of the European remanufacturing industry to be just under €30 billion, employing around 190,000 people. The market study also showed that the industry could grow to €90 billion by 2030 and employ as many as 255,000 people.[27]

When discarded parts are adapted for another function, the circular strategy 'repurposing' (R7) is in place. The discarded parts and materials get a distinct new life cycle.

First robotized electronic remanufacturing plant

Alec (Advanced Lean Electronic Components) has 15 years of experience in developing and performing high-quality remanufacturing of electronic components from vehicles. From their facility in Munich (D) they serve multinational companies throughout Europe. The remanufacturing starts with an initial inspection of the components by technical experts. Then, the products are transferred to a fully automatic remanufacturing process. Robots take the products to the relevant department, where they are diagnosed with extreme precision and then remanufactured and tested.

Specialist coating prolongs lifetime and saves material

Revamo's activities can be divided into two groups. In one group, existing machine parts are repaired with laser cladding and thermal spraying and additional techniques to the specifications of new parts, or even better. Resulting in a CO_2 footprint of 10-15% compared to a new part. In the second group, a coating is applied to a new product in order to obtain better specifications and to reduce the total cost of ownership. For a pump manufacturer, they coated the part of the pump shafts that needed to be chemically resistant and prevented the entire shaft from being made of the precious material. Other examples include coating critical machine parts to extend service life and reduce maintenance frequency.

Second life for ICT equipment

SNEW's mission is to give business telecom and IT a second life. Companies who hand over their depreciated ICT equipment can be sure all data will be removed certified and will receive a fair price for their old equipment. SNEW can also provide maintenance for their current equipment even after the end of the initial provider warranty and customer support. In the recent years SNEW has built some great partnerships with NGO's, universities, governments and several key players in the ICT industry. Since 2013 they have given a second life to over 200,000 products. SNEW is looking for new partnerships with European companies across the ICT chain.

Gearing up (re)manufacturing

SEW-EURODRIVE is known as one of the major international players in the development of motion control and industrial gearboxes. These drive units are extremely suitable for remanufacturing. The Dutch division developed a new approach to repair. In the event of a defect, clients can choose for remanufacturing for a fixed price. The drive is disassembled, the reusable parts and the new parts are put together and the whole is assembled as new. The drive is tested, given the same warranty as a newly engineered product, and is returned to the owner within three working days. The new approach resulted in remanufacturing of around 2,000 'old' drives per year.

Creating a worldwide network for remanufacturing

Lely operates within an early adaptors market with high innovative solutions for dairy farms. In 2011 Lely started a centralized remanufacturing program to create trust and activate new customers to make the step to robotization with refurbished equipment. In 2018 the worldwide franchise network of Lely Centers was involved to decentralize the remanufacturing strategy and create certified refurbishment business, reducing also transportation. Currently about 10% of the robots sold is pre-owned. Due to effort and technology adoption this will soon reach 30%. Remanufacturing extends the initial lifetime of 10-14 years with an additional 5-7 years. To create access to second-hand Lely launched an open trader platform in 2020.

Recycling (R8-R9 Recycle, Recover)

Recycling (R8) includes processing material to obtain the same (high grade) or lower (low grade) quality. This means that these materials can be used as a resource for new components within the same product. Materials can also be used to recover (R9) energy by incinerating the materials.

Metal recycling has already a long history. However, new innovative technologies are developed that focus on specific waste streams like metal that is contaminated with asbestos or that retrieve a larger variety of metals from electronic waste.

Pragmatic solutions for Sustainable ICT

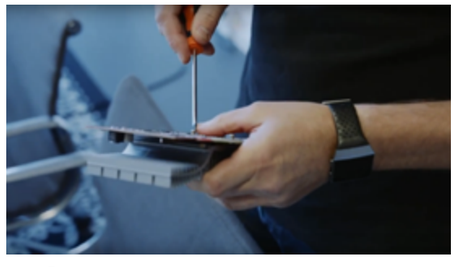
Instead of a high level, long term topic, Closing the Loop sees circular economy as a practical tool to start implementing sustainability today. The company's basic value proposition is quite simple: the customers pay as a small fee per device, a mobile phone, a tablet or laptop, and Closing the Loop collects and recycles an equivalent amount of electronic waste from countries where it is needed the most. This approach showcases that circularity is not only about long-term visions, but provides organizations with a way to get started on circularity today. Closing the Loop works with clients and partners, such as Samsung, Ingram Micro, KPMG, the Dutch Central Government and T-Mobile, to create value.

CLOSING THE LOOP

Local collection of old electronic devices and textiles

The E-waste Race is an educational competition between ten primary schools to collect old electronic devices. Participants of the project get an introductory lecture about reuse, recycling and the valuable materials electronic devices contain. Then they start collecting e-waste and the school who collects most e-waste wins an educational and fun school trip. The project was initiated in 2014 in the Netherlands and over 100 races with 1000 schools were organized, with 1,6 million of old electronic devices collected.
E-waste Race organizes the first E-waste Race in Germany in 2021." After great success they launched a similar education project about circular textiles in 2020: 'Textiel Race'. During the pilots already 40.000 kg of post-consumer textiles were collected for reuse and recycling and 800 clothing-items were repaired by kids to gain extra points in the competition.

E-WASTE RACE



Extracting Critical Raw Materials from complex waste flows

Circular Industries has developed an Urban Mining Factory that extracts (Critical) Raw Materials from low-grade Printed Circuit Boards. A new configuration of widely proven technologies enables the conversion of a maximum number of 99.99% pure elements without toxic emissions and residual flows. This makes the factory futureproof for increasing miniaturization of electronics with low yields of metals. The first factory will be located in the Netherlands, the home base of Circular Industries. After that, an international expansion strategy will follow to become the leading player in this field.

CIRCULAR INDUSTRIES

The role of new business models

In a circular economy, products last longer and retain as much value as possible. To achieve this, additional services are required such as repair, upgrading and take-back of end-of-life products. After that, a shift from "ownership" to "use" can be attractive: a model in which the user no longer buys the product but pays for the solution. The business model is changing and with it the revenue model.[21] A well-chosen revenue model helps to make a circular business model commercially successful and to increase the circular impact. Revenue models such as rental or lease are not new in themselves. It is mainly the way in which they are elaborated that determines how circular they are.

Making cities more livable

Swapfiets is the world's first 'bicycle as a service' company. Founded in the Netherlands in 2014, it now has 220.00 members in 9 Europeans countries and is still expanding. For a fixed price per month, you get a Swapfiets bicycle with the distinctive blue tyre, and the guarantee your bicycle always works. If the bicycle is broken, a working bicycle is delivered for free at a chosen location. Swapfiets has started to design its own products that last, while being easy to repair, reuse and recycle. For every single bike a passport is created to monitor every piece of material in the supply, from chain to saddle, helping to avoid wasted resources and the need for producing new components.

Swapfiets

Selling performance

Mitsubishi Elevator Europe offers with M-Use® the use of elevators instead of ownership. The customer closes a contract based on the expected performance: minimum outage and maximum availability, far above market standard and against contractual penalties if this Service Level is not achieved. By providing additional contractual insurance, Mitsubishi can provide the necessary service and collateral is provided for their investment, there is no initial payment for installation. The M-Use® elevator remains in the maintenance portfolio for at least 40 years, supported by life-extending capabilities through innovation, sensors and remote monitoring. This is resulting in extremely low operating costs, so that the costs for the building owner are not higher, despite the financing component. After the usage period, based on the enclosed material passport, customers will be offered money for the components / materials in the shaft to enable high-quality re-use and when a higher level is not applicable: ultimately recycling.

MITSUBISHI ELECTRIC

Chapter 4

High Potential sectors for Circular Innovation

To answer the need for an effective and fast transition, it is key to focus on sectors that combine a large potential for decreasing environmental impact with opportunities for economic benefit. Within the manufacturing industry, 5 clusters of products can be distinguished with different characteristics (see figure 5).

Each cluster has its own opportunities and challenges for a circular approach, but the most potential can be found in the cluster Capital Goods. Other influences like the energy transition or digital transformation can create momentum for change in specific sectors and product groups. Clustering according to characteristics for circularity enables us to link the right circular strategies to the clusters.

Based on the complexity and intrinsic value and lifespan of the products, the following six projects were determined as they can form an innovation system in conjunction.[28]

1. Circular Windfarms
2. Capital Equipment
3. Smart Industry
4. Batteries for e-mobility
5. Circular solar systems
6. Heat as a service

For each of the projects the Dutch Circular Manufacturing Implementation Program had knowledge institute TNO calculate the potential CO_2 impact and economic impact for the Netherlands based on the applicable circular strategies. Although these impacts cannot be extrapolated directly to the global impact, they do give insight in the relative impact of the different strategies.

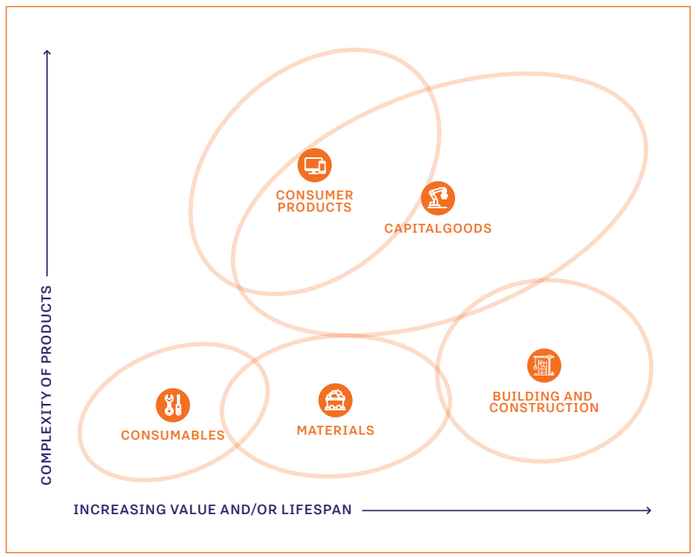


Figure 5: Product clusters within the manufacturing industry

Source: Uitvoeringsprogramma Circulaire Maakindustrie/ Ministier van Economische Zaken en Klimaat, 2020. De industrie maakt het circulair: Facts & Figures about the circular transition of the manufacturing industry. Available at: https://circulairemaakindustrie.nl/app/uploads/2020/12/Feiten_Cijfers_CirculaireMaakindustrie.pdf

Circular Windfarms

Onshore and offshore wind energy plays a critical role in the renewable energy ambitions of Europe. The upcoming years will be crucial for the wind industry in the transition towards a circular industry. The share of wind energy in the European electricity supply mix was 14% in 2018. This will increase towards 50% in 2050.[26] The first large batch of wind turbines is quickly reaching the end of its lifetime. The residual flow is already creating challenges. At the same time, the wind industry is installing a new, unprecedented capacity of wind energy.

Impact in the Netherlands

Circular strategies / CO_2 impact (Kton/year)

R0-R2 Circular Design	24
R3-R7 Lifetime extension	24
R8-R9 Recycling	142

This poses new questions, such as: where can we find the critical metals needed for additional wind turbines? How can we use the wind turbine parts or materials that are coming available with minimal loss of quality? How can we design new turbines with circularity in mind?

In the Dutch Moonshot Project on Circular Wind Farms (2020) , concrete steps were taken towards the integration of circularity in the wind industry and to realise transformations in the supply chain. The project was commissioned by Versnellingshuis Nederland Circulair! and executed by ECHT. The first phase of this project has focused on identifying the challenges that come with the transition from a linear to a circular wind industry. More than 100 companies and governmental institutions active in the wind energy industry shared their views and knowledge, showing their commitment to the circularity transition of the wind industry.

During the stakeholder sessions came to light that current initiatives are mainly focused on the material streams that become available after the decommissioning of wind turbines. To preserve the quality of structural elements, the future focus on circularity should be broadened and include circular strategies focused on product design and lifetime extension.

The participants of the project have identified circular opportunities that are translated into nine circular action agenda themes:

1. Circular tender criteria regarding wind farm projects
2. Modular design of the structural elements
3. Collaboration in design with partners in- and outside the wind energy sector
4. Environmental-specific foundation design and usage
5. Retaining data (e.g. on modules, components, and material levels) for decommissioning and EoL strategies
6. Responsibility of materials (or components) to enhance circularity
7. Rare earth elements (REE) refinery strategies
8. Circular clusters of companies around ports
9. Platform for European wide circular collaboration

Together with 50+ supply chain partners within Europe a three-year program is started with working groups for each theme: The Circular Wind Hub. Commitment of the stakeholders will be created and sustained by organising large involvement of industry partners and adjusting the theme focus whenever necessary. Creating consortia within the wind industry is key next to organising synergy with related sectors on shared challenges.

The wind industry transcends the borders and is a perfect example of European collaboration. While the German and the Danish are excellent manufacturers, the Dutch excel in transport and installation. Countries like Germany, Spain and France are already large consumers of wind electricity and time will tell which countries will excel in end-of-life strategies. Therefore it is key for companies in the wind industry to change to more circular value chains on a European level.

It is recommended to start an EU-wide platform that aims at increasing transparency between projects. Inspired by the EU Battery Alliance, a Circular Wind Energy Alliance may be the answer for the wind industry in its road towards circularity.

A committed industry in the complex road towards circularity is important to accelerate this transition. Therefore, it is recommended to continue organising sessions to keep the momentum and enthusiasm in this transition and to keep developing circular action agenda projects that can be further developed and tackled by the industry.

Finally, it is recommended for EU Member states to have a focal point to help companies in the wind industry with EU legislation, finance, and collaborations for sustainable and circular development.

In-depth focus on circular business opportunities

In November 2020 the CIRCO track ‘Circular Wind farms’ attracted a wide range of participants from the wind energy value chain, from manufacturers to marine contractors and the port authorities of Rotterdam and Amsterdam. In this three-day workshop the companies developed circular business propositions together. They identified value loss in the linear business model, ranked the value losses on influence and impact and translated into circular business opportunities. Various design strategies were thought through. The most potential business cases were further developed like offshore disassembly, onshore decommissioning infrastructure and cable recovery and reuse.

CIRCO creating business through circular design

Photo: Philips

Capital Equipment

Capital equipment represents a broad group of physical hardware products as diverse as servers, medical scanners and machinery. These products enable us to meet a wide range of societal needs while also expanding what we can achieve in areas such as connectivity, healthcare and logistics. Production of capital equipment uses 7.2 million tons of resources per year (6.5% of global annual material consumption) and uses more than half (56%) of global ore consumption.[29]

In the capital equipment sector, the financial capital -invested and at stake- is relatively high. Because of this, the capital equipment sector is leading the way in many aspects of the transition to a circular economy. For example, their customers, mostly in a business-to-business setting, are more used to service-based business models which can lead to higher circularity. This means capital equipment can offer important lessons to other industries.

In a circular economy, capital equipment products are designed with reuse in mind, using fewer resources in production—especially non-renewable resources—and more refurbished or reused components and recycled materials, as well as materials that can be economically recycled, reducing demand for natural resources and pollution. Digitally enabled maintenance, shared access, and services that see beyond one-off sales to focus on functionality instead of material goods offer innovative ways to keep products in use for longer, reducing waste.

Instead of being sent to landfill or uncontrolled incineration, products no longer suitable for use are refurbished, remanufactured, repurposed or used for parts harvesting—extending the lifetime of other products that are still in use.

The Platform for Accelerating the Circular Economy (PACE) launched a Circular Economy Action Agenda for the Capital Equipment Sector in 2021 with 10 calls-to-action[30] (see p.48).

The Dutch Circular Manufacturing Implementation Program has started to identify and activate product groups in the High-Tech Equipment sector where the most added value can be created. Development of material passports and new standards to validate the economic value of reuse will be part of this. The knowledge will be applied in the value chain of machine construction and process installations, with special attention to the role of the suppliers. The Dutch Implementation Program will closely align priorities and collaborate with the (Dutch partners in) the PACE Capital Equipment Coalition.

Keeping medical devices in use for as long as possible

Philips has set the goal of obtaining 25% of their revenue from circular products, services and solutions by the end of 2025, and is currently already at 15%. In addition, Philips is committed to offering a trade-in on all medical equipment by 2025. This builds on a long experience of trading in large medical devices. Philips refurbishes devices or reuses parts to create a new use cycle and maximize life-time value. When that is no longer an option, they recycle materials in a responsibly way.

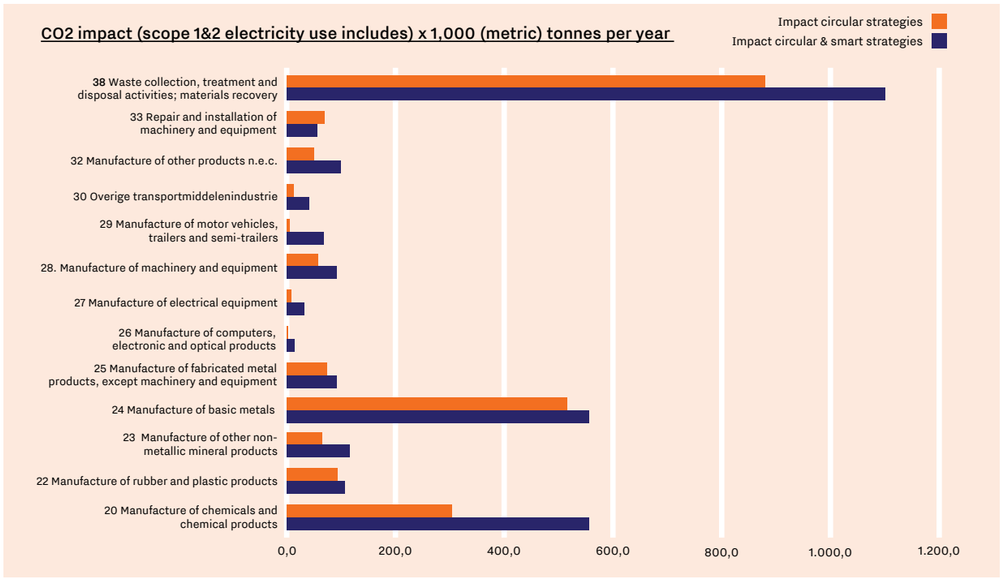
Photo: Lely

Photo: ASML

Smart Industry

By combining servitisation and smart technologies with resource efficiency, the circular economy has the potential to become the “new business as usual” for the manufacturing industry. Innovations in the manufacturing industry contribute to a more circular economy. In most cases, the use of sensor technology is crucial in achieving these results. In that sense, «smartness» makes a strong contribution to more efficient use of materials at the companies themselves and at their customers. This also translates to reduction of CO_2 emissions in addition to the reductions achieved by circular strategies (See figure 6 for expected impact in the Netherlands). The manufacturing industry can thus form a source of inspiration for many other sectors and entrepreneurs.

Figure 6 Potential CO_2 impact of circular strategies and additional smart manufacturing strategies per sector



Source: Ton Bastein, Toon van Harmelen, Mara Hauck, Diana Godoi Bizarro, Sara Wieclawaska, TNO (2021) De impact van slim èn circulair -hoe innovaties in de maakindustrie bijdragen aan een lagere footprint-

In a research project by Dutch knowledge institute TNO more than 70 companies were interviewed about the combination of smart and circular technologies.[31] The research showed that the smart manufacturing companies already act circular in many ways. By their nature, original equipment manufacturers and system suppliers design their products in such a way that repairability is high and thus uptime at their customers is as high as possible.

The innovations and business models that were encountered during this survey contribute to a further reduction of the use of materials in 5 different ways:

1. Circular design of products to be able to offer better maintenance to customers (generic to all OEMs and system suppliers)
2. More efficient use of raw materials by production companies (more efficient production, 3D printing, use of production waste)
3. Lifetime extension of components and products (through remanufacturing, maintenance contracts optimized by ICT sensors, upgrading)
4. Asset sharing: making more intensive use of production equipment by not purchasing machines yourself, but by sharing capacity (ICT enabling to reveal the availability of the asset at any time)
5. Keep control over goods by retaining ownership (and therefore also controlling the return flows) and only offering the services that the products deliver (ICT revealing the condition of the asset, thereby also facilitating pre-financing)

The Dutch Circular Manufacturing Implementation Program will work with four Dutch provinces with the largest presence of manufacturing industry to integrate smart industry and circular economy. With companies in selected sectors synergy will be sought with digitization, artificial intelligence, photonics, sustainability, energy transition, resource scarcity and business opportunities.

Selling smart solutions instead of products

Aebi Schmidt develops and produces machines and vehicles for de-icing, street cleaning and garden cultivation. But more than selling machines they provide solutions for their customers based on performance guarantees, changing the focus from the product to the result it delivers: a clean and safe road. For 15 years Aebi Schmidt is using data collection which enabled them to develop smarter propositions. Data controllers collect performance and technical data of the machines’ performances during their lifetime. The data is analysed – in many cases – together with the customer. This can result in the decision to buy less machines or to upgrade machines instead of buying new ones."

aebi schmidt group

Batteries for e-mobility

Electric vehicles are a promising solution for cleaner, more efficient passenger transport. However, the current global production of critical metals like lithium, nickel, cobalt, graphite and manganese will need to be scaled up drastically to support a large-scale transition to electric transport. When looking at future prospects, the worldwide demand for some of these metals, as a result of electric transport, is forecasted to exceed current annual global production by three times in 2030.[12] Batteries can possibly be reused for the storage of sustainable energy. Even though, there always comes a time when the battery must be recycled in order to recover the raw materials.

In several member states of the European Union, companies are already participating in the European Batteries Alliance, benefiting from private sector, EU and national funding, both for the exploitation of the raw materials and for their processing in Europe. The forthcoming proposal for a Batteries Regulation will address the responsible sourcing of battery raw materials and the European Commission is considering making a horizontal regulatory proposal on due diligence.

Impact in the Netherlands

Circular strategies / CO_2 impact (Kton/year)

R0-R2 Circular Design	
R3-R7 Lifetime extension	17
R8-R9 Recycling	3

The Netherlands is looking into business opportunities to extend the lifetime of batteries and to start up a recycling industry. Currently, more than 40% of all new bicycles sold in the Netherlands each year are E-bikes.[34] In 2020 this came down to 420,000 new e-bikes and in 5 to 8 years the batteries of almost all those bikes will be replaced.[34] However, the real volume will come from the batteries that are used in an electric car or city bus. With the ambitions of the automotive industry, all new cars should be fully electric by 2030, which is 420-440,000 cars annually in the Netherlands alone. Each car contains 250 kg of battery materials, which means every year 120,000 tons of batteries will have to be recycled. A quick calculation shows that in the long term 120,000 tons of batteries will have to be recycled from the electric cars alone. Buses and other transport can provide just the same amount.

Bringing new energy to batteries

NOWOS supports business-to-business customers with circular design, repair and recycling of Li-ion batteries used in e-mobility. They manage to repair 70-80% of the batteries they receive. By using original components and other measures the products continue to comply with European legislation and standards. If repair isn't possible the reusable components are removed. What is really broken goes to the recycler. Nowos reaches out to battery manufacturers to influence the design so that they can be better repaired and recycled. Started out in the Netherlands in 2019, NOWOS opened a new repair facility in France in 2020.

NOWOS

Photo: Nowos

Circular Solar systems

Solar panels and installations are a necessary part and one of the most promising technologies of the energy transition. The solar photovoltaic (PV) market is growing rapidly: almost 80% of the installed capacity worldwide has been realized in the last 5 years and it is expected to be the largest form of sustainable energy worldwide by 2030. For the production of solar panels raw materials with a large ecological footprint are needed. Silver is a critical raw material for the widely used silicium based solar panel. Other technologies are using indium and tellurium: materials that have the risk to become scarce. With waste PV modules globally to amount to 1,7–8,0 million tons cumulatively by 2030 and to 60-78 million tons cumulatively by 2050 solutions are needed.[32]

The recycling industry is currently still in its infancy. In theory, solar panels can largely be recycled, but in practice the solar panels that are now on the market are only partially recyclable. To become circular, new solar panels should be designed in a way they can easily be recycled and they should be produced from well-stocked and low-impact materials. Existing panels should be used as long as possible and be recycled at the end of their lifespan to a high standard. As solar panels are part of a larger system, attention should also be paid to supporting structures, inverters, cables, etc.

Impact in the Netherlands

Circular strategies / CO_2 impact (Kton/year)

R0-R2 Circular Design	6
R3-R7 Lifetime extension	6
R8-R9 Recycling	142

Solar panels are on a large scale produced in China, but they are also made in the United States, Europe and in the Netherlands. Research in the field of circularity of PV now often takes place in European and Dutch projects under the flag of the International Energy Agency (IEA). In the European Union plans are discussed to implement guidelines for circularity of solar panels in the Ecodesign Directive. In their 'Kennisnotitie zonnepanelen' [32] (Knowledge document on solar panels) the Dutch Province of South Holland lists research questions that should be addressed on an international scale:

- How do we currently produce solar panels so that they can be recycled in the best possible way?
- How do we produce solar panels with as few scarce and toxic materials as possible?
- How do we extend the lifespan of panels to 35 to 40 years?
- What are good "design for recycling" guidelines?
- What is the best balance between lifespan, price and durability?
- How do we ensure that project developers have a business case that guarantees the sustainability of panels (eg a business case that stimulates reuse or high-quality recycling)?
- How do we ensure that parts of solar panels can and will be reused?
- How do we ensure that all materials from panels are recycled to a high standard?

The Dutch Circular Manufacturing Implementation Program will focus on re-powering, refurbishment and upscaling of circular solar panels, and high-quality recycling. Building an (international) coalition for a successful solar value chain will be an important task.

Driving force towards a circular transition of the solar industry

Circular Solar Energy is one of the focus themes within the Circular Strategy "Samen Versnellen" (accelerate together) of the Dutch Province of South Holland. The province stimulates the use of solar panels but is at the same time aware of the critical materials used and the ecological impact of manufacturing and end of life. The province embraces a transition management approach with explorations of frontrunners to see how South-Holland could contribute to a more circular solar energy transition. In 2020 the province has built a network of experts, organised a learning circle with municipalities, initiated a circular design track with businesses and made an inventory of available knowledge. In May 2021 the province hosts "a Helpathon"; an event with this solar network to co-create a circular solar energy transition agenda.

provincie Zuid-Holland

Heat as a service

One of the major challenges of the energy transition is heating of homes and buildings. Fossil sources like oil and natural gas will have to be replaced by sustainable energy sources, such as solar energy, green gas or district heating on biomass. This offers huge opportunities to minimise the footprint of buildings, introduce healthy and renewable materials and use smart technology.

The building sector is one of the largest energy consumers in Europe and is responsible for more than one third of the EU's emissions. Many buildings in the European Union still rely on fossil fuels for heating and cooling, and use old technologies and wasteful appliances. Currently only 1% of buildings undergo energy efficient renovation every year, so effective action is crucial to making Europe climate-neutral by 2050. In 2020 the European Commission published a new strategy to boost renovation called "A Renovation Wave for Europe – Greening our buildings, creating jobs, improving lives".[33] It aims to double annual energy renovation rates in the next ten years. A refurbished and improved building stock in the European Union will help pave the way for a decarbonised and clean energy system.

Impact in the Netherlands

Circular strategies / CO_2 impact (Kton/year)

R0-R2 Circular Design	349
R3-R7 Lifetime extension	349
R8-R9 Recycling	58

In 2019 the Dutch heating sector has set the ambition to offer Heat as a Service with the guarantee of the lowest possible CO_2 emissions for the best price. This target falls under the larger goal of the sector to be fully circular by 2050 and to accelerate the energy transition. Traditionally an outdated or defective installation is replaced by a new one and the old product is seen as waste. About 375,000 boilers in the Netherlands are replaced every year in this way.[9] In many cases, the old, discarded boilers still contain properly functioning components. In the new circular economy, this is seen as a source of valuable raw materials. Heat supply is also considered from this perspective. After as successful project in the housing market in 2020, in 2021 the activities will be extended to the utility construction market. The Heat as a Service roadmap focuses mainly on circular system designs, circular business models and concrete propositions for the lifespan extension and refurbishment of heating systems.

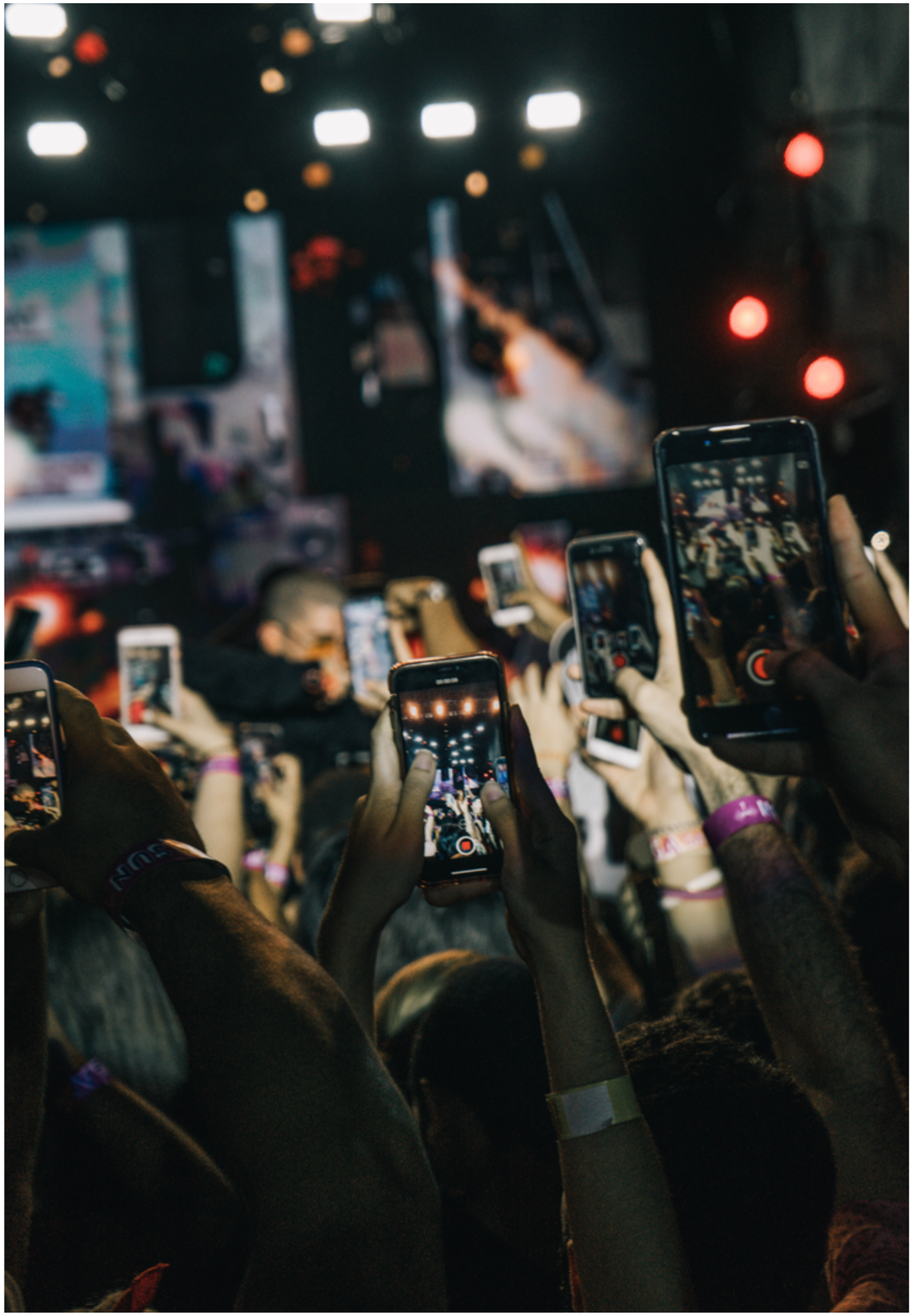
Circular strategies to deal with the energy transition

Boiler manufacturer Remeha expects that in 30 years' time, natural gas-fired central heating boilers will no longer exist. Heating as a service will be the future, and it will differ per case whether this is done via a heat pump, heat network, hydrogen or something completely different. At this moment Remeha already refurbishes gas air units, safety devices and control boxes and sells them again with a 2-year warranty. Mechanics are encouraged by a trade-in premium to return valuable boiler parts. Remeha repairs and tests the parts and sells them again. Together with partners they are working on further development of heating as a service.

remeha

Chapter 5

Circular manufacturing: next actions for transition



As we have seen in this publication, the manufacturing industry is facing serious challenges with regards to an increasing demand of resources, not at least scarce critical raw materials. However, many barriers have to be overcome to make the transition to a circular manufacturing industry. The industry is also very diverse, each segment with its own challenges and solutions. Everywhere collaboration is needed from the beginning of the value-chain to the end, between various sectors and crossing national borders. Action will be required from all stakeholders: industry, consumers, waste managers, national and local authorities as well as from knowledge institutes.

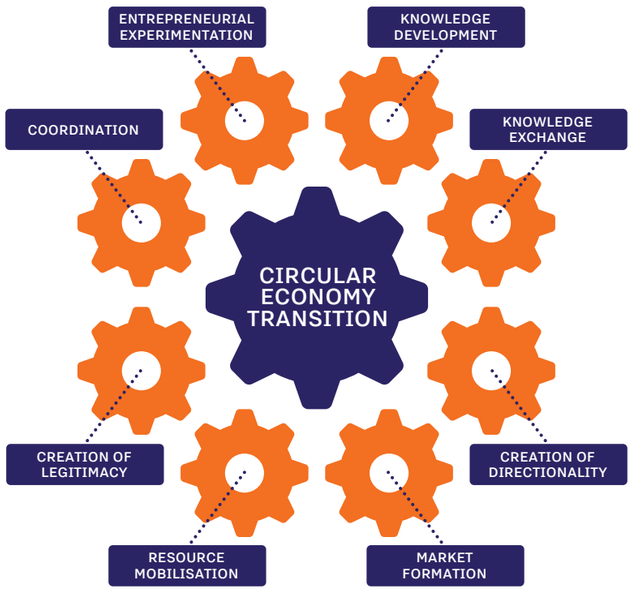
Even though challenges and solutions can differ per sector, per country and even regional, in this chapter we intend to give a generic action perspective that can be applied today, in each sector, country or region.

Organising successful circular innovation

Circular solutions will benefit from a well-functioning innovation system. Research by Hekkert et al. has brought to light that eight processes together form the engines of innovation of such a system (see figure 7).[28] With this framework the innovation system of OEMs in the high-tech equipment sector was analysed. The outcomes agreed well with almost 70 interviews with companies in the high-tech industry by knowledge institute TNO. The assessment led to the observation that the creation of directionality (overarching vision), creation of legitimacy and coordination of activities are the largest barriers that need to be overcome. Other conclusion was that demand-pull policies are likely to be more effective than supply-driven routes. Also market formation is an important aspect.

Furthermore, it became clear from this assessment that many circular innovations are the unintended by-products of other innovations. Digitization plays a substantial role with innovations in the manufacturing processes and in the relation with the customer. So, combining circular strategies with digitization and other upcoming developments can create strong synergies. The research also gave insights in the roles that different parties can play.

Figure 7 The 8 engines of innovations



Source: Ton Bastein, Toon van Harmelen, Mara Hauck, Diana Godoi Bizarro, Sara Wieclawaska, TNO (2021) De impact van slim èn circulair -hoe innovaties in de maakindustrie bijdragen aan een lagere footprint-

Important role for governments

To start with, governments can play a strong stimulating role by setting the direction and ambition level and the boundary conditions to get there. Targets and policies related to climate change and dependency on critical raw materials could accelerate alignment of stakeholders and lower thresholds for circular solutions.

Governments can enable market development with sustained regulations that will enable the shift from linear to circular business models. They can create opportunities for innovators to experiment with or scale-up circular business models by R&D support and funding. They can also help to find solutions for obstructing legislation (like the classification of reusable products as waste). New legislation measures could be considered, preferably in close consideration with industry to make it successful. There is an increasing voice advocating stronger economic incentives to achieve “true pricing” and shift tax from labour to resources.[35]

Importantly, governments can take a role as launching customer for circular products and services, for example in the areas of ICT hardware, mobility and equipment. Circular Public Procurement is preferably based on Total Costs of Ownership (TCO) rather than the lowest price. To support procurement and communication with the value chain, material passports are a valuable tool.

Industry taking leadership

Although far from mainstream, many manufacturing companies have become active in the field of circular entrepreneurship as shown by the cases in this publication. Companies develop circular strategies and have started implementation by circular design, development of new circular business models, co-creation with suppliers and much more. They work together with knowledge institutes to put into practice circular technologies, methodologies and tools. Assessment tools help to identify potential risks of critical raw materials or to calculate the impact of circular strategies.

The complexity of circular design is a barrier. There is a strong need for training of SME's and for increased communication between producers, service companies, recyclers of waste products to optimise services and high-quality waste treatment.

International business leaders in the Capital Equipment Sector like Philips, KPN and Lely have shown leadership by starting a coalition on circularity within The Platform for Accelerating the Circular Economy (PACE). By openly sharing progress, insights and learnings, the Capital Equipment Coalition members help each other. They also create awareness on the need to transition and the coalition engages and enables other players in the public and private sector. In 2021 PACE launched the Circular Economy Action Agenda for the Capital Equipment Sector to accelerate collective progress towards a circular economy (see p.48).[30]

Intensify collaboration

International cooperation and knowledge exchange are key in realising a global circular manufacturing industry. Many initiatives have been started in the last years that are building on insights from research and involvement of many partners from the public and private domain.
In the table (p. 47) we have listed these and other initiatives as an illustration of the momentum for action, without the ambition to be complete. The listed initiatives reflect the diversity within the manufacturing industry and the difference in pace for the variety of sectors.

Table 2: List of various initiatives wihin the manufacturing sector

Initiative	Organisation	Purpose
EU Circular Economy Action Plan	European Commission	Promoting circular economy processes, fostering sustainable consumption, and aiming to ensure that the resources used are kept in the EU economy for as long as possible.
Action Plan on Critical Raw Materials	European Commission	Reduce Europe's dependency on third countries, diversifying supply from both primary and secondary sources and improving resource efficiency and circularity while promoting responsible sourcing worldwide.
European Batteries Alliance	European Commission	Bring together industrial and innovation actors, from mining to recycling, with the common objective to build a strong and competitive European battery industry.
A Renovation Wave for Europe – Greening our buildings, creating jobs, improving lives	European Commission	Double annual energy renovation rates in the next ten years
Circular Economy Action Agenda for Capital Equipment	Platform for Accelerating Circular Economy (PACE)	Call to advance a circular economy for capital equipment, fro example by leveraging servitization, guide and support product use rates and life extension, and leveraging digital technologies for the circular transition.
Circular Economy Action Agenda for Electronics	Platform for Accelerating Circular Economy (PACE)	Call to advance a circular economy for electronics, for example incentivize and support product design for circularity and setting up effective collection systems.
Dutch Circular Manufacturing Industry Implementation program	Ministry of Economic Affairs and Climate, sector organisations FME and Koninklijke Metaalunie and other public and privat partners	Circular transition of Dutch manufacturing industry
The Circular Windhub	ECHT, Versnellingshuis Nederland Circulair	Integration of circularity in the wind industry and realization of transformations in the supply chain

Source: Compiled by the author.

European Circular Economy Politics

The European Commission sees circularity as an essential part of a wider transformation of industry towards climate-neutrality and long-term competitiveness. The future of manufacturing in Europe is expected to lead to better jobs, requiring new and higher skills. Taking the lead in the commercial adoption of emerging technologies is expected to give a competitive advantage over other trading blocs and will create more jobs.

In 2020, the Commission adopted the EU Circular Economy Action Plan and the European Digital Strategy. The Circular Economy Action Plan builds on the success of the previous EU Circular Economy Package (2015) and the conclusions of its implementation report. It identifies seven key product value chains: electronics, ICT equipment, textiles, furniture and high-impact intermediary products, such as steel, cement and chemicals. In implementing the action plan, the European Commission intends to cooperate closely with stakeholders within these product chains.

The action plan strengthens product policies aimed at circular design, reuse of products and extended producer responsibility (EPR). The reinforcement of consumer rights to repair is also explicitly part of this policy. Following Ecodesign-regulations, starting March 1st 2021, manufacturers are obliged to keep spare parts of electronic products like dishwashers and (television)monitors longer available.

Dutch Circular Manufacturing Industry Implementation Program

In 2016, the Dutch cabinet outlined how they want to transform the economy in 'The Netherlands Circular in 2050' program. This policy has been elaborated for 5 priority sectors in transition agendas, one of which is the manufacturing industry. In the Transition Agenda for the Circular Economy for the Manufacturing Industry (2018) goals have been formulated and ideas elaborated, resulting in the Circular Manufacturing Implementation Program (2019-2023). The strategic vision for 2050 is that moving to a circular manufacturing industry will be an important basis for a new and more resilient economy, bringing economic and social value, while reducing the environmental footprint to within the boundaries of our planet.

The primary goals associated with this strategic vision are:

- Increase value creation and retention of products / services in the manufacturing industry
- Reduce the environmental impact of products / services in the manufacturing industry
- Increase assurance of supply of (critical) raw materials

Research by the Dutch knowledge institute TNO indicated that a circular transition of the Dutch manufacturing industry can create €3,2 billion added value and save 2,3 million kg of CO_2 in the Netherlands alone. The research by TNO also found potential that the draw on critical materials such as Magnesium, Titanium, Aluminum, Phosphorus and Antimony could significantly be lowered.

The program comprises various projects within the circular manufacturing industry: wind farms, PV solar systems, high-tech equipment, capital equipment, batteries and heat as a service will be explored together with parties in the value chain. Furthermore, efforts will be made to apply digitisation widely within the program.

Platform for Accelerating Circular Economy (PACE)

PACE is an international public-private platform that connects industry leaders committed to creating a circular economy. In cooperation with more than 200 experts from > 100 businesses, governments and civil society organisations, PACE established a Circular Economy Action Agenda. This Action Agenda was launched in 2021 and is made up of five publications: plastics, textiles, electronics, food, and capital equipment. Each publication lists 10 call-to-actions. These are the actions for the Capital Equipment Sector:[III]

1. Provide Incentives and Guidance for Product Design for Circularity
2. Transform Customer Perception and Procurement Models to Increase Market Demand for Circular Products and Services
3. Leveraging Servitisation, Guide and Support Product Use Rates and Use Life Extension
4. Increase End-of-Use Product Return
5. Enable Efficiency and Transparency in Compliant and Responsible Reverse Logistics
6. Collaborate across Value Chain and Sectors to Strategically Plan Reuse Operations
7. Increase Incentives for Investment in Reuse Technologies and Facilities
8. Enable Manufacturers to Increase Sourcing of Secondary Components
9. Leverage Digital Technologies for the Circular Transition
10. Evaluate the Contribution of Circular Capital Equipment to the Sustainable Development Goals

Mitigating supply risks with web-based tool

The Resources Scanner is a web-based tool to assess and improve supply chain risks for products and materials. Companies can discover to what extent the materials they depend on pose a potential risk to their business, to the people in their supply chain and to the natural environment. The assessment is based on security of supply, price volatility and the conditions under which the materials are produced. Action perspectives are presented to mitigate the supply chain risks. The tool is available in Dutch and English and is supported by the Ministry of Economic Affairs.

Material passports support circular procurement

The Dutch governmental ICT procurement agency (DICTU) started in 2019 with an inventory of the origin of its own hardware. Throughout the value chain, the use of critical raw materials, production, power consumption and lifespan were considered using a Circular Product Passport (CPP) with the "minimum required circular information" that matches the ICT sector. The inventory resulted in new guidelines for lifetime extension and reuse of the most used ICT hardware.

Creating business through circular design

Design Institute CIRCO has developed a unique yet simple method that is both inspiring and activating and that supports creative professionals within the manufacturing industry to create circular business. The method is used in a 3-day workshop where entrepreneurs and industry professionals identify business opportunities and use circular design strategies to redesign their own propositions, products, services and business models. Supported by various cases, expert input and value chain interaction, participants leave with a concrete implementation roadmap. Research shows: 66% of the participants have implemented their new circular propositions! The CIRCO workshop track is used within the Dutch Circular Manufacturing Implementation Program to create communities and solutions for priority value chains.

Measuring impact of circular innovations

Knowledge institute TNO developed the Fingerprint methodology for manufacturers in various sectors to make their products more sustainable. It expresses in numbers what resources are saved during manufacturing, the extent to which the new product is less harmful for people and the environment and, thirdly, what the economic effects are. This method can also be applied to sectors, giving insights into potential CO_2 reduction and expected additional value.

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Colophon

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Authors
Diana de Graaf, Holland Circular Hotspot
With support from Claudia Yamile Espinal Pelaez (HCH), Sandra Kolodszinskyi and Suzan van Kruchten (RVO Netherlands Enterprise Agency)

Editorial board
On behalf of the NL Strategic Platform of the Circular Manufacturing Industry Implementation program:
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Design and lay out
Tymen Cieraad, Buro Goedwijs

Website
www.hollandcircularhotspot.nl
www.circulairemaakindustrie.nl

Email
info@HollandCircularHotspot.nl
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