THE CIRCULARITY GAP REPORT

Denmark

Closing the Circularity Gap in Denmark

CIRCLE ECONOMY

CIRCLE ECONOMY

We are a global impact organisation with an international team of passionate experts based in Amsterdam.

We empower businesses, cities and nations with practical and scalable solutions to put the circular economy into action. Our vision is an economic system that ensures the planet and all people can thrive.

To avoid climate breakdown, our goal is to double global circularity by 2032.

BEHIND THE COVER

The Infinite Bridge by Danish studio Gjøde & Povlsgaard Arkitekter perfectly captures the transition to circularity for Denmark. As well as being a literal circle, the bridge connects people with each other and nature—just as a circular economy strives to do. 'Walking on the bridge you experience the changing landscape as an endless panoramic composition and at the same time you enter a space of social interaction with other people experiencing the same panorama,' notes Johan Gjøde, partner and co-founder of the studio.

Cover design: Alexandru Grigoras

PARTNERS

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TEKNOLOGISK INSTITUT

DTU

Dansk Design Center DDC

Lifestyle & Design Cluster.

IN SUPPORT OF THE *CIRCULARITY GAP REPORT DENMARK*

MAGNUS HEUNICKE

Danish Minister of the Environment

‘We have not inherited the Earth from our ancestors; we are borrowing it from our children. Therefore, we have to move away from a throwaway culture. It affects our climate and environment when plastic packaging or our clothes are incinerated. We are in the process of moving towards a more circular economy through several initiatives, such as the streamlined waste sorting system, extended producer responsibility and an upcoming action plan on plastics. In this way, we will reduce our amount of waste, while also increasing reuse and recycling – which is crucial, if we want to pass on a greener future to our children and grandchildren. This report underlines the need to change our production and consumption patterns. At the same time, the report shows the significant potential of the transition to a circular economy, which can open new opportunities for companies engaged in the green transition, and serve as inspiration to act – both for the public sector and for society as a whole.’

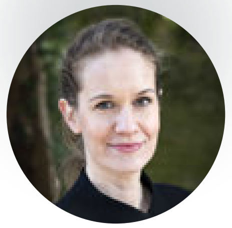
MORTEN BØDSKOV

Danish Minister for Industry, Business and Financial Affairs

‘This report gives important insight into the potential and necessary skills in companies across sectors to deliver on the circular transition in Denmark. In particular, new EU regulations will require companies to engage in developing circular business models and products. A wide range of information requirements will put pressure on companies in the transition. The sharing of these information in digital and automated manners will underpin a cost-effective transition. Close collaboration between the public sector and companies will be required to ensure the right competencies and skills, in order for companies to upgrade their way of doing business.’

MARIA REUMERT GJERDING

President at the Danish Society for Nature Conservation



‘This report underlines very clearly that Denmark must step up its political efforts to strengthen its circular economy to mitigate the consequences of climate change and biodiversity loss. The report also stresses that recycling is not enough: it’s critical that we reduce our enormous material consumption and focus on structural changes that prevent waste to begin with. I hope that this report can accelerate the circular economy debate in Denmark and move us a step closer to an ambitious national strategy for a circular economy for all sectors.’

CAMILLA HAUSTRUP

Deputy CEO at Plus Pack and Chairwoman at DI Produktion

‘The *Circularity Gap Report Denmark* is an important read for all stakeholders in society. Now that we have the tangible data and measurements needed to guide action for a more circular Denmark—and a solid base from which to set an ambitious trajectory for a circular economy—it’s time to achieve the massive potential which is clearly demonstrated in this report. The report points to the sectors in which a circular economy could have the greatest impact. The transition from a linear to a circular economy will require a significant effort from all of us, but change is exactly what is needed in the green transition.’

DITTE LYSGAARD

Associate at Lendager and Chair of the Danish Design Council

‘Buildings are a key part of what can best be described as our gigantic resource problem: we consume too many materials and are far from utilising them at their highest value. We can—and must—do better. To ensure the circular economy becomes a tool to do so, we need quantitative data. This report makes it abundantly clear that we are currently missing out on a grand opportunity to decouple value creation from the use of virgin materials and emissions. Let this be the start of collective action that drives systems change and empowers the creation of innovative solutions.’

CONNIE HEDEGAARD

Chair at CONCITO, Denmark's green think tank

‘This report gives a unique insight into material consumption in Denmark, and it shows the close correlation between consumption and climate impacts. By changing behaviour and using materials far more smartly there is huge potential to reduce Denmark’s environmental pressure from all sectors. In a world of limited resources, it is crucial to prioritise everything—the use of minerals, carbon, land, biomass, labour—and to use resources where the most value is created and where the benefit for the transition is highest.’

IN SUPPORT OF THE *CIRCULARITY GAP REPORT DENMARK*

DORETHE NIELSEN

Chairman of the Board at TRACE and Vice President at Novo Nordisk

'The numbers in the *Circularity Gap Report Denmark* speak for themselves. We need to speed up the circular transition in Denmark. The TRACE partnership, consisting of more than 90 partners within universities, knowledge institutions and public and private companies, has come together to kick-start a number of projects to ensure the recycling of plastics and textiles with the aim of reaching the Danish 2050 climate goals. An ambitious roadmap has been developed, which is guiding the curation of investments in the most promising research and developing projects. I am sure TRACE will be able to contribute to better circularity for Denmark within the plastics and textiles value chain.'

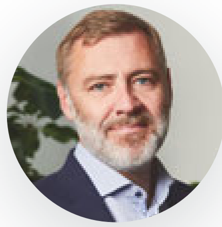
MARIA GLÆSEL

CEO & Partner at AIAYU

'As this report points out, linear business models in the textile sector are causing too much pressure on our planet's resources, and our ways of working must adapt to a more circular economy. The sector collaboration is an important step towards guiding, supporting and monitoring this much needed transition for SMEs and larger enterprises in Denmark. Competitors are working side-by-side to exchange knowledge, report on yearly progress on circular goals, and identify innovation possibilities and gaps to accelerate the development and adoption of textile-to-textile circularity. Lastly, in close coordination with the Danish Environmental Minister and the Environmental Protection Agency, the collaboration acts as a unified voice between the industry and legislators, ensuring the development of effective and feasible EU regulation that will hold all of us accountable.'

HENRIK GRAND PETERSEN

CEO at Stena Recycling



'This report reveals—once again—that we are facing huge challenges in creating a sustainable future. Material consumption is too high for most value chains in Denmark, as well as the rest of the EU. However, our strong collaborative culture to explore circular initiatives, and share knowledge and skills among industry sectors, universities and public institutions is the way forward. Our ability to collaborate across value chains and leverage our collective wisdom will enable us to close material loops in new and innovative ways. To accelerate progress towards a circular economy, it is important that we do not just focus on the challenges, but also consider the strategic business opportunities for both new and established businesses in Denmark. We need to invest in and explore circular opportunities to keep the future bright for the coming generations.'

KATHERINE RICHARDSON

Professor in Biological Oceanography, University of Copenhagen's Sustainability Science Centre

'Like all other organisms, humans prosper by using the Earth's limited resources. In spite of a finite supply of resources, nature has been able to survive on Earth for over 2 billion years. It has managed this by arranging itself in ecosystems based on sustainable circular economies, where all waste is recycled and the building blocks necessary for creating new life are regenerated. Nature teaches us that the only way modern civilization can continue to thrive on a planet with limited resources is by replacing our "use and throw out culture" with a circular economy. This transformation has begun but there is still a very long way to go before it is complete. This report shows the potential impact this shift could have on Denmark's economy.'

PREFACE

Denmark's resource consumption is far above the EU and world averages. This is affecting our climate, biodiversity and future access to resources. Therefore, we will not succeed in the necessary green transition without taking a hard look at our resource consumption and consumption-related carbon dioxide emissions. To do so, the circular economy is the crucial tool that must come into play at a far higher extent than it does today.

This partnership—consisting of the Danish Industry Foundation, the Danish Society of Engineers, Confederation of Danish Industry, DTU Sustain at the Technical University of Denmark, the Danish Design Centre, and the Lifestyle & Design Cluster—has looked forward to publishing the results of the *Circularity Gap Report Denmark*.

It is our hope that with this report we can create awareness for the need to transition to a circular economy in Denmark. In this context, we find it crucial that discussions consider an up-to-date and realistic status of our country's circularity, and understand the effect that our consumption has on the environment.

Our work does not end with the presentation of the report and the extensive data basis on which it is built. We hope that this will only be the beginning: the kick-off of a dialogue on how to ensure that Denmark will become a leader within circular solutions where we use resources smarter—getting more from less and keeping products and materials in the loop as long as possible. The *Circularity Gap Report Denmark* shows beyond any doubt that action is needed. The results presented in the report speak for themselves: we are just 4% circular. This is simply not acceptable!

With a transition to a circular economy, we can reduce Denmark's pressure on the Earth's resources, reduce carbon dioxide emissions, and pave the way for new business models and technologies to the benefit of jobs and exports.

Our key aim is to spread awareness of this report's conclusions among the many stakeholders that must contribute to the transition. We do not imagine that the report on its own provides all the answers, but we hope that it will strengthen the foundation for finding them. We need to set clear political ambitions and frameworks for the circular transition. As citizens, we must each change our consumption habits, and businesses and the public sector must pull up their sleeves and get to work.

We, the partnership, are grateful for the keen interest we have met in connection with the creation of this report. We would like to offer a special thanks to the members of the advisory board that have contributed constructive inputs along the way, and of course to Circle Economy, for quantifying Denmark's circularity and laying out clear examples of what can be done to change our course and ultimately close the Circularity Gap.

We wish you a pleasant read!

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Thomas Hofman-Bang, Director at the Danish Industry Foundation

Laura Klitgaard, Chairperson at the Danish Society of Engineers

Lars Sandahl Sørensen, CEO at the Confederation of Danish Industry

Claus Hélix-Nielsen, Director at DTU Sustain

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EXECUTIVE **SUMMARY**

Denmark's Circularity Metric is 4%—leaving a Circularity Gap of 96%. This means that the vast majority of material inputs to the Danish economy—used to satisfy residents' needs and wants—comes from virgin sources. This is considerably lower than the Circularity Metric for the global economy, measured at 7.2% in 2023.[1] Denmark consumes 142.2 million tonnes of virgin materials—metal ores, non-metallic minerals, biomass and fossil fuels—each year, equivalent to 24.5 tonnes per person; well above the EU average of 17.8 tonnes per person, and the global average of 11.9 tonnes per person. This figure is more than three times higher than the estimated 'sustainable' level of consumption, 8 tonnes per capita.[2] Extraction within Danish borders, at 19.9 tonnes per capita, also substantially tops EU and world averages—and much of what is extracted is exported, its use and end-of-life management contributing to environmental impacts around the world. For Denmark, reducing both consumption and extraction is the imperative of our changing era: globally, material use and handling is responsible for 70% of greenhouse gas emissions,[3] while material extraction and processing is linked more than 90% of biodiversity loss and water stress.[4] By tackling its consumption patterns, Denmark can remedy the root causes of climate change and environmental degradation, both at home and abroad. With this end in mind, this report analyses how materials are used to meet Denmark's societal needs, from Housing and Nutrition to Transport and Manufacturing, highlighting where changes can be made to lessen impact and work towards a circular Denmark.

Denmark has high material and carbon footprints, mostly stemming from extraction abroad. The country imports a large volume of materials and finished products from abroad: around 72% of the total extraction needed to meet Danish demand takes place beyond its borders. Material consumption is dominated by non-metallic minerals, which largely feature in construction projects, for example, and biomass, used to feed residents and livestock. As electricity has largely been decarbonised, fossil fuels—largely imported—make up just 12% of the material footprint. Denmark's carbon footprint is more moderate at 11.1 tonnes per capita, falling just above the EU average of 9.5 tonnes per capita. Less than one-third of the Danish carbon footprint can be attributed to domestic consumption: emissions produced within the country due to consumption taking place locally. 54% of emissions are embedded in imports, while the remainder are direct emissions (from households and industry) and land use emissions. Denmark's production-based goal to cut domestic emissions by 70% by 2030—while admirable—thus overlooks the significant amount of carbon embedded in goods produced abroad. Reducing these must be a key focus of the country's climate strategy going forward. To this end, this report takes a consumption-based approach for much of its analysis.

The three biggest sectors contributing to Denmark's material and carbon footprint are construction, manufacturing and agrifood. Combined, these sectors represent 64% of the material footprint and 56% of the carbon footprint. It must be noted that a significant portion of this material use takes place through production processes abroad for goods imported and consumed in Denmark—this is especially true for manufacturing and agrifood. Construction claims the largest portion of Denmark's footprints—31% of the total material footprint and 17% of the total carbon footprint. This is unsurprising, given the country's growing building stock: construction volume, turnover and employment have all surged over the last decade. Although there are signs of the construction industry slowing down, activity is still set to remain high overall with expansion of district heating infrastructure and tunnels, as well as road maintenance, for example.[5] The Manufacturing sector comes second, representing 18% of the material footprint, and claims the largest portion of the carbon footprint at 22%. Much of the sector's material use can be attributed to petroleum refineries and the manufacture of vehicles (largely abroad),[6] machinery and equipment. Agrifood trails behind Manufacturing, claiming 15% of the total material footprint—largely from the processing of food products, cattle farming and wheat cultivation. Livestock farming is the largest culprit, accounting for nearly half of the agrifood sector's material footprint. Agrifood's carbon footprint, at 16% of the total, takes third place: the bulk comes from processing dairy and pork. While these three sectors are notably high-impact, Denmark is well-positioned to make improvements. Shifting to a more circular economy in these sectors and beyond will require collective action from decision-makers, workers and residents alike: training and upskilling, as well as behavioural change, will be needed to drive the transition.

Examining the Circularity Gap helps paint a picture of the Danish economy. While Denmark is just 4% circular, this doesn't mean that the other 96% of the materials flowing through its economy go to waste or are inherently 'bad'. The Circularity Gap is made up of many different elements:

1. Half **(49.2%)** of Denmark's material use is locked into **stock**, from buildings and infrastructure to machinery and vehicles. As these materials won't become available for reuse or recycling for many decades, it's crucial that circular elements like design for durability, repairability and cyclability are considered now to enable positive outcomes further down the road.
2. Another **27.3%** of Denmark's material consumption is represented by **renewable, carbon-neutral biomass** with the *potential* for cycling: food crop residues, timber and wood products, for example.
3. **Non-carbon-neutral biomass** is biomass that is not carbon neutral: not all CO_2 embedded in the bio-based materials Denmark consumes is theoretically 'sequestered'. At **1.6%**, this share is quite low: while Denmark cannot fully compensate for all the embedded CO_2 in the bio-based materials it consumes, it isn't far off. Carbon sinks can be increased through afforestation or regeneratively managed land, for example.
4. Inherently **Non-circular inputs**, such as fossil fuels, represent **17.3%** of material use.
5. **Non-renewable inputs**—which include materials such as metals, rocks, chemicals, glass and plastics—represent **0.5%**. These are materials that could be cycled but currently are not. This figure is low due to Denmark's current recycling rate relative to the total footprint.

Denmark must focus on reducing Non-circular inputs while also boosting its Circularity Metric. As the stocking rate is so high, ensuring additions to stock are made as circular as possible and that biomass is cycled back into nature will also be key avenues to improve circularity in the country. Decreasing the absolute stocking rate would also be an avenue by which to reduce consumption.

Circular strategies across five areas could almost double the Circularity Metric and cut material use by 39%. To bridge the Circularity Gap, this report explores five 'what-if' scenarios, each applying multiple strategies that bolster circularity, cut material use and emissions, and provide a wealth of other co-benefits. The selection of the scenarios was based on quantitative and qualitative research, and was informed by what we're able to model based on methodological limitations. The scenarios are: Build a circular built environment, Embrace a circular lifestyle, Rethink transport & mobility, Nurture a circular food system, and Advance circular manufacturing. Interventions related to the built environment and lifestyle were found to be the most impactful in terms of reducing the material footprint: these are key leverage points to act on. Altogether, the scenarios have the power to transform the economy, bumping the Metric from 4% to 7.6%. What's more, the material footprint could be reduced by 39%, bringing it down to 86.8 million tonnes, while the carbon footprint could be cut by 42%, bringing it down to 35.7 million tonnes of carbon dioxide equivalents (CO_2e). This would equate to a material footprint of 15 tonnes per capita (down from 24.5 tonnes)—far closer to the global average, a solid step towards the estimated sustainable level, and a carbon footprint of 6.2 tonnes per capita. Other co-benefits would be numerous, from bolstered biodiversity and stronger, more resilient communities to positive opportunities for the labour market if the transition is approached correctly.

There are limitations as to how much the Circularity Metric can grow—but this doesn't downplay the Danish economy's potential for improvement. The scenarios presented are transformative and would require deep changes in the way businesses, governments and residents operate. Why, then, does the Metric 'only' grow to 7.6%? Firstly, it's not technically feasible to achieve 100% circularity: the quality of materials typically degrades each time they are cycled and, therefore, can't be cycled infinitely. Secondly, the structure of economic activity across borders in our highly complex and globalised world economy also makes circularity difficult to control within a single country. Measures to control the circularity of imports that are consumed domestically—or to reduce the need for them—shouldn't be overlooked. Ensuring that domestic industry designs for circularity, benefitting both domestic consumers and export markets, will also be crucial. Thirdly, large amounts of materials will always be needed to a degree to sustain residents—in terms of housing and infrastructure, for example, although these needs can be provided in a far more efficient way. In spite of these limitations, even a small improvement in the Metric can have a big impact—so Denmark's potential to boost its Metric to 7.6% is an opportunity to seize. And while it's important to ensure closed loops, engaging in higher-level strategies—using less, using longer and using cleaner resources—will be crucial. As such, potential big wins for Denmark are exemplified by the possible reductions in the material and carbon footprints, which represent a true metamorphosis for the Danish economy.

The circular transition will be driven by work and workers. If well-designed, the Danish labour market can anticipate and prepare for the circular transition, which can, in turn, accelerate this shift. Our analysis finds that approximately 9.6% of jobs in Denmark currently contribute to the circular economy, either directly or indirectly.[7] The vast majority—more than three-quarters—of these jobs are generated by sectors that indirectly support the circular economy, which goes to show that all manner of jobs will have a role to play in the transition. Denmark may focus on increasing jobs in core circular sectors—waste management, repair or renewable energy, for example—while encouraging collaboration from enabling and indirect sectors. Training across the board will be critical to ensure that Danish workers are well-equipped with the skills needed to execute new roles that will emerge as part of the transition: this will include technical skills in special material use or design, for example, or soft skills in collaboration. Ensuring that the Danish labour market is ready to tackle the transition to circularity will also mean fostering greater awareness of circularity, establishing competence centres where crucial stakeholders can learn and be inspired, increasing vocational education and training, integrating circular know-how across all higher education and training, boosting adult education and lifelong learning, and integrating circularity in existing sustainability initiatives. The country boasts many positive factors that can help action these recommendations, from its high concentration of quick-to-adapt, innovative small and medium-sized enterprises, strong social dialogue around environmental considerations, well-established flexicurity system and strong tradition of adult education.

The time for transformational change is now. In many areas of sustainability, Denmark is excelling. The 1973 oil crisis sparked a united effort to diversify the country's energy mix almost overnight, for example—the kind of commitment needed to drive the circular transition. Now, Denmark boasts some of the world's most ambitious climate goals, along with mostly-renewable electricity generation and well-established waste management measures. However, focus on waste reduction and smarter resource use could be improved. As a means to an end, the circular economy offers a 'toolbox' of strategies that can help realise these goals and further the country's sustainable endeavours by providing a way to meet Danish residents' needs through fewer materials. Although Denmark has a way to go in reducing its material footprint and its global impact as a consequence, it is well poised to take on the challenge. In the scenarios, our analysis identifies some of the key levers to reduce environmental pressures. Everyone in the country will have a role to play in changing their consumption patterns and prolonging the lifetime of products and materials through new models based on reuse, sharing, product-as-a-service and repair, for example. As with many high-income countries, a shift in lifestyles will be of just as much importance as a change in industry.

This report lays the path forward for a more circular Denmark. Achieving a more circular economy requires more than technical solutions—and will require political action on five recommendations:

1. **Coordinate and collaborate to advance circularity.** Leverage Denmark's strong collaborative culture to explore circular initiatives and share knowledge, skills and resources among industries.
2. **Ensure Denmark is ready for new circular economy requirements.** Ensure Denmark is ready to meet new EU requirements for circularity by driving technological advancements, behavioural changes, new business models, circular products and the new skills required to facilitate these.
3. **Create a fit-for-purpose policy framework that prioritises and facilitates smarter material use.** Embed reductions in the material footprint, consumption-based emissions and waste into targets and national policy-making to drive change at the scale, scope and speed needed.
4. **Support and encourage small and medium-sized enterprises (SMEs) on their circular journeys.** SMEs make up a large share of Danish businesses and will be vital for driving the circular transition—but they will also face challenges in doing so. Ensure SMEs are given access to financing and skills development opportunities.
5. **Measure, monitor and evaluate progress to capture the entire circular economy.** Ensure a fit-for-purpose monitoring framework is developed that captures all aspects of the circular economy—not just cycling—and align this with existing environmental goals.

CONTENTS

GLOSSARY

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

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

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

Decoupling refers to a trend that occurs when the growth rate of an environmental impact (for example, CO_2 emissions) is less than that of its economic driving force (for example, gross domestic product) over a given period. Decoupling can be either absolute or relative. **Absolute decoupling** is defined as when the environmental impact is stable or decreasing when the economic driving force is growing. **Relative decoupling** is defined as when the growth rate of the environmental impact is positive, but less than the growth rate of the economic driving force. [Source]

Domestic Extraction (DE) is an environmental indicator that measures, in physical weight, the amount of raw materials extracted from the natural environment for use in any economy. It excludes water and air. [Source]

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

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

Environmental stressor, in Input-Output Analysis, is defined as the environmental impact occurring within the region subject to analysis. There is, therefore, an overlap between the stressor and the footprint, as they both include the share of impact occurring within a region as a result of domestic consumption. This is how they differ: while the rest of the stressor is made up of impacts occurring within a region as a result of consumption abroad (embodied in exports), the footprint includes impacts occurring abroad as a result of domestic consumption (embodied in imports).

Greenhouse gases (GHG) refers to a group of gases contributing to global warming and climate breakdown. The term covers seven greenhouse gases divided into two categories. Converting them to **carbon dioxide equivalents** (CO_2e) through the application of characterisation factors makes it possible to compare them and to determine their individual and total contributions to Global Warming Potential (see below). [Source]

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

Materials, substances or compounds are used as inputs to production or manufacturing because of their properties. A material can be defined at different stages of its life cycle: unprocessed (or raw) materials, intermediate materials and finished materials. For example, iron ore is mined and processed into crude iron, which in turn is refined and processed into steel. Each of these can be referred to as materials. [Source]

Material footprint, also referred to as Raw Material Consumption (RMC) within this report, is the attribution of global material extraction to the domestic final demand of a country—referred to as a **consumption-based approach**. In this sense, the material footprint represents the total volume of virgin materials (in Raw Material Equivalents) embodied within the whole supply chain to meet final demand. The material footprint, as referred to in this report, is the sum of the material footprints for biomass, fossil fuels, metal ores and non-metallic minerals. This differs from a **production-based** approach, which measures the total amount of material extracted, processed and used within the borders of a territory, regardless of where the products are consumed. [Source]

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

Net Extraction Abroad (NEA) represents the difference between the trade balance of products and that of the raw materials needed to produce them. The difference between the two represents the 'actual' or net quantity of raw materials that have been extracted abroad to satisfy domestic consumption.

Planetary boundaries define the 'safe operating space' for humanity based on the planet's key biophysical processes. Originally developed by Rockström et al. (2009), the framework quantifies nine 'limits': 1. Climate change, 2. Novel entities,[8] 3. Stratospheric ozone depletion, 4. Atmospheric aerosol loading, 5. Ocean acidification, 6. Biogeochemical flows (nitrogen and phosphorus), 7. Freshwater use, 8. Land-system change, and 9. Biosphere integrity.[9] Six of nine boundaries have now been transgressed. [Source]

Raw Material Equivalent (RME) is a virtual unit that measures how much of a material was extracted from the environment, domestically or abroad, to produce the product for final use. Imports and exports in RME are usually much higher than their corresponding physical weight, especially for finished and semi-finished products. For example, traded goods are converted into their RME to obtain a more comprehensive picture of the 'material footprints'; the amounts of raw materials required to provide the respective traded goods. [Source]

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

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

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

Sector describes any collective of economic actors involved in creating, delivering and capturing value for consumers, tied to their respective economic activity. We apply different levels of aggregation here—aligned with classifications as used in Exiobase V3. For more information on our sectoral aggregations, please refer to Appendix F on page 121.

Socioeconomic cycling is the technical term for the Circularity Metric. It comprises all types of recycled and downcycled end-of-life waste, which is fed back into production as secondary materials. Recycled waste from material processing and manufacturing (such as recycled steel scrap from autobody manufacturing, for example) is considered an internal industry flow and is not counted as a secondary material. In the underlying model of the physical economy used in this report, secondary materials originate from discarded material stocks only. The outflows from the dissipative use of materials and combusted materials (energy use) can, by definition, not be recycled. Biological materials that are returned back to the environment (for example, through spreading on land) as opposed to recirculated in technical cycles (for example, recycled wood) are not included as part of socioeconomic cycling. Energy recovery (electricity, district heat) from the incineration of fossil or biomass waste is also not considered to be socioeconomic cycling, as it does not generate secondary materials.

Socioeconomic metabolism describes how societies metabolise energy and materials to remain operational. Just as our bodies undergo complex chemical reactions to keep our cells healthy and functioning, a nation (or the globe) undergoes a similar process—energy and material flows are metabolised to express functions that serve humans and the reproduction of structures. Socioeconomic metabolism focuses on the biophysical processes that allow for the production and consumption of goods and services that serve humanity: namely, what and how goods are produced (and for which reason), and by whom they are consumed. [Source]

Territorial-based carbon footprint is based on the traditional accounting method for GHG emissions, with a focus on domestic emissions, mainly coming from final energy consumption. A **consumption-based carbon footprint** uses input–output modelling to not only account for domestic emissions but also consider those that occur along the supply chain of consumption (for example, accounting for the embodied carbon of imported products).

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

1. INTRODUCTION

The planet we live on today has largely been shaped by our globe's dominant linear economy: the extraction, transport, processing, use and disposal of materials to satisfy societal needs and wants has hugely contributed to the overshoot of many of the planetary boundaries that support life on this planet.[10, 11] Global material extraction and use heavily contributes to this overshoot, and has more than tripled since 1970 to 100 billion tonnes a year.[12, 13] What's more, our global *Circularity Gap Report 2023*[14] found that the global economy is only 7.2% circular—meaning that more than 90% of the materials we consume come from virgin sources. This report finds that Denmark's overall Circularity Metric is 4%, falling well below the global average. At 24.5 tonnes per person per year, its material footprint is more than double the global average of 11.9 tonnes per capita and more than three times the estimated sustainable level of 8 tonnes per capita.[15, 16] Our analysis provides an avenue for change: one that could, if managed well, both maintain Danish residents' high standard of living while reducing pressure on the environment, both domestically and abroad. This big shift is the circular economy: a toolbox to combat ecological breakdown and remain within planetary boundaries by rethinking our relationship with resources, using less and designing out waste.

THE RISKS OF LINEARITY: DENMARK IN A CHANGING WORLD

With increasing biodiversity loss, resource depletion and extreme weather events, we are now feeling the daily effects of Earth's boundaries being pushed to its limits. A healthy planet is essential for human beings to not only survive, but thrive. Although the impacts of waste and emissions vary by material—and can be softened through technological developments and end-of-the-pipe solutions—a clear link remains between overall material consumption and ecological impact.[17] As such, material use can act as a proxy for measuring environmental degradation: 70% of global greenhouse gas (GHG) emissions stem from material handling and use,[18] as well as over 90% of biodiversity loss and water stress,[19] for example.

Globally, we're on the wrong path: material extraction has exploded over the past fifty years, more than tripling from 27 billion tonnes in 1970[20] to more than 100 billion tonnes as of 2023.[21] This has stimulated economic development across the world, but has also come at the expense of the environment. At least six of the nine planetary boundaries that we must remain within to ensure a stable, resilient Earth system have now been crossed.[22] And as global material use has reached new heights, more than 100 billion tonnes per year, the Circularity Metric has decreased, shrinking from 9.1% to 7.2% within six years.[23]

Our global economy's material consumption is already excessive: the average global level of material consumption technically requires 1.75 Earths to sustain.[24] Where does Denmark fit into this context? Looking at the analysis in the global *Circularity Gap Report 2020*,* we can see that Denmark exemplifies the *Shift* country profile alongside most other high-income countries in the global North. This means that it scores very highly on the United Nations' Human Development Index (HDI), between 0.8 and 1, but its Ecological Footprint—an indicator that accounts for human demand for biological sources—reflects its high level of consumption. If everyone on Earth were to live like the average Danish resident, we would require the resources of over four planets.[25] *Shift* countries account for around two-thirds of global gross domestic product (GDP), yet house just one-fifth of the global population.

Like much of the globe, Denmark's prosperity has been tightly linked to its material use: GDP increased by around 75% between 2000 and 2020, while its material footprint has remained the same over this period.[26] This relative decoupling can be partly attributed to improvements in energy efficiency[27] and partly to an increase in wind power for electricity generation.[28] However, there may be a limit as to how much Denmark can continue to increase its GDP while decreasing its material use to achieve the necessary absolute decoupling. Steady population growth[29] poses an extra challenge: how can Denmark meet the needs of its residents while decreasing its material use?

THE CIRCULAR ECONOMY: A NEW ECONOMIC PARADIGM FOR PEOPLE AND PLANET

The imperative is clear: to combat the breakdown of our climate and other ecological systems, countries around the globe must bring their economic activity back within planetary boundaries. Denmark's Circularity Metric provides a useful benchmark and forms the basis from which to consider factors beyond secondary material use, from emissions to material toxicity. Denmark's circular transition will require a reimagining of how it relates to materials: a downscaling of resource consumption while maintaining—or even raising—standards of wellbeing. By enlisting a holistic circular economy approach—using less, using longer, making clean and using again—Denmark can maintain a prosperous society that does more with less, tackles material and energy use and contributes to its strategic environmental goals.[30]

The circular economy provides solutions for systemic inefficiencies. Let's consider food waste as an example: food consumption in Denmark generates 814,000 tonnes of avoidable food waste per year—140 kilogrammes per person—with approximately 47% of this waste occurring in industry and 30% occurring in households.[31] Far more food is grown, harvested and transported from place to place than is needed to feed the population. Transport can be similarly inefficient: the average car sits unused around 95% of the time, for example,[32] meaning that the materials extracted to produce such vehicles are not used as optimally as they could be. But we can do things differently: an electric vehicle, powered by renewable energy, designed for efficient repair and reuse, and shared amongst several people, can deliver the same—or even better—outcomes as a privately-owned motor vehicle, yet with a fraction of the environmental cost from its production, use and end-of-life.[33, 34] By redesigning systems of production and consumption to tackle linear inefficiencies, a circular economy allows us to decouple material consumption and its associated impacts from the essential service that is delivered, be it transport or nutrition.

THE ROAD TO CIRCULARITY: DENMARK IS ON ITS WAY

Transitioning to circularity may prove an antidote to many linear risks—and Denmark is already excelling in many areas of sustainability, positioning itself as an ambitious frontrunner in the race to net-zero.[35] It already boasts mostly-renewable electricity generation, with targets to achieve 100% green electricity by 2027 and entirely renewable energy by 2050. The Government's Climate Act aims to cut carbon dioxide (CO_2) emissions by 70% compared to 1990 levels by 2030 and become climate neutral by 2050, ending the extraction and use of oil, gas and coal.[36] If achieved, this will mark a sharp departure from Denmark's current status as a top European oil producer, ranking first in the EU in 2019.[37]

Strategies go beyond tackling emissions: Denmark's *Action Plan for Circular Economy* lays out 129 initiatives, including the *Climate Plan for a Green Waste Sector and Circular Economy, Strategy for Green Public Procurement, National Strategy for a Sustainable Built Environment, Strategy for Circular Economy* and *Action Plan on Plastic*. Waste management measures have a firm foothold, with the first deposit-return scheme for beverage containers launched in the 1980s;[38] now, the country boasts one of the most successful systems in the world, with the highest plastic bottle return rate in Europe—96%.[39] Waste prevention, however, is less common: while earlier strategies, such as *Denmark Without Waste I/II*, aim to shift focus away from waste-to-energy incineration to a more circular approach,[40] this has not yet been realised.

While these initiatives have attracted their share of criticism—with little funding set aside for their realisation, for example—Denmark's action to date hasn't gone unnoticed: the 2020 Environmental Performance Index ranked the country first in the world on climate action, while the World Energy Council ranked it third best in the world for its energy system. But the country still has work to do in bringing its overall material consumption down to sustainable levels. Because 70% of global emissions stem from material use and handling, the circular economy is instrumental for Denmark to achieve its

** Find out more about how Circle Economy categorises countries as Build, Grow or Shift in Appendix E, on page 120.*

bold climate goals and cut emissions both at home and abroad.[41] Denmark's fossil-free by 2050 goals tackle domestic emissions, but so far, no plans are in place to address consumption-based emissions. Overall, the foreign share in the carbon footprint of Denmark was a relatively-high 65% in 2019, with the domestic share accounting for the other 35%. By embracing circular strategies, Denmark can begin to account for extraction, emissions and waste driven beyond its borders as a result of its domestic demand.

The mobilisation needed to bring Denmark from linear to circular is not beyond reach—in fact, the country is well positioned to do so. In 1973, Denmark was one of the OECD countries most dependent on oil for energy, with more than 90% of its supply fed by imported oil. When the oil crisis struck and prices surged, the country's oil policy changed rapidly: the crisis sparked mobilisation to diversify the energy mix.[42] Denmark has spearheaded a difficult transition before and can do it once again: this is the commitment that will make the circular economy a success.

A SOCIAL, ECONOMIC AND ENVIRONMENTAL CROSSROADS

The circular economy is a means to an end: the end goal being an economy where societal needs are met for current and future generations within the ecological limits of the planet. A holistic circular economy must put people at its core and endeavour to provide greater access to—and distribution of—resources. Social considerations, such as decent employment opportunities and leveraging the skills of the existing workforce, should be front and centre. For example, as oil and gas extraction is gradually being phased out, workers employed in this industry need to be carefully considered to ensure they have sufficient opportunities and the appropriate skills to work in other industries.

Denmark's labour market has a solid foundation to take on the challenge of transitioning to a circular economy: it's characterised by strong social dialogue that has driven systemic transformation in the past, as well as a very low unemployment rate, high proportion of flexible and innovative small- and medium-sized enterprises, and strong pathways for skills development. Although there are avenues for improvement—integrating more circular knowledge and skills in vocational and higher education, for example—Denmark's labour market will have a key role to play in accelerating the transition.

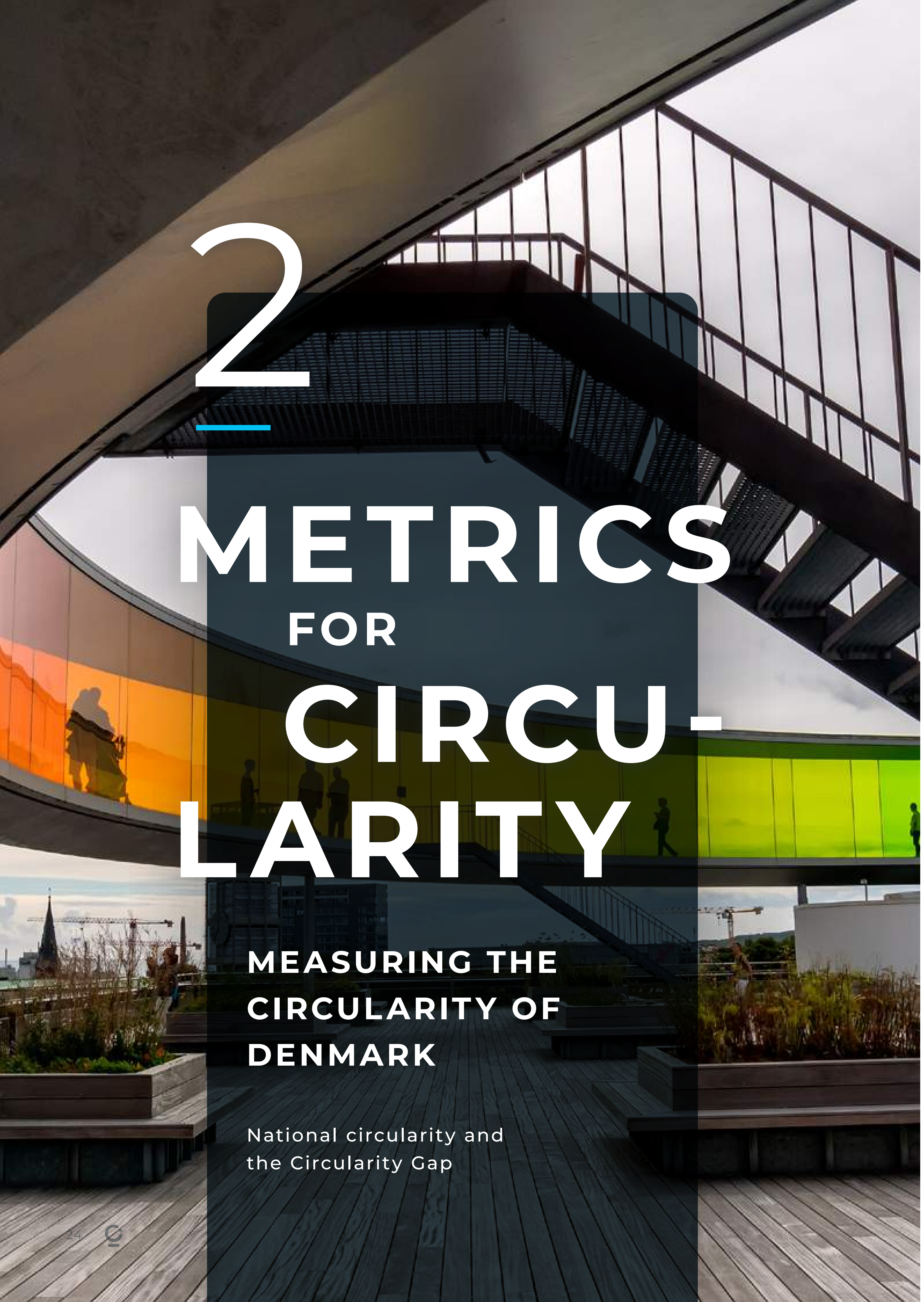
AN ECONOMY FULL OF POTENTIAL

A head-on approach to the circular economy will require Denmark to unlock its massive potential for innovation and leverage its highly skilled workforce to increase economic competitiveness. With the circular economy comes opportunity: economic value for businesses, new services for consumers and potential for the creation of new and—if possible shortcomings are addressed—decent jobs.[43] This includes opportunities regarding recovered resource value, access to new markets and green investment funds, as well as the value created through new circular products and services. Simultaneously, such circular approaches can offset resource, market, operational, business and legal risks associated with the current linear 'take-make-waste' model.

Our analysis finds several avenues to cut Denmark's material and carbon footprints, advance resource efficiency and substantially increase material circulation in the economy, progress towards environmental goals, and bring the country from theory to action: the kind of systemic shift needed to realise a circular economy. Combined, Denmark could cut material consumption by 39%, bringing it down to 86.8 million tonnes, and reduce its carbon footprint by 42%, bringing it down to 35.7 million tonnes of CO_2e. By transforming the way it provides for Danish residents' societal needs and wants, the country can boost its Metric from 4% to 7.6%. This report shows how.

AIMS OF THE *CIRCULARITY GAP REPORT DENMARK*

1. **Provide a snapshot** of how circular Denmark is by applying the Circularity Metric.
2. **Identify how materials flow** throughout the economy and how they may limit or boost the current Circularity Metric.
3. **Spotlight possible interventions** within significant industries that can aid Denmark's transition to circularity and reduce its material footprint.
4. **Spotlight avenues** for businesses and governments to change their behaviour to encourage circular consumption.
5. **Explore the jobs and skills** necessary to realise a circular economy in Denmark and close the Circularity Gap in an equitable way.
6. **Communicate a call to action** based on the above analysis to inform future goal-setting and agendas.



2

METRICS FOR CIRCU-LARITY

MEASURING THE CIRCULARITY OF DENMARK

National circularity and the Circularity Gap

Measurements are critical to understanding the world around us. As it becomes more urgent for us to adapt our socioeconomic system and become more circular, we need to provide a tactical approach for measuring the transition. In the first edition of the global *Circularity Gap Report*, in 2018, Circle Economy calculated the Circularity Metric for the global economy for the first time. This analysis adapts the Metric to suit a national profile. This chapter explains how this report has assessed Denmark's circularity and introduces supporting metrics that help us understand the significant material flows that make up the country's large Circularity Gap. These additional insights allow us to formulate a plan for moving toward greater circularity: they provide an initial assessment by locating circular opportunities and priorities in material flows. By measuring circularity in this way, businesses and governments can track their circular performance over time and put trends into context, as well as engage in uniform goal-setting and guide future action in the most impactful way possible.

THE CIRCULARITY METRIC EXPLAINED

In order to capture a single metric for circularity in an economy, we need to reduce this complexity somewhat. So, we take the metabolism of a national economy as the starting point. This approach builds on and is inspired by the work of Haas et al.[44] (2015), and continues the approach applied in all other national *Circularity Gap Reports*. Taking an 'X-ray' of the economy's resource and material use, we consider six fundamental dynamics of what the circular economy transition aims to establish and how it can do so. This translates into two objectives and four strategies, based on the work of Bocken et al. (2016).[45]

The core objectives are:

- **Objective one:** Resource extraction from the Earth's crust is minimised, and biomass production and extraction is regenerative;
- **Objective two:** The dispersion and loss of materials is minimised, meaning all technical materials have high recovery opportunities, ideally without degradation and with optimal value retention; emissions to air and dispersion to water or land are prevented; and biomass is optimally cascaded.

The four strategies we can use to achieve these objectives, depicted in Figure one on the next page, are:

- **Narrow flows—Use less:** The amount of materials (including fossil fuels) used in the making of a product or in the delivery of a service are decreased. This is done through circular design, greater resource efficiency or increasing the usage rates of materials and products. In practice: Sharing and rental models, material lightweighting (mass reduction), multifunctional products or buildings, energy efficiency, digitisation.
- **Slow flows—Use longer:** Resource use is optimised as the functional lifetime of goods is extended. Durable design, materials and service loops that extend life, such as repair and remanufacturing, both contribute to slowing rates of extraction and use. In practice: Durable material use, modular design, design for disassembly, reuse, repair, remanufacturing, refurbishing, renovation and remodelling over building new structures.
- **Regenerate flows—Make clean:** Fossil fuels, pollutants and toxic materials are replaced with regenerative alternatives, thereby increasing and maintaining value in natural ecosystems. In practice: Regenerative and non-toxic material use, renewable energy, regenerative agriculture and aquaculture.
- **Cycle flows—Use again:** The reuse of materials and products at end-of-life is optimised, facilitating a circular flow of resources. This is enhanced with improved collection and reprocessing of materials and optimal cascading by creating value in each stage of reuse and recycling. In practice: Design for recyclability (both technical and biological), design for disassembly, reuse and recycling.

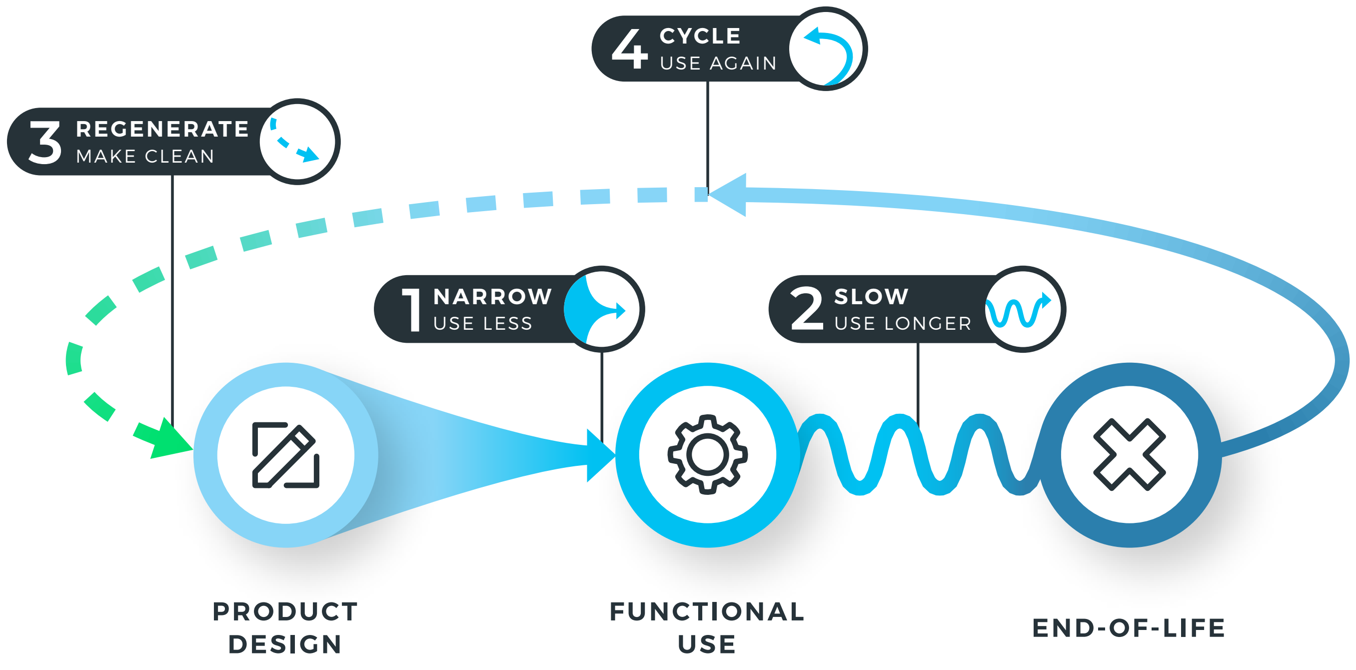


Figure one depicts the four strategies to achieve circular objectives: narrow, slow, regenerate and cycle.

There are potential overlaps between some of these strategies: for example, slow and cycle interventions often work together. By harvesting spare parts to use again, we are both cycling—by reusing components—and slowing, by extending the lifetime of the product the components are used for. And ultimately, slowing flows can result in a narrowing of flows: by making products last longer, fewer new replacement products will be needed—resulting in decreased material use. There are also potential tradeoffs between the four strategies to be acknowledged. Fewer materials being used for manufacturing—narrow—means less scrap available for cycling. Similarly, if goods like appliances and vehicles are used for longer—slow—their energy efficiency falters in comparison with newer models, thus preventing narrowing. Using products for a long time—slowing flows—also decreases the volume of materials available for cycling: this can have a significant impact on material-intensive sectors like the built environment, where boosting the availability of secondary materials is particularly important. What's more: some strategies to narrow flows, like material lightweighting, can result in decreased product quality and thus shorten lifetimes—making it more difficult to slow flows.

While all four flows are crucial to the success of a circular economy, our Circularity Metric captures circularity in one figure based on **cycling:** it measures the share of cycled materials as part of the total material consumption in an economy. Total consumption must decrease—through strategies such as narrow, slow and regenerate—as cycling increases for the Metric to grow meaningfully. In this way, the Metric illustrates the current progress towards achieving the circular economy's ultimate goal of designing out waste and lowering material consumption through the four listed strategies.

Communicated as a percentage, our input-focused Metric is a relative indicator of how well global or national economies balance sustaining societal needs and wants with materials that already exist in the economy. The value of this approach is that it allows us to track changes over time, measure progress and engage in uniform goal-setting, as well as benchmark countries' circularity against each other as well as at the global level. Additionally, it should provide direction as to how Denmark can embrace its circular potential. Since its launch in 2018 at the World Economic Forum, the Circularity Metric has formed a milestone for global discourse on the circular economy.

DYNAMICS INFLUENCING THE CIRCULARITY METRIC

Applying the Circularity Metric to the global economy is relatively simple, largely because there are no exchanges of materials in and outside of planet Earth. For countries, however, the dynamics of trade introduce complexities to which we must adapt the Metric, resulting in certain methodological choices.[46] These are:

1. **We take a consumption-based perspective.** This means we only consider materials consumed domestically and allocate responsibility to consumers by excluding exports.
2. **We use demand-based indicators.** This allows for a reallocation of environmental stressors from producers to final consumers.
3. **We consider imports and exports in terms of their raw material equivalents (RMEs): the amount of material extraction needed, anywhere in the world, to produce a traded product.** This allows us to more accurately interpret the true impact of finished and semi-finished products. For more information on RMEs, read page 38.
4. **We consider waste imported from abroad for reuse in our calculation of the Circularity Metric.** We give 'credit' for saving virgin materials to the country that uses that secondary material—recovered from former 'waste'.

For a more detailed explanation of these choices, please refer to Appendix A, on page 118.

INSIDE THE CIRCULARITY GAP

In our Circularity Metric Indicator Set, we consider 100% of inputs into the economy: circular inputs, non-circular flows and non-renewable inputs, and inputs that add to stocks. This allows us to further refine our approach to closing the Circularity Gap in a particular context, and answer more detailed and interesting questions: how much biomass is Denmark extracting domestically, and is it sustainable? How dependent is Denmark on imports to satisfy its population's basic societal needs? What volume of material is being added to Denmark's stock each year in the form of buildings, infrastructure and other long-lasting goods? The categories that follow are based on the work of Haas et al. (2020).[47]

CIRCULAR INPUTS

Socioeconomic cycling rate (4%)

This refers to the share of secondary materials in the total consumption of an economy: this is the Circularity Metric. These materials are items that were formerly waste but now are cycled back into use, primarily consisting of recycled materials from the technical cycle (such as recycled concrete and metals)[48] but also a small fraction from the biological cycle (such as paper and processed wood).[49] In Denmark, this number falls well below the global average of 7.2%, totalling 4% of total material input (5.9 million tonnes). As we take a consumption-based perspective, we only credit recycling efforts occurring in Denmark—including materials imported for recycling. Waste collected and prepared for recycling abroad is not included as part of the Circularity Metric. If waste collected for recycling abroad were to be taken into account, the Circularity Metric would rise to around 6%. Therefore, Denmark's Circularity Metric is impacted by the fact that it's a relatively small economy where domestic recycling facilities aren't always feasible, given the close proximity to larger economies such as Germany.

WHY DOES DENMARK HAVE A LOWER CIRCULARITY METRIC THAN SOME OTHER COUNTRIES?

In measuring circularity, a number of different variables come into play: the portion of materials cycled back into the economy, for instance—but also the size of the material footprint of a nation. When the material footprint outsizes the volume of cycled materials, this creates a Circularity Gap. Different countries have different economic and consumption patterns, as well as different waste management practices, leading to varying Circularity Gaps. This is why some countries perform 'better' than others in terms of their Circularity Metric, despite having similar waste management practices. Denmark's material footprint is very high, making it difficult to cycle materials at the scale and speed needed to elicit a high Circularity Metric.

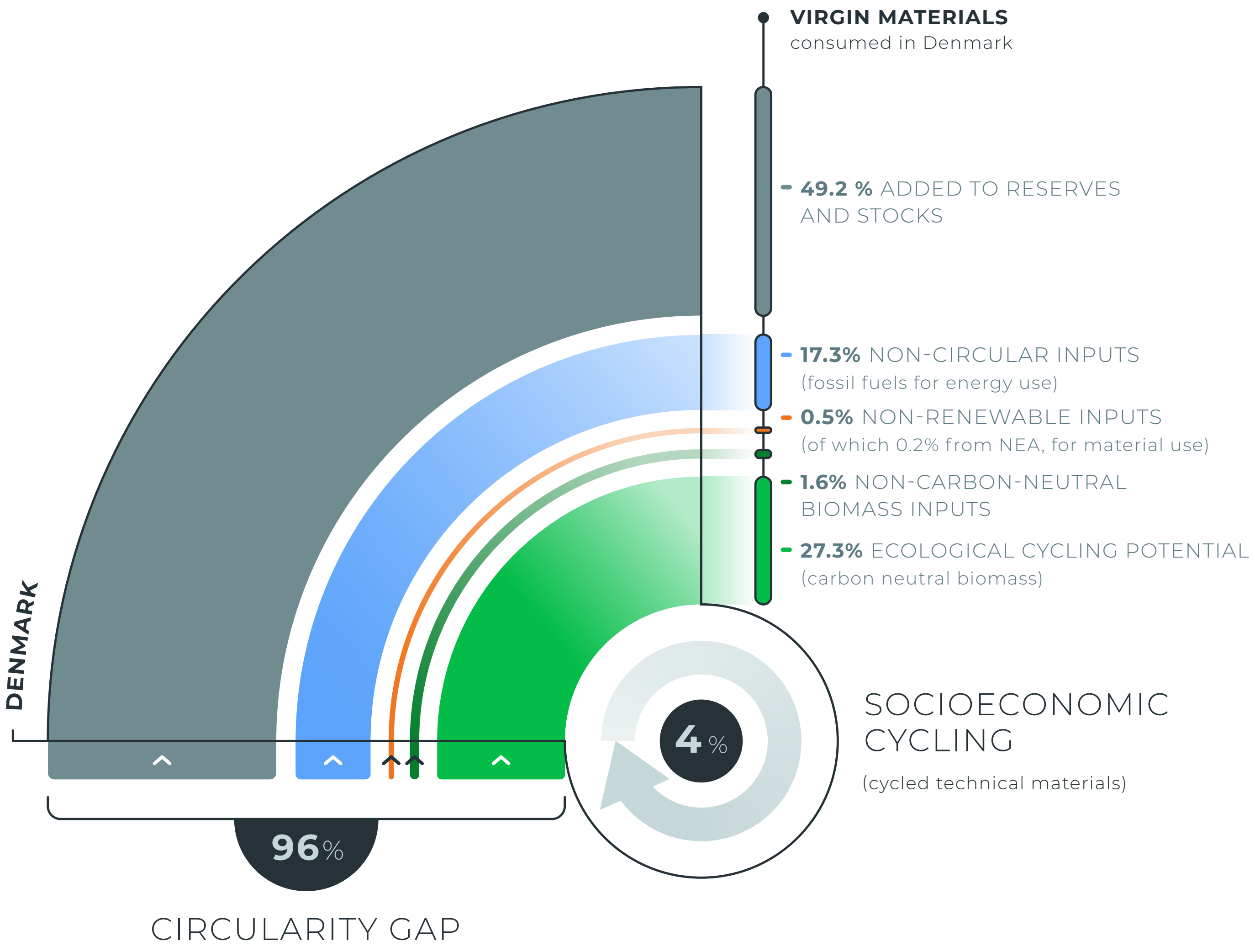


Figure two shows the full picture of circular and non-circular materials that make up Denmark's Circularity Gap.

Ecological cycling potential (27.3%)

Ecological cycling concerns biomass, such as (unprocessed) wood, manure, food crops or agricultural residues. To be considered ecologically cycled, biomass should be wholly sustainable and circular: this means it must, **at the very least**, guarantee full nutrient cycling—allowing the ecosystem biocapacity to remain the same—and be carbon neutral. The nutrient cycles of biomass are intricate, so we rely on a broader approach to estimate ecological cycling potential: to estimate the flow of primary biomass, which can't be regarded as carbon neutral, we subtract the biomass-related net emissions of carbon from Land Use and Land Cover Change (LULCC)[50] from socioeconomic biomass flows. In Denmark, Ecological cycling potential represents 27.3% of materials (40.5 million tonnes). This makes up a larger share of the total inputs compared to previously analysed countries (see Table one on page 30), meaning that (carbon neutral) biomass represents a higher portion of Denmark's overall consumption compared to other European countries. This can partially be attributed to the rapidly increasing use of biomass—particularly wood—for power plants for heat and electricity generation.[51] The share of material use represented by non-carbon neutral biomass is described by the following indicator.

LINEAR INPUTS

Non-carbon-neutral biomass inputs (1.6%)

This metric indicates a biomass input rate that is not carbon neutral. This is determined by positive LULCC emissions: theoretically, not all of the CO_2 embedded in the bio-based materials Denmark consumes is 'sequestered' (CO_2 embedded in biomass in Domestic Material Consumption). For Denmark, such biomass represents around 1.6% of total material consumption (2.4 million tonnes). This is a relatively low share of total biomass consumed, meaning that although Denmark cannot fully compensate for all of the embedded CO_2 consumed, it isn't far off. To minimise Non-carbon-neutral biomass inputs, Denmark can aim to increase its carbon sinks through afforestation and the conversion of intensively farmed land to regeneratively farmed land, for example.

WHY DON'T WE INCLUDE ECOLOGICAL CYCLING POTENTIAL IN THE CIRCULARITY METRIC?

While carbon neutrality is a necessary condition for biomass to be considered circular, it is not sufficient in itself: other nutrients, such as nitrogen and phosphorus, should be fully circulated back into the economy or the environment as well. As of yet, methodological limitations exist in determining nutrient cycling. To this end, in line with past *Circularity Gap Reports*, we have excluded ecological cycling in our calculation of Denmark's Circularity Metric, even though this could potentially boost the country's circularity rate to 31.3%. For all nations, we take a precautionary stance with its exclusion, knowing that its impact on the Metric may not be accurate. For example, we cannot track biomass extracted in Denmark to its final end-of-life stage, so ensuring that the nutrient cycle has closed isn't easy. If this were the case, however—and if circular biomass management were to become the norm—circularity could significantly increase.

Non-circular inputs (17.3%)

This category centres on fossil fuels for energy use. Fossil-based energy carriers, such as gasoline, diesel and natural gas that are burned for energy purposes and dispersed as GHG emissions in our atmosphere are inherently non-circular. Here, circular economy strategies such as cycling are not applicable as the loop cannot be closed on fossil fuels—although the circular transition will inherently reduce emissions through 'narrow' and 'regenerate' strategies. At over 17% (or 25.6 million tonnes), Denmark's rate of non-circular inputs is moderate, highlighting the fossil fuel-dependent character of the economy, especially for space heating and to power transport and industry. This is in spite of a largely decarbonised electricity mix.

Non-renewable inputs (0.5%)

Non-renewable inputs into the economy that are neither fossil fuels nor non-cyclable ecological materials include materials that we use to satisfy our lifestyles, such as the metals, plastics and glass embodied in consumer products. These are materials that potentially can be cycled, but are not. Denmark's non-renewable input rate is 0.5% (or 0.75 million tonnes), which is significantly lower than other countries that have been analysed. This means that Denmark recycles the vast majority of those products that can potentially be recycled—although not necessarily at the highest quality possible. Additionally, it should be noted that the majority of this stems from extraction happening abroad for materials and goods imported into Denmark.[52] All of Net extraction abroad is allocated under Non-renewable inputs.

STOCK BUILD-UP

Net additions to stocks (49.2%)

The vast majority of materials that are 'added' to the reserves of an economy are Net additions to stocks: any good in long-term use, from buildings and infrastructure to machinery and vehicles. Countries are continually investing in stocks to provide housing, roads and means of transport, for example. This stock build-up is not inherently bad; many countries need to invest to ensure that the local populations have access to basic services, as well as build up infrastructure globally to support renewable energy generation, distribution and storage capacity. These resources do, however, remain locked away and not available for cycling and therefore weigh down the Circularity Metric. At almost half of the total material consumption (or 72.8 million tonnes), Denmark's **stocking rate is very high** compared to other countries for which this was estimated (see text box on page 30).

DIFFERENCES IN COUNTRIES' INDICATOR SETS

- Table one compares countries for which we've derived an Indicator Set using the same methodology.[53]
- Denmark scores lower than most of these countries in terms of socioeconomic cycling, meaning that it is less 'circular', only topping Scotland and Sweden.
- Ecological cycling potential is, however, one of the highest rates. This means that if this input could confidently be labelled as circular and combined with socioeconomic cycling, Denmark would be 31.3% circular, giving it one of the highest rates of circularity alongside Northern Ireland and Sweden.
- In terms of non-circular inputs, such as fossil fuels, Denmark ranks on the higher side compared to other countries, meaning that the resources consumed are still not close to being decarbonised, so great focus is needed on the value chains of these resources.
- Denmark's **stocking rate is very high** compared to other countries for which this has been estimated so far. To compare, in absolute terms, net stock additions per capita in Denmark are **12.5 tonnes**, compared to 4.5 tonnes in Scotland and 10 tonnes in Sweden. Both Scotland and Sweden have much lower population densities than Denmark—which tends to yield a higher figure for per capita net stock additions. However, Denmark's rate still exceeds both countries: this suggests that more urban development is taking place and hints at higher consumption of long-lasting products. Therefore, reducing the stocking rate will be a key lever to increase circularity in Denmark.

NATION	SOCIOECONOMIC CYCLING	ECOLOGICAL CYCLING POTENTIAL	NON-CARBON-NEUTRAL BIOMASS INPUTS	NON-CIRCULAR INPUTS	NON-RENEWABLE INPUTS	NET ADDITIONS TO STOCK
Denmark	4.0%	27.3%	1.6%	17.3%	0.5%	49.2%
Switzerland	6.9%	10.7%	0.0%	9.2%	40.9%	32.4%
UK	7.5%	15.6%	1.4%	13.0%	41.7%	20.6%
Poland	10.2%	13.8%	1.4%	18.7%	20.7%	35.2%
Northern Ireland	7.9%	22.9%	0.9%	16.6%	17.9%	33.7%
Scotland	1.3%	16.6%	1.6%	15.0%	45.1%	20.4%
Sweden	3.4%	36.3%	-	7.4%	13.1%	39.8%

PRACTICAL CHALLENGES IN QUANTIFYING CIRCULARITY

Providing a year-zero baseline measurement of the circularity of a national economy based on resource flows offers many advantages, not least that it can be used as a call to action. But the circular economy is full of intricacies, and therefore, simplifications are necessary, which result in limitations that must be considered.

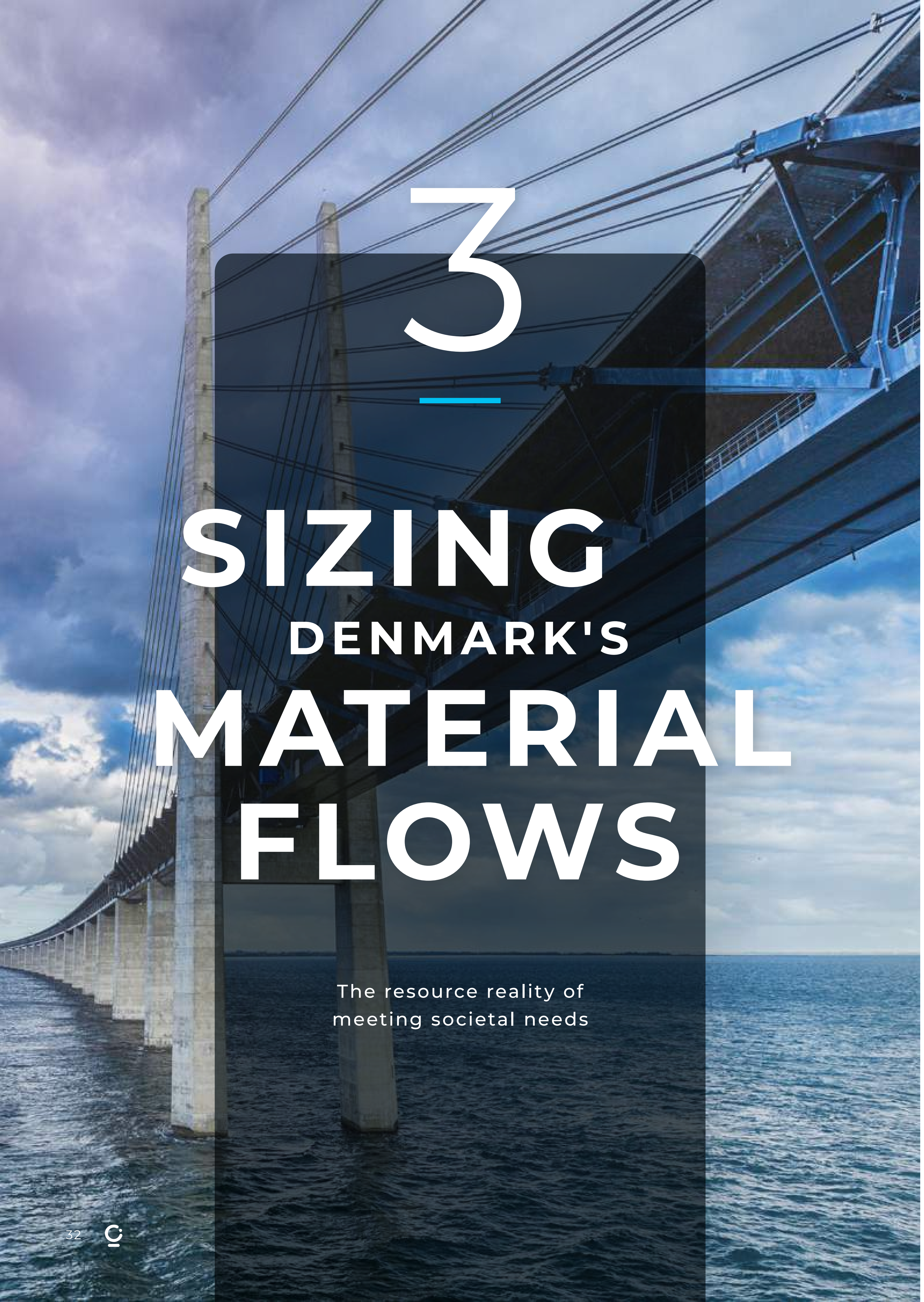
1. **There is more to circularity than (mass-based) cycling.** As seen from the examination of the four strategies, there are other important aspects to circularity, namely: using less, using longer and regenerating natural systems. In many cases, cycling is less desirable than using less or using longer: demolishing all of Denmark's buildings and recycling all these materials, for example, would cause a massive spike in the Circularity Metric, despite this being an undesirable means for increasing circularity.
2. **The Metric focuses on one aspect of circularity.** We focus only on material use without examining other factors such as biodiversity loss, pollution, toxicity and so on.
3. **Data quality isn't always consistent.** Whilst data on material extraction and use are relatively robust, data on the end-of-life stage can often be weak, presenting challenges in quantifying material flows and stocks. This also varies between countries.
4. **We consider relative, not absolute, numbers.** This means that if cycling increases at a faster rate than material consumption, the Metric will improve—even if the ultimate goal is for consumption to decrease.
5. **Achieving 100% circularity isn't feasible.** There are technical and practical limits to cycling, and some materials will always be required for stock build-up. Some materials, like fossil fuels, are also inherently non-circular and cannot be cycled.

For more detail on each of these points, please refer to Appendix B, on page 118.

For an even more exhaustive look into the methodology behind the Circularity Gap, please refer to the methodology document.

Table one (previous page) provides comparisons between countries for which we have derived an Indicator Set. Each country's Circularity Gap Report can be referred to for a more in-depth explanation of these figures. These can be found on circularity-gap.world.

** Note: Any discrepancies in the sum of these figures is due to rounding.*



3 SIZING DENMARK'S MATERIAL FLOWS

The resource reality of meeting societal needs

Denmark is 4% circular: 96% of the materials flowing through its economy come from virgin sources. This chapter dives into the country's socioeconomic metabolism, exploring how materials are used—and at which proportions—to meet various societal needs and wants, from housing and nutrition to mobility and manufactured goods. Our analysis reveals key themes that illustrate the country's resource use: Denmark presents a material- and carbon-intensive profile, driven by heavy resource extraction, both domestically and abroad, to meet Danish demand. On a sectoral level, the construction, manufacturing and agrifood sectors comprise the largest portions of the country's material flows.

MEASURING DENMARK'S MATERIAL FLOWS AND FOOTPRINTS

This analysis takes the socioeconomic metabolism of Denmark—the way in which materials flow through the economy and are kept in long-term use—as the starting point for measuring its level of circularity. Measuring the material impact of an economy depends on the perspective from which the material flows and greenhouse gas (GHG) emissions are measured. Figure three provides a schematic depiction of the difference between consumption-based and production-based material and carbon accounting.

To ensure our data is in line with the reality of Denmark, we worked with data from Statistics Denmark, Danish Environmental Protection Agency (EPA), the Danish Energy Agency (DEA) and the Danish National Inventory Report. For more information on the data behind this report, refer to the methodology document.

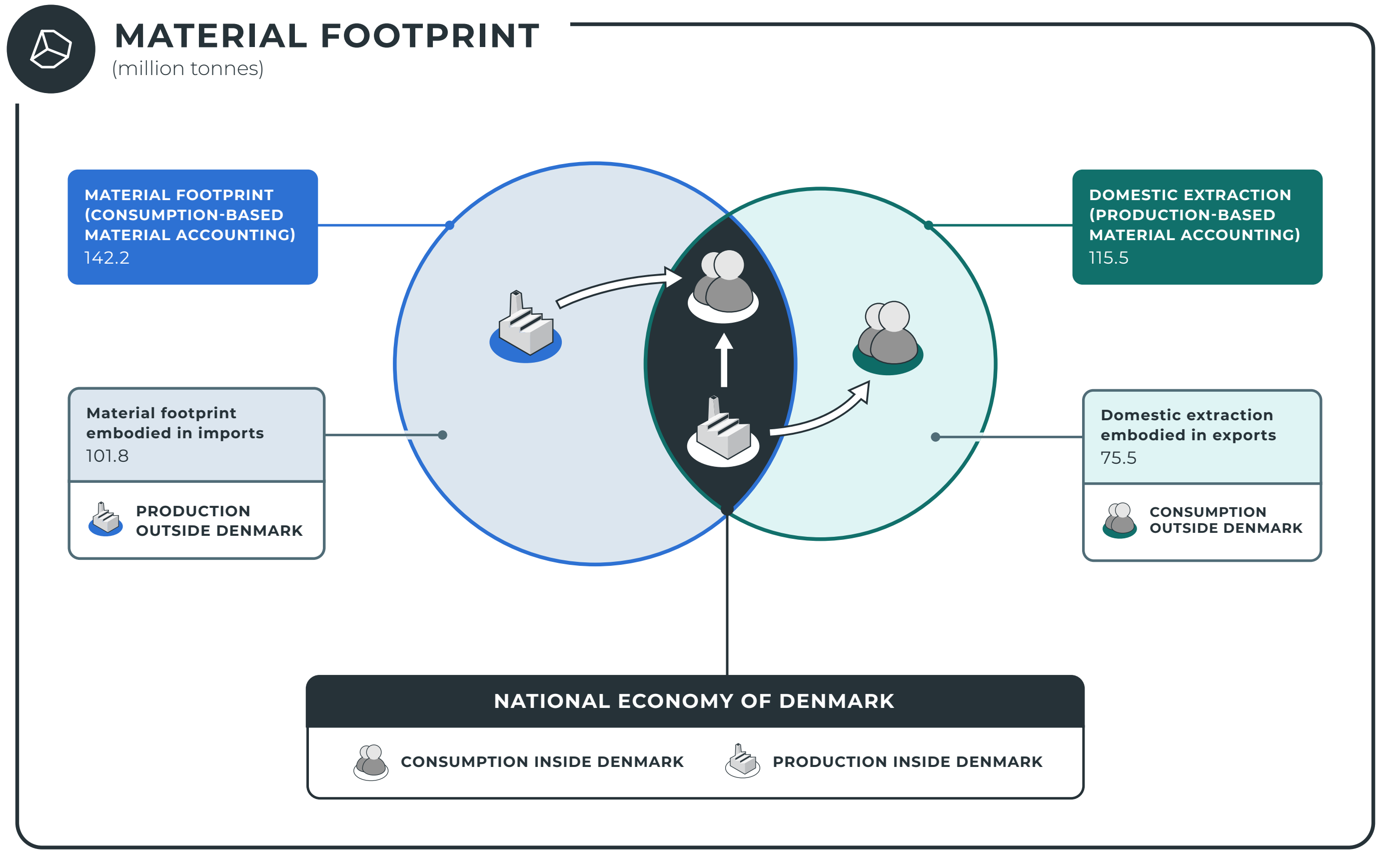
Consumption-based accounting

Consumption-based material flow accounting measures the amount of materials used to meet the consumption needs of a country, regardless of where the materials were extracted or where the products were produced. This approach accounts for the materials embodied in imported products and services. Similarly, consumption-based carbon footprinting measures the GHG emissions generated by the consumption of goods and services, regardless of where they are produced. This approach provides a more comprehensive view of an economy's contribution to global emissions and identifies the carbon footprint of consumption. By accounting for the emissions embodied in imports and exports, carbon footprinting can provide an accurate picture of a country or region's contribution to global emissions.

Production-based accounting

Production-based material flow accounting measures the total amount of material extracted, processed and used within the borders of a territory, regardless of where the products are consumed. This approach focuses on the physical flows of materials associated with production activities within an economy and thus allocates the use of natural resources or the impacts related to natural resource extraction and processing to the location where they physically occur. Similarly, production-based accounting for carbon measures GHG emissions stemming from production activities within a country's borders.

Both approaches are useful in understanding the environmental impacts of material use and GHG emissions while identifying opportunities to improve resource efficiency and reduce waste. However, consumption-based accounting provides a more comprehensive view of an economy's environmental footprint: it accounts for society's needs and thus forms the basis of our analysis. An exploration of how Danish society consumes materials to fulfil needs like food, transport and housing can be found on page 37.



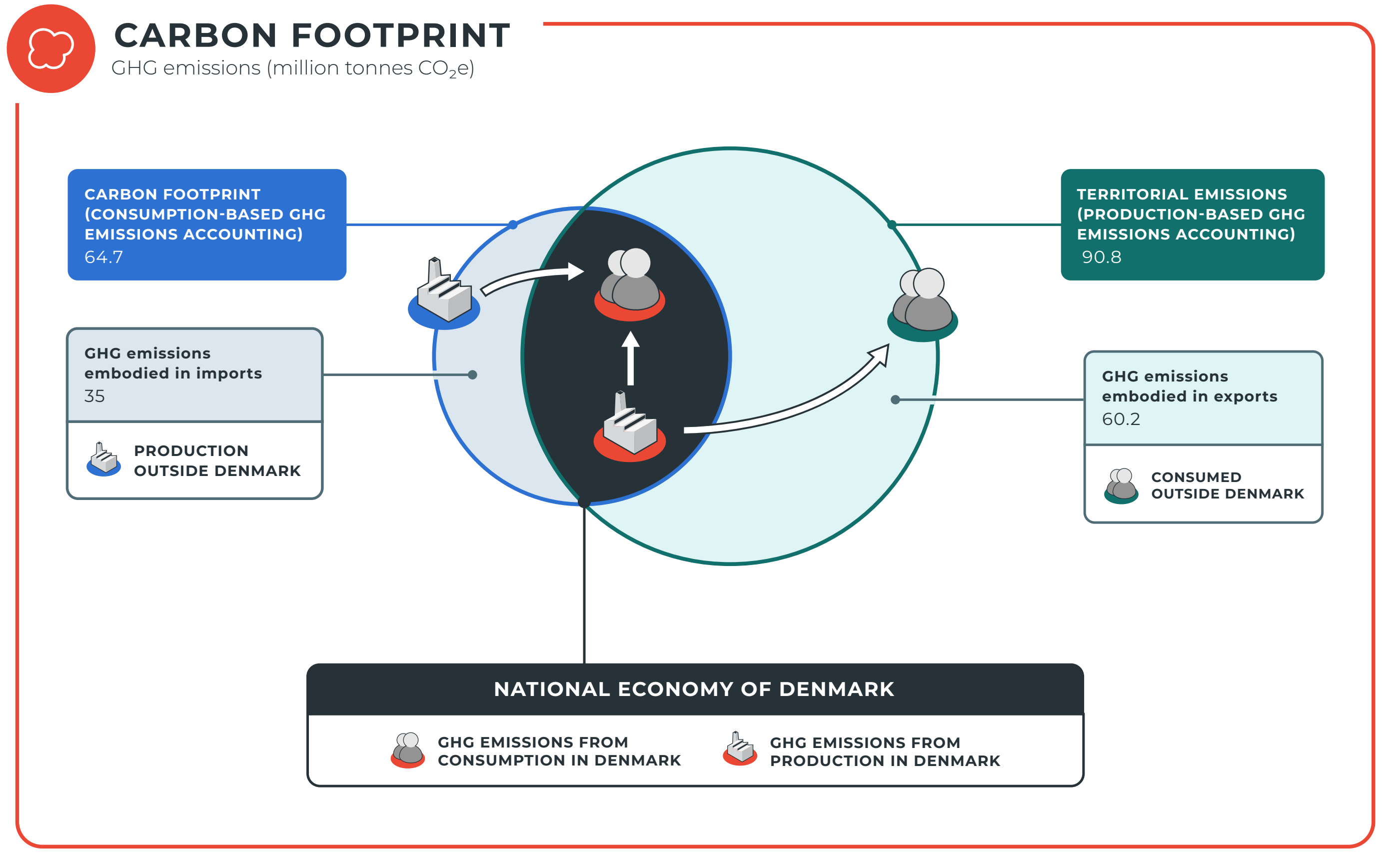


Figure three shows a schematic depiction of the difference between consumption-based and production-based material and carbon accounting.

Societies require materials to operate. In fulfilling people's needs, three connected spheres need to be taken into account: 1) how materials are put to work, to 2) deliver social outcomes, via 3) provisioning systems. Provisioning systems comprise physical systems such as road infrastructure, technologies and their efficiencies,[54] and social systems, which include government institutions, businesses, communities and markets.[55] Provisioning systems are the essential link between biophysical resource use and social outcomes. For example, different forms of transportation infrastructure (railways versus motorways or car-sharing versus car ownership) can generate similar outcomes, but at very different levels of material use: this is how the circular economy can allow us to thrive with minimal environmental impact.

On the next page, we describe the seven key societal needs and wants and which products and services they include, as well as the volume of materials it takes to fulfil them from Denmark's total material consumption of just over 148.4 million tonnes. Some materials—such as fossil fuels—play a significant role in all societal needs. Because various products can be allocated differently, here we make explicit choices. For example, 'radio, television and communication equipment' can be classified as either Communication or Manufactured Goods. We decided to subsume it under 'Communication'. Since previous *Circularity Gap Reports*, we have also reallocated infrastructure to various appropriate societal needs: it is no longer purely allocated under 'Housing', meaning that comparisons with analyses prior to October 2022 are no longer accurate.

* *Figures may not sum to total due to rounding.*

SEVEN SOCIETAL NEEDS & WANTS

HOUSING

46.9 million tonnes (32% of total material consumption)

This includes the construction, maintenance and renovation of housing, as well as other activities mostly concerned with the 'built environment', such as real estate activities, and the extraction and manufacturing of building materials such as concrete, steel and timber and the use of utilities such as power consumption, water supply and sanitation, and waste management and treatment.

SERVICES

28.9 million tonnes (19% of total material consumption)

The delivery of services to society ranges from education and public services to commercial services like banking and insurance. This typically involves the use of commercial buildings, professional equipment, office furniture, computers and other infrastructure.

NUTRITION

23.2 million tonnes (16% of total material consumption)

Agricultural products such as crops and livestock are used to create food and drink products. These tend to have short life cycles in our economy, being consumed quickly after production.

HEALTHCARE AND EDUCATION

20.8 million tonnes (14% of total material consumption)

With an expanding, ageing and, on average, more prosperous population, healthcare services are increasing globally. In addition to buildings, typical products used include capital equipment such as X-ray machines, pharmaceuticals, hospital outfittings (beds), disposables and homecare equipment.

MOBILITY

16.1 million tonnes (11% of total material consumption)

A considerable share of total material consumption is taken up by the need for mobility. Two material types are particularly used: the materials used to build transport technologies and vehicles like cars, trains and aeroplanes, as well as infrastructure like roads and railways, plus, predominantly, the fossil fuels used to power them.

MANUFACTURED GOODS

10.8 million tonnes (7% of total material consumption)

Manufactured goods consist of a diverse group of products—appliances, clothing, cleaning agents, personal-care products and paints, and more—that generally have short to medium lifetimes in society. Textiles also consume many different kinds of resources, such as cotton, synthetic materials like polyester, dye pigments and chemicals. Manufactured goods belonging to other societal needs, such as vehicles and capital equipment for healthcare, are not included in this category.

COMMUNICATION

1.2 million tonnes (1% of total material consumption)

Communication is an increasingly important aspect of today's society, provided by a mix of equipment and technology ranging from personal mobiles to data centres. Increased connectivity is also an enabler of the circular economy, where digitisation can make physical products obsolete or enable far better use of existing assets, including consumables, building stock or infrastructure—smart meters and teleconferencing instead of in-person meetings, for example.

THE MATERIAL FOOTPRINT SATISFYING SOCIETAL NEEDS IN DENMARK

Figure four, depicted on pages 40–41, shows how materials move through the Danish economy. It depicts the amounts of materials (clustered into four key resource groups) embodied in the inputs and outputs of highly aggregated industry groups.[56] Because the majority of materials flow through just a handful of sectors in an economy, we have limited our visualisation to show these. The left side shows the four resource groups: non-metallic minerals (sand, gravel and limestone, for example), metal ores (iron, aluminium and copper, for example), fossil fuels (petroleum and coal, for example) and biomass (food crops and forestry products, for example, but not livestock).

On the left, we also see the volume of resources entering the national economy through **imports**. These are represented in terms of Raw Material Equivalents (RMEs)—the amount of material extraction needed anywhere in the world to produce a traded product. A motor vehicle, for example, may weigh 1 tonne when imported, but all the materials used to produce and transport it across global value chains can be as much as 3.4 tonnes; while 1 kilogram of beef for consumption has a total material footprint of 46.2 kilogrammes. Together, the domestic extraction and the **RME of imports** comprise the total inputs (raw material input, which does not include secondary material inputs) of a national economy.

Once in the economy, extracted or traded raw materials—as well as traded or domestically produced components, semi-products and products—undergo operations that either transform them into end products or make them part of the production process of another end product. Beginning with extraction, the resources are processed (from metals into ores, for example) and then manufactured into products in the 'produce' stage. The finished products satisfy societal needs and wants, such as Nutrition, Housing and Mobility, or they are exported. Of these materials entering the national economy every year, the majority are utilised by society as short-lived **Products that Flow**—reaching their end-of-use typically within a year, such as an apple, food packaging or a standard toothbrush. At end-of-use, these products' materials are typically either lost or cycled back into the economy. The remaining materials enter into long-term stock—referred to as **Products that Last**. These are products such as capital equipment, buildings and infrastructure. Knowing what happens to products and materials after their functional use in our economy is essential for identifying and addressing opportunities for a more circular economy. For more detailed information on how our model classifies different waste types, and how this waste is processed, refer to Appendix D on page 119.

So how are materials extracted, used, traded and managed at end-of-life in Denmark?

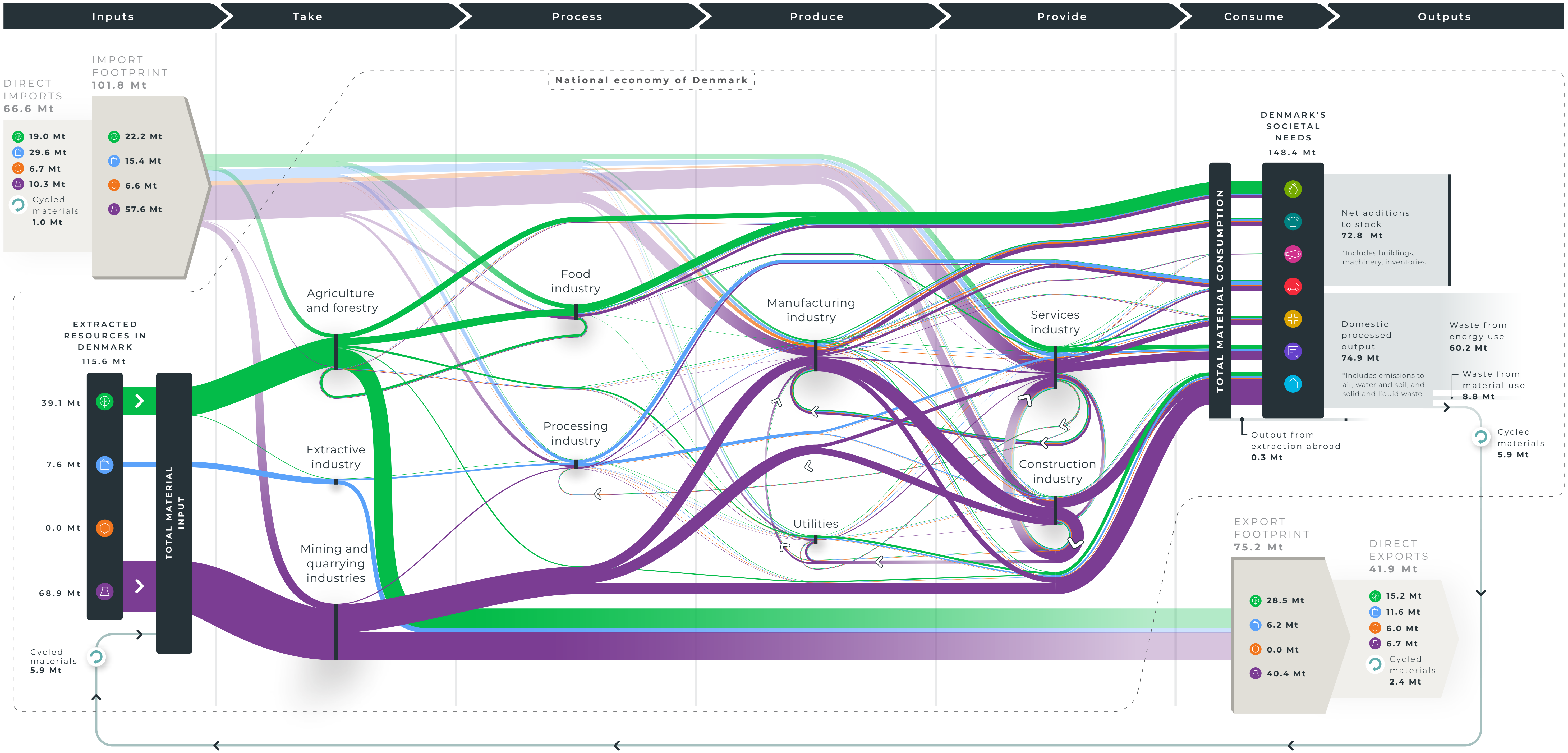
- Domestic extraction amounts to **116 million tonnes** or **19.9 tonnes** per capita per year. This is largely non-metallic minerals, such as sand and gravel, and biomass, including crops and crop residues (mostly fodder). This is significantly higher than EU and world averages.
- Raw (virgin) material consumption (the material footprint) sits at **142.2 million tonnes**, combined with a net consumption of secondary materials of **5.9 million tonnes** and a balancing factor for net extraction abroad[57] (**0.3 million tonnes**). Altogether, this yields a total material consumption of **148.4 million tonnes**.
- Directly imported products weigh 66.6 million tonnes. Considering RMEs, Denmark's total import footprint is **101.8 million tonnes**.
- Exported products weigh 41.9 million tonnes, with an export footprint of **75.2 million tonnes**.
- Of the waste treated in Denmark, around **46%** is 'technically' recycled,[58] while 22% is incinerated, and 2% is landfilled. The remaining 30% is treated in wastewater treatment plants or spread on land.
- Denmark exports much more recyclable waste (1.9–2.4 million tonnes) than it imports (0.6–1 million tonnes).
- Five different waste streams make up 86.5% of the total waste treated and 81.4% of the total waste recycled, as detailed in Table two. These streams, alongside the remainder, contribute to the Circularity Metric. Mineral waste and mixed ordinary waste are most prevalent, respectively, claiming **39.1%** and **31.6%** of the total waste treated in Denmark (by weight).
- Denmark has moderate recycling rates[59] for chemical and medical waste (52%), very high rates for traditional recyclable waste[60] (91%) and very high rates for mineral waste (93%). In comparison, only 11% of mixed ordinary waste is recycled,[61] with most incinerated instead.
- Better recycling rates for mixed ordinary waste in particular, therefore, would be a key opportunity for Denmark to boost its Metric.

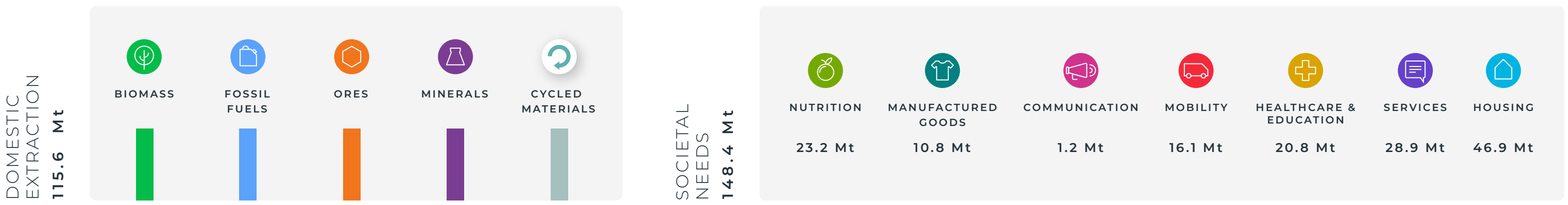
	SHARE OF TOTAL TREATED WASTE	SHARE OF RECYCLED WASTE	RECYCLING RATE
Mineral waste	39.1%	55.5%	93%
Mixed ordinary waste	31.6%	5.2%	11%
Traditional recyclables	12%	16.7%	91%
Chemical & medical waste	2.4%	1.9%	52%
Equipment	1.4%	2.1%	98%
Other streams	13.5%	18.6%	-

Table two shows the waste breakdown and waste recycling rates for Denmark.[62]

X-RAY OF DENMARK'S ECONOMY

Figure four shows an X-Ray of Denmark's economy: the resources that feed into meeting key societal needs.





Mismatches between inputs and outputs at the sector level are due to a cut-off for small flows set at 0.5 Mt in order to preserve image clarity.

The grey flows represent a "virtual" reallocation of resources embodied in exports originating from take industries (e.g. mining and agriculture) that should rather be attributed to Process, Produce or Provide industries.

KEY THEMES OF THE DANISH ECONOMY

Denmark's economy is resource and import-dependent and presents a material- and carbon-intensive profile. This can largely be attributed to two reasons: 1) high levels of material consumption and 2) the large import footprint for all resource groups but especially for non-metallic minerals. On a sectoral level, the construction, manufacturing and agrifood sectors concentrate the largest shares of the country's material flows.

HIGH DOMESTIC EXTRACTION, MUCH OF WHICH IS EXPORTED

Denmark is rich in some natural resources and is characterised by high levels of domestic extraction. With a total of 115.6 million tonnes per year in 2019—around **19.9 tonnes per capita**—Denmark's extraction significantly tops both EU and world averages, at 10.3 tonnes per capita and 12.3 tonnes per capita. This is largely claimed by non-metallic minerals at **60%**, followed by biomass (**34%**) and fossil fuels (**7%**). No extraction of metal ores takes place domestically.

Non-metallic minerals are largely dominated by sand and gravel, the bulk of which serves demand domestically, with a portion exported abroad. Biomass extraction feeds into a strong agricultural sector: contributing nearly one-quarter of total Danish exports, playing a significant role in the local economy.[63] Extraction, therefore, is almost equally split between crops—from cereals and sugar crops to roots and tubers—and used crop residues, fodder crops and grazed biomass, which are largely used to feed livestock. Denmark's pork industry relies on feed primarily from fodder crops, such as barley and wheat, which are largely grown domestically.[64] Denmark's forest cover has increased significantly over the last few decades,[65] owing to policy aimed at fostering biodiversity and supporting carbon sequestration.[66] To this end, only a small portion of biomass extraction—around 10%—is represented by timber and wood used for fuel: much of the wood Denmark uses to feed its thriving furniture and fuelwood industry is imported from nearby countries Sweden and Russia.[67] A substantial majority of the timber Denmark extracts and imports is used domestically, with only around one-fifth exported.

Fossil fuel extraction is dominated by crude oil, with natural gas playing a smaller role. As a share of total extraction, fossil fuel extraction is relatively low—and has been on the decline for the last two decades. Between 2004 and 2020, oil extraction decreased by 80%, with gas extraction decreasing by 85% in the same period.[68] Although Denmark has historically been a strong oil producer, the business case for continuing has become less favourable, with production and exploration activities expected to halt by 2050.[69] It's not just fossil fuel extraction on the decline: on the whole, Denmark's domestic extraction decreased by 3.3% between 2019 and 2020, falling to 112 million tonnes.[70] This hints at a general shift towards stricter environmental regulations, as well as profits from extraction falling in tandem with rising CO_2 prices. Efforts to reach ambitious targets for territorial emissions reduction have also seen an increase in imports matched by a decrease in domestic extraction in many countries.

This, however, merely transfers environmental burdens abroad. Extractive processes are not without impact: sand mining, for example, is linked to poor outcomes for biodiversity from harm to local ecosystems, land losses due to erosion, stress on the water supply through lowered water tables and pollution, and even extreme weather events by reducing natural protection from floods, droughts and storms.[71] Oil and gas production in Denmark has been shown to contaminate the surrounding marine environment, contribute to noise pollution and cause chronic, widespread issues due to flaring—the burning of natural gas during oil extraction—and the discharge of 'produced water', a byproduct of oil and gas production.[72] Similarly, biomass extraction through agricultural activities is among the main causes of nitrogen overload in coastal waters: 98% of coastal water bodies are negatively impacted by pollution from agriculture in Denmark.[73]

In total, less than half of Denmark's extracted materials serve demand domestically: 58% are exported abroad, primarily to the rest of Europe (44%), with 9% going to Asia & the Pacific, 4% to the Americas and 1% to Africa. This is unsurprising, given Denmark's status as an EU Member State, with free trade between itself and neighbouring countries. Of total exports, around 49% are non-metallic minerals, 42% are biomass and 9% are fossil fuels: much of this comes from Denmark's own domestic extraction, although some are represented by materials handled in the country before being re-exported. Although exported materials don't contribute to the calculation of Denmark's material footprint, they still have substantial impact on the local environment.

HIGH MATERIAL AND CARBON FOOTPRINT, LARGELY OWING TO EXTRACTION ABROAD

In spite of significant and well-known efforts in the environmental arena, Denmark's material footprint exceeds planet-healthy levels: at **142.2 million tonnes**, or **24.5 tonnes per capita**, it surpasses the EU average of 17.8 tonnes per capita and the world average of 11.9 tonnes per capita. It's also slightly more than triple the level of consumption considered sustainable: 8 tonnes per capita per year. Nonetheless, the material footprint fell slightly between 2019, the year of analysis, and 2020, dropping by 4.1% to 136 million tonnes. Similar to Denmark's extraction profile, the country's consumption is dominated by non-metallic minerals (61%), followed by biomass (23%), fossil fuels (12%) and metal ores (5%). Non-metallic minerals claim the largest share of material consumption due to the nature of their use: large-scale projects like construction and infrastructural development. Biomass is largely used to feed residents and livestock: Denmark's livestock industry, dominated by pork production, requires a large amount of imported feed, for example.[74] As electricity is largely decarbonised, with around two-thirds stemming from wind power, fossil fuels are primarily used to power transport, heat homes, fuel industry and to produce additional fossil-fuel-based products—plastic, for example. Finally, metal ores are transformed into metals such as steel and aluminium or made into finished products like complex electronic equipment.

As 42% of Denmark's domestic extraction is used within its borders, it follows that imports are high: the country is characterised by a consumption-based, import-heavy economy that externalises many of its impacts elsewhere. Around two-thirds of the country's material footprint stems from materials imported from abroad, and 72% of the total extraction needed to meet final Danish demand takes place beyond its borders. Non-metallic minerals contribute the largest share of the import profile, around 57%. Around half of what's imported is sand and gravel, with the rest composed of a mix of products: cement, ceramics, glass and lime, as well as chemical and mineral fertilisers. Biomass claims 27% of imports, largely industrial roundwood timber used for construction timber and furniture, for example.[75] Some crops for human consumption, feed crops (soy, for example, of which Denmark imports a fairly large amount[76]), live animals and wild animals are also imported. Fossil fuels claim 15% of the total, mostly consisting of natural gas and oil. Finally, metal ores represent 9% of imports and mainly comprise 'complex' products such as ICT equipment and household appliances.

The consumption-based material footprint, at **24.5 tonnes per capita**, tops the production-based material footprint, at **20 tonnes per capita**: Denmark relies more on goods produced abroad to satisfy its residents' needs and wants. This trend is common—and even more exaggerated—amongst other high-income nations: Switzerland, for example, exhibits a consumption-based material footprint of 19 tonnes per capita, compared to a production-based footprint of 7 tonnes. This contrasts with more production-oriented (and slightly lower-income) Poland, which boasts a consumption-based footprint of 14 tonnes per capita and a production-based footprint of 16 tonnes per capita.

From Denmark's relatively high material footprint follows a more moderate carbon footprint: at **64.7 million tonnes** of CO_2e, or **11.1 tonnes per capita**,[77] it is only slightly above the EU average of 9.5 tonnes per capita. However, this is still more than double the global average of 5.5 tonnes per capita. Less than one-third (29%) of the carbon footprint can be attributed to domestic consumption,[78] with 54% stemming from imports. Only 12% of the carbon footprint is represented by direct household emissions, including transport and energy use such as heating and electricity. Finally, 4.5% of the footprint is represented by LULUCF emissions. In contrast to the material footprint, Denmark's production-based emissions top its consumption-based carbon footprint at **91 million tonnes**. This means that Denmark is emitting more through the goods it produces than those it consumes—a pattern uncommon for high-income nations. Around 66% of what the country produces is exported: domestic consumption accounts for just 20.9%, or 19.1 million tonnes of CO_2e.

THE CONSTRUCTION, MANUFACTURING AND AGRIFOOD SECTORS ARE THE HEAVIEST CONSUMERS

Upon examining the composition of the Danish economy, three sectors stand out as key contributors to the country's material footprint: Construction, Manufacturing and Agrifood. Construction is by far the largest, claiming nearly one-third (**31%**) of the total material footprint: the sector uses 38 million tonnes of non-metallic minerals, 3 million tonnes of fossil fuels and 1.5 million tonnes of metal ores to produce building materials, such as material- and carbon-intensive concrete and steel both within Denmark and abroad. It emits around 9.3 million tonnes of CO_2e, representing the second-largest portion of the carbon footprint at **17.2%**. Denmark's building stock is growing: over the past decade, enterprises in the construction sector, production volume, turnover and employment have surged, contributing to the country's very high share of Net additions to stock, at 49.2%. This is only set to increase: the Danish government is forming plans to tackle a housing shortage affecting the country, as well as to further develop infrastructure by improving national road and railway systems.[79] This will put a considerable strain on efforts to reduce the material and carbon footprints, given the material-intensive nature of the sector and the high carbon intensity of traditional building materials. It also, however, presents an opportunity to incorporate circular economy principles in future projects, as discussed further in Chapter four. Some of the Danish construction sector's key challenges—a strong shortage of skilled workers and limited innovation capacity—will crucially need to be addressed in the transition to a more circular built environment, which will inevitably require new jobs and skills, as well as knowledge of new materials and processes. This will be discussed in further detail in Chapter five.

The Manufacturing sector is primarily represented by heavy manufacturing industries—largely stationed abroad—and is the second largest contributor to the Danish material footprint, claiming 18% of the total material footprint.[80] Within the sector, petroleum refineries, the manufacture of motor vehicles, trailers and semi-trailers and the manufacture of machinery and equipment are the most material-intensive, claiming 4.9 million tonnes, 2.9 million tonnes and 2.7 million tonnes of materials, respectively. Denmark is a heavy consumer of fossil fuels for both industrial activities and transport, which are refined both domestically and abroad—around 16% of the refinery industry's material footprint can be traced to refineries in the country, with an additional 27% stemming from other European countries. This can be linked to the high prevalence of private vehicles in the country: Danes tend to buy more new cars than residents of other EU countries, with one of the highest shares of cars under two years old across the continent.[81] Domestically, vehicle production is very low, with only some construction vehicles manufactured in Denmark. The production of machinery and equipment largely powers Denmark's other key sectors, in addition to other manufacturing industries: Construction and Agrifood. Take the example of the petroleum refinery industry, the products can be used to fuel the food processing industry. Like Construction, Manufacturing's carbon footprint is tightly coupled with its material footprint, representing the highest sectoral contribution to Denmark's total carbon footprint at 22%. Indeed, of the carbon footprint attributed to the Manufacturing sector, the largest share is represented by petroleum refinery: a sector still primarily based on fossil fuel feedstocks, despite increasing efforts to shift towards bio-based feedstocks. Chapter four discusses circular strategies for manufacturing taking place within Denmark. Due to the substantially higher share of manufacturing taking place abroad, however, strategies to reduce reliance on imports may also be a key avenue to lessen environmental impacts while also potentially cutting costs.

The Agrifood sector trails behind Manufacturing, claiming around 15% of the total material footprint, with the biggest contributions stemming from the processing of food products, cattle farming and the cultivation of wheat. In terms of the carbon footprint, Agrifood is the third largest contributor, claiming 16% of the total. In all, livestock farming accounts for nearly half (44%) of the agrifood sector's material footprint, with food processing industries contributing another 34%. The remainder is accounted for by the direct cultivation of crops. The processing of food products, while consuming plenty of biomass, also makes use of non-metallic minerals, metal ores and fossil fuels to produce and power machinery, equipment and capital infrastructure. Cattle farming's material use is largely accounted for by the production of feed, from grass and fodder to crop residues. From the carbon perspective, the bulk of the footprint is contributed by the processing of dairy products (30% of Agrifood's carbon footprint), processing of meat pigs (18%), cultivation of wheat (14%), processing of food products (14%) and processing of meat cattle (6%). Here, a clear link is observable between carbon intensity and animal-based foods, especially considering that a large portion of the wheat cultivated is done so for animal feed.[82] Circular strategies applied to both the production and consumption side, discussed in depth in Chapter four, will be crucial to reduce the agrifood sector's material intensity.

4 BRIDGING DENMARK'S CIRCULARITY GAP

Exploration of ‘what-if’ scenarios for key sectors

Now that we have presented how Denmark’s Circularity Metric and Indicator Set are derived, examined the country's material footprint and investigated the messages it portrays, it’s time to suggest a remedy. For key areas—those with the biggest potential for impact—we have formulated scenarios that explore and entertain the ‘what-if’, allowing us to dream big and imagine a more circular, resource-light and low-carbon Denmark. They explore a potential path forward and sketch which sectors and interventions could be most impactful in steering the Circularity Metric and material and carbon footprints. Combined, the scenarios could cut the material footprint by 39% and the carbon footprint by 42%, while raising the Metric from 4% to 7.6%.

BRIDGING THE CIRCULARITY GAP: 'WHAT IF' SCENARIOS

> **Scenarios in the *Circularity Gap Reports* are largely free from the constraints of law or political realities: they are deliberately non-time-specific and exploratory. Ultimately, their real-life materialisation does not inform our analysis.**

This approach allows us to freely imagine what our society could look like with truly transformational change: a close to fully circular economy. Below, we present possible interventions that allow us to 'dream big' and sketch which levers are most impactful in driving forward the Circularity Metric, as well as impacting the material and carbon footprints.

We have funnelled our focus for the ‘what-if’ scenarios into five key resource-intensive areas and industries that represent key leverage points for Denmark's economy, using 2019 as the baseline year for our analysis. These scenarios are 1) Build a circular built environment, 2) Embrace a circular lifestyle, 3) Rethink transport and mobility, 4) Nurture a circular food system and 5) Advance circular manufacturing. By focusing on a few key sectors, we can dive deep and apply a diagnostic lens to identify where we can best apply interventions to increase Denmark’s circularity and resource efficiency and optimise the transformation of resource use into social benefits. The scenarios explore changes in the links between 1) the economic and financial dimension (monetary flows, financial transactions and capital accumulation), 2) the material and biophysical dimension (aggregate material throughput, infrastructure and stock expansion), and 3) the sociocultural dimension (desires, efficiency and productivity).

The selection of the scenarios was based on quantitative and qualitative research, which allowed us to paint a picture of what we're able to model based on methodological limitations. In calculating the total impact of the scenarios on Denmark's economy, we can only measure the changes to the material footprint and the Circularity Metric, taking a mass perspective. With this in mind, the five scenarios in this chapter are presented in order of impact: from greatest to least effect on material footprint reduction. Additionally, under each scenario, we report the co-benefits of the chosen circular strategies beyond their impact on material flows. Our modelling capacity is continuously evolving and improving: this is reflected by the approach in this report and will continue to improve for future editions. For more information on our scenario modelling, you can refer to our methodology document.

The interventions modelled in this report are similar to those in other national *Circularity Gap Reports*, to allow for comparison across countries. Of course, there are many other ways to increase circularity in Denmark beyond those mentioned in this report. Shifting business models from product-based to service-based, better integrating excess heat in the energy system and fully utilising biomass through cascading, for example, all represent viable options—but modelling their effects proves challenging.

We are aware that measuring the suggested interventions in terms of their effect on the Circularity Metric and material and carbon footprints is a crude simplification that must ignore other relevant aspects, such as impacts on biodiversity or other ecological parameters. However, we see the value of this analysis as contributing to the dynamic debate on where to place our bets for enhanced circularity and reduced consumption in Denmark and beyond.

Our scenarios are informed and developed by the ultimate aims of **slowing, narrowing, cycling and regenerating** resource flows, as described on page 25, which provide a jumping-off point for the strategies needed to spur systemic changes.

1. BUILD A CIRCULAR BUILT ENVIRONMENT

The impact of the built environment is enormous: construction and operation activities account for approximately a third of material consumption, carbon emissions and solid waste generation worldwide.[83, 84] Buildings are huge banks of often-reusable materials, and the way they are designed and built is fundamental to determining the size and nature of future available materials.[85] In Denmark, the expansion of the built environment—which for this analysis includes residential and commercial buildings and excludes infrastructure[86]—claims almost 32% of total material consumption. At the same time, construction is a crucial economic sector in Denmark, employing 6.2% of the country's total workforce in 2022.[87] The International Energy Agency's (IEA) sustainable recovery report found that, per euro invested, building renovation is the country's biggest job creator with 12 to 18 local jobs for every million invested. The EU Commission estimates the potential for an additional 160,000 green jobs in the construction sector in the EU by 2030.[88] National legislation and policy focus, in addition to current trends and developments in the sector, show that sustainable buildings are now a focus area of construction in Denmark.[89] Going forward, continuing to apply a circular lens to building practices will be crucial to ensure the construction industry's impact doesn't continue to rise.[90]

Revamping the entire construction ecosystem, from material choices to building practices, as well as shifting to more sustainable and inclusive urban planning, will be crucial for realising a more circular—low-carbon and resource-light—Denmark. To this end, this scenario comprises four interventions that explore how Denmark can optimise its building stock expansion, create a low-carbon, energy-efficient building stock, and prioritise multifunctional buildings.

1.1 OPTIMISE HOUSING STOCK EXPANSION

This scenario's first intervention comprises strategies to lower the Danish construction industry's material footprint by **narrowing** and **cycling** flows. For example, Denmark can use digital tools to manage construction and demolition waste. Reused building materials can be put to good use for new residential construction and maintenance. Even as Denmark is ahead of the curve in terms of sustainable construction, this intervention aims to illustrate the balance between new construction and renovation.

Estimating housing demand in Denmark can be challenging. There is a clear internal migration pattern with households moving from the western parts of the country to urban centres in the east. Thus, in the coming decades, there will be a surplus of homes in some areas, whilst others may see shortages. Based on this scenario, one estimate of the demand for housing suggests that from 2013 to 2040, around 390,000 new homes will be required, or around 15,000 per year.[91] Based on the total construction cost of active, planned and completed construction projects in 2020, the Ministry of Environment for Denmark expects 23% of new builds to be German Sustainable Building Council (DGNB)[92] and Nordic Ecolabel certified.[93] Clearly, new builds are necessary in some areas, and many new builds meet sustainability criteria. However, these still require significant resources and should call the balance between new builds and other solutions into question, in terms of meeting rising housing demand. The major offshoot of new construction is waste. In Denmark, waste from construction and demolition amounts to approximately 5 million tonnes per year—more than 40% of the country's total waste.[94] That being said, most of this is recycled, albeit for lower-value applications like backfilling for road foundations. Factors such as quality, toxic substances and suitability must be carefully considered to allow for use in higher-value activities. In Denmark, it's estimated that primarily buildings constructed pre-1950 are suitable for reuse—following this period, toxic substances became more prevalent in buildings, which will inevitably impact the extent of reuse possible.[95] Today, still, less than 1% of building materials and components are reused,[96] representing an essential avenue for meaningful change.

While Denmark remains a world leader in high-value recycling, its handling of construction-related waste reveals room for further innovation. Denmark is seen as a EU front-runner in adopting Building Information Modelling (BIM), for example, yet accessing financing and reluctance to invest in new technologies like BIM hinders circularity in the construction sector. BIM is used during the planning, design and construction phase of buildings and can ultimately improve Construction and Demolition Waste (C&DW) management through design optimisation, providing information for material recovery procedures and the identification of hazardous substances.[97] Fortunately, Denmark is already aiming to boost the use of BIM with a national strategy and some important sector initiatives that strive to increase digitalisation in construction.[98] Recently, the Danish government has worked to reduce the environmental impact of construction and demolition by updating building regulations, limiting buildings' climate footprints, and implementing requirements to improve the traceability of C&DW. Requirements for selective demolition can be expected by 2024.[99] Improving the reuse of building materials (steel and timber, for example) and components (doors and window frames, for example) can further reduce the need for virgin inputs. An increase in ancillary renovation activity—improving or fixing broken and outdated structures—can ensure a reduction in the virgin materials used to meet the demand for housing.

In modelling this scenario, we assume that the construction of new residential buildings using virgin materials is capped, with the demand of new buildings being met through the optimal use of secondary materials from C&DW. This cap is applied to residential buildings only,[100] and assumes the maximum possible collection of C&DW and that 50% of it is suitable for reuse. As a result, investments in the construction of new buildings made of virgin materials are reduced by 28%. To keep up with the building demand, an increase in spending on renovation works is modelled. In this intervention, renovations are structural—related to fixing, changing, removing or adding load-bearing elements—and are not related to energy-saving improvements. By applying these strategies, Denmark could cut its material footprint by 6.9% and its carbon footprint by 3.6%. Its Circularity Metric could grow by 0.56 percentage points, up to 4.56%. This intervention is one of the most impactful of the built environment scenario. Due to the sheer volume of virgin materials used by the construction sector, shifting such demand proves a significant lever for material footprint reduction. Increasing the use of secondary building materials in new construction is the primary driver of growth for the Circularity Metric in the sector.

1.2 ENSURE AN ENERGY-EFFICIENT HOUSING STOCK

This intervention centres on the possibility of improving existing buildings over demolition. To this end, we look at the impact of deep retrofitting: this will **narrow** flows by reducing the energy required to heat homes through significant improvements in building insulation, for example. In doing so, secondary and non-toxic, regenerative materials should be prioritised to **cycle** and **regenerate** flows. At home, Danish residents can make behavioural changes to narrow flows and ensure resource efficiency: thinking twice before turning up the heat and using energy-efficient appliances, for example.

Danish buildings are already more energy efficient than other EU countries, but significant improvements are still needed.[101] In Denmark, approximately 25% of energy consumption is used for space heating and hot water in buildings, largely due to increased floor space over the last 30 years.[102] Therefore, realising energy savings in buildings has garnered more attention in energy policies.[103] The government is focusing on retrofitting to meet its climate targets: the Green Housing (*Grøn boligaftale*) initiative, a kr. 30 billion (around €4 billion) financial package for social housing renovations (*almene boliger*) from 2020 to 2026, for example. According to the Danish Ministry of Transport and Housing, approximately 1 million Danes currently live in social housing.[104] As part of this initiative, at least 14% of those employed in Green Housing construction must be apprentices. This will help increase the workforce's capacity to meet Denmark's current goal of climate neutrality by 2050.[105] In addition to the Green Housing initiative, a renovation scheme is launching under the Danish National Building Fund, which will focus on social and affordable housing over the period of 2020–2026 to support a socially-balanced, green transition for the existing housing stock.[106] Denmark has also set the target to have 100% coverage of smart meters in buildings by 2020; as of 2019, this was already over 80%.[107]

This intervention models the necessary measures to maximise energy efficiency in the housing stock, such as deep retrofitting and greater use of energy-efficient home appliances. It is important to emphasise that this intervention only considers energy efficiency improvements in buildings—however, energy efficiency extends beyond energy savings in buildings, and includes industry, services and the public sector. It embraces flexibility in the energy system, especially demand-side flexibility—using more energy when renewable energy generation is high and less when it is low—and electrification, for example. What's more, energy efficiency entails plans for more robust and integrated energy systems, increasing electrification and the use of renewables as well as supporting more flexible use of energy across industries, citizens and governments. Integrating and harnessing available energy resources across sectors is also essential to reduce overall energy demand. It is, for example, too difficult today to integrate excess heat from companies and industry into the heating of households. This means that the potential for energy efficiency improvements is far greater than the effects calculated in this intervention.

In modelling this intervention, energy savings of 67%, 41%, 12% and 0% are assumed for deep, medium, light and structural renovations, respectively, according to EU data.[108] Average energy savings from current renovations are estimated at 8.7% and a net energy reduction of 58.2% was applied to this intervention. This implies that the rate of deep energy renovations is raised from the current 0% to 7.4% (the sum of all the other renovation rates).[109] A decrease in room temperatures of 2-degrees and the use of energy-efficient household appliances are also considered. Combined, this intervention could cut the material footprint by 5.7%, bringing it down to 134 million tonnes. The carbon footprint would decrease by 3.5% to 59.7 million tonnes of CO_2e. Overall, the Metric would grow by 0.23 percentage points to 4.23%.

1.3 CREATE A LOW-CARBON AND RESOURCE-EFFICIENT BUILDING STOCK

Our third intervention for the built environment comprises a range of strategies to improve the resource efficiency of buildings. We consider the impact of choosing lightweight materials, such as timber—**narrowing** flows—while increasing the lifetime of bearing materials like steel, **slowing** flows. Material choice is important, as embodied carbon in certain materials may counteract benefits from improved energy efficiency. This also applies to imported materials. We further seek to **narrow** flows through improved construction processes, such as modularisation and off-site construction, that can limit material losses by keeping the supply chain as local as possible.

Today, only 8% of Danish buildings are constructed from wood.[110] Yet a Danish case study of hybrid timber apartments revealed that wood produces 70% less CO_2 emissions and has 28% fewer life-cycle costs than buildings using traditional materials.[111] This is especially relevant to new builds where embodied carbon limits are impending.[112] While using wood has numerous environmental benefits—such as reducing the overall material needed for construction—several factors are currently causing Denmark to lag behind neighbouring countries. The Danish construction sector has had a tradition of bypassing wood due to uncertainty and misunderstandings about methods, fire prevention, legislation and the economic benefits of wood construction.[113] Currently, Denmark imports steel products from neighbouring countries to use in the construction sector.[114] With an abundance of forests in the Nordic region, moving towards more locally-sourced and sustainably produced wood as a building material could help bolster supply chain resilience and reduce transport-related emissions from importation. In addition to shifting towards local, sustainable materials like wood, there are other opportunities involving building processes that the construction industry can take advantage of. For example, industrialised production and 3D printing of building modules—reducing time and material cost of construction and renovation—could lead to a net value of €450–600 million (kr. 3.3–4.5 billion) annually by 2035.[115] A key strategy for Denmark should be closing the knowledge gap regarding sustainable materials and building practices among engineers, architects, municipalities and building owners.

A combination of specialised interventions should be applied to increase resource efficiency in the Danish built environment. In modelling this scenario, we assume a reduction in primary steel and aluminium consumption by construction activities. We also assume an increase in construction activities to represent the more costly demolition and assembly work caused by modular and off-site construction practices. In addition, on-site losses are cut by 15 to 20% for different construction materials[116]—by including criteria for on-site production processes proven to reduce waste in tenders for public projects, for example. Finally, the transport of construction materials is reduced by 15%, assuming that sourcing local construction materials cuts the number of kilometres travelled to supply construction materials.[117] By embracing more resource-efficient building practices, Denmark could cut its material footprint by 2.3% and its carbon footprint 2.1%. Its Circularity Metric could grow by 0.1 percentage points, up to 4.1%.

1.4 INCREASE OCCUPANCY, COHOUSING & MULTIFUNCTIONAL BUILDINGS

Our fourth intervention for the built environment entails a range of strategies to boost building occupancy, which will also reduce the total number of buildings needed. As empty buildings tend to deteriorate more quickly due to insufficient maintenance, boosting occupancy can also make buildings last longer, **slowing** flows. Strategies such as cohousing and multifunctional spaces further serve to increase the overall efficiency of building stock use.

Unlike the rest of Europe, Denmark has seen a rise in overcrowded dwellings since 2010. However, this rate remains much lower than the EU average.[118] Denmark is said to have among the largest average home sizes with one of the lowest person-per-dwelling rates in Europe—in 2021, 42% of Danes lived in an under-occupied home.[119, 120] What's more, overall utilisation of floor space is low. Only 35–40% of office space is utilised during European working hours, and around 6% of the total dwelling stock is vacant.[121, 122] Certain strategies, like cohousing and multifunctional buildings, can be applied to reduce these rates by using building stock more efficiently. Cohousing refers to communities of private homes oriented around a shared space, and multifunctional buildings are spaces that integrate several functions—an in-office kitchen or gym, for example. The term 'cohousing' originated in Denmark in the 1960s and has undergone a revival in recent years due to societal changes such as more elderly people and singles, changing family patterns and a growing desire for community.[123] To date, three government-commissioned reports have aimed to promote cohousing in Denmark.[124] Nevertheless, a cost-efficient and profit-driven real estate market prohibits the wider spread of cohousing and multifunctional buildings. A study based in neighbouring Germany identified the main barriers to implementing cohousing, which could shed light on some of the challenges likely to also be present in Denmark. These could be, for example, a lack of professional partners to provide advice on finance and legal aspects, lack of equity to pre-finance the properties and high competition for properties and land.[125] Government policies, such as a tax or levy on unoccupied spaces, can also address occupancy issues.

To assess the impact of this intervention, we model a mix of supply and demand-side measures. We assume that the number of second homes and holiday rental homes are regulated, matched by incentives for cohousing and multifunctional spaces: tax incentives, for example. We modelled a maximum potential increase of 25% in the occupancy of residential and 20% in that of commercial buildings. These are modelled as reductions in real estate purchases by households and the service sector. We assume a proportional reduction in electricity and fuel consumption due to increased building occupancy.[126] By implementing this scenario, Denmark could expect a reduction of 7.3% in the material footprint, bringing it to 131.7 million tonnes, and 4.9% in the carbon footprint, bringing it to 58.8 million tonnes of CO_2e. The Metric would increase by 0.3 percentage points, growing to 4.3%.

Impact on Denmark's circularity: This scenario's four interventions have the highest overall potential to reduce Denmark's material footprint and increase its Circularity Metric. Overall, Denmark could cut its material footprint by 19.2%, lowering it from 142.2 million tonnes to 114.8 million tonnes. The carbon footprint could be reduced by 11.9%, from 61.8 million[127] to 54.5 million tonnes of CO_2e. The Metric could grow by 1.2 percentage points, up to 5.2%. This highlights the energy-intensive nature of the built environment while showing that circular economy strategies are crucial to tackling climate change. This scenario would also usher in a range of **co-benefits** for Denmark: reduced household energy consumption, for example. Deep retrofitting can also serve to boost consumers' awareness, as it encourages users to think more critically about how they power and heat their homes. Measures to reduce overall energy consumption will reduce fossil fuel use, thereby improving air quality and health. At the same time, creating a local market for secondary construction materials, coupled with the labour intensity of renovation and retrofitting activities, could bring new business and employment opportunities to the Danish economy.

DENMARK'S SHIFT TOWARDS A CIRCULAR BUILT ENVIRONMENT

- Circular strategies, such as **cycling** end-of-life C&DW, are already being implemented in Denmark, reducing pressure on demand for virgin materials and, thus, **narrowing** flows. Gamle Mursten, for example, uses an innovative cleaning technology that transforms old bricks into building material: just 2,000 cleaned bricks can prevent one tonne of CO_2 pollution.[128]
- RGS Nordic and DK Beton have joined forces to produce certified factory-made concrete for new construction using recycled concrete aggregate from concrete waste. Through the collaboration, technology has been developed that ensures this concrete can be used exactly the same way as traditional ready-mix concrete.[129]
- There are several enabling resources for more circular construction in Denmark. For example, the Reuse Guide of the Danish Knowledge Centre for Circular Construction (VCOB) provides an overview of companies and other actors who can receive used building materials for reuse or recycling.[130]
- The Circle Bank is launching a digital platform that serves as a building and material bank—a stock exchange for circular materials and circular decision support.[131]
- Denmark is also paving the way for major renovation projects. For example, the public housing project, FOB Kalundborg, in northwestern Zealand underwent a vast renovation with multifold benefits. By incorporating energy efficiency measures, the renovation of FOB Kalundborg surpassed the energy saving target in the original industry standard renovation—by more than double! The FOB Kalundborg renovation project's expected CO_2 savings doubled using just 8% of the total renovation budget. Smart meters were installed, in addition to energy-friendly windows and optimal insulation. The project has realised savings on heating, electricity and water, amounting to a reduction of approximately 600 tonnes of CO_2 per year. The savings were made possible by the ESCO 2.0 financing model developed by the Danish energy efficiency contractor and advisory company Sustain.[132] Renovation activities like these **slow** the flow of materials in the economy by allowing buildings to be used longer and more efficiently.

** Smaller activities and case studies are plentiful, but there's still a large gap to be bridged—such initiatives must be scaled up across sectors to maximise Denmark's circular impact.*

2. EMBRACE A CIRCULAR LIFESTYLE

Overconsumption is the driving force behind our current linear economy: consuming too much has damaging effects on individual wellbeing, as well as the environment.[133] Governments and businesses have a role to play in mitigating climate breakdown, but people have the power when it comes to everyday consumption. Unlike other sectors, such as construction, individual consumers have a high, direct influence on reducing environmental impacts associated with consumer goods. This is especially true in Denmark. The country is one of Europe's highest municipal waste-generating countries per capita, with most of this waste coming from households.[134] This is a pattern amongst high-income nations worldwide: there is a correlation between GDP per capita and municipal waste generation per capita. The more people earn, the more they consume and discard. In Denmark, around half of municipal waste is incinerated, and an almost equal portion is recycled.[135] Danish waste incineration takes advantage of energy recovery, providing heat to industries and households—but also produces hefty GHG emissions.[136] Therefore, cutting consumption and, ultimately, municipal waste will be a key driver for reducing GHG emissions.

The wheels are already in motion to combat this issue. The Danish government's *Action Plan for Circular Economy* is the national plan for preventing and managing waste from 2020 to 2032. The question remains: will Danes be willing or able to adopt a more circular lifestyle? 62% of surveyed Danes are concerned about climate change, and 55% are ready to make lifestyle changes.[137] The Danish *Action Plan* outlines how the country can deal with its waste, but to truly go circular, Denmark will have to get to the root of the problem: over-consumption. This 'what if' scenario explores the role of consumption in a circular economy,[138] examining the impact of a 'material sufficiency' lifestyle—a low-impact lifestyle that prioritises minimalism over excess by consuming fewer resources and keeping products in the value chain for longer.[139] This will require heavy consumers to buy and own less, especially high-impact goods like electronics, appliances and clothing, and will entail the adoption of strategies such as Product-as-a-Service, reuse and repair.

2.1 PROMOTE A MATERIAL SUFFICIENCY LIFESTYLE

This intervention explores strategies to help Danish residents adopt a lower-impact lifestyle that values minimalism and conscious living over excess and waste. Danes can **narrow** flows by shifting to more circular consumption models and intra-community-based solutions such as exchanges of services and goods, and repairing, reusing and renting rather than owning. This must be made possible not just by consumers changing behaviour, but also by companies converting to circular business models. Business can—and must—enable consumers to live with less by making high quality, long-lasting and repairable products, and providing spare replacement parts, for example. The role of manufacturers in producing more circular consumer goods is explored in further detail in Scenario five. Minimising the consumption of everyday goods—or choosing more resource-light options—will **narrow** flows, while encouraging product repairs will stretch their lifetimes, thereby **slowing** flows. Simply put: Danes would buy fewer and better-quality items. By embracing more circular consumption models, Danish consumers can majorly impact the nation's overall circularity.

Consumption is high across product types in Denmark, but an analysis of electrical and electronic equipment revealed the country consumes a considerable amount of electronic goods.[140] In 2020, the EU average for WEEE was 10.3 kilogrammes per capita,[141] while in Denmark, it was 13.5 kilogrammes per capita.[142] This figure shows that Denmark overall produces much more Electrical and Electronic Equipment Waste (WEEE) per capita than the EU average. To facilitate the collection of WEEE, the *Danish Environmental Protection Act* established an Extended Producer Responsibility (EPR) system. The DPA—the data centre and register for various national producer responsibility schemes on electrical and electronic equipment, batteries and end-of-life vehicles— distributes collected WEEE and batteries to the national producers' organisations responsible for sorting and recycling.[143] But despite the creation of the EPR for WEEE, the collection rate for Danish WEEE was only 43% in 2020, well below the EU target of 65%.[144] Denmark both produces more and collects less electronic waste than the EU average. Improving WEEE collection infrastructure can help increase how much electronic waste is cycled, while the implementation of a reparability rating and increased access to repair services could prevent waste in the first place. Educated consumers should be empowered and enabled to keep their electronics and appliances longer, rather than perpetually seeking out the newest models. And at their end-of-life, options for take-back and reuse should be supported: these are already emerging, with some companies establishing programmes to ensure Danish appliances are returned to the market after repair and maintenance.[145]

Alongside electronics, textiles play a key role in Denmark's consumption profile. According to an analysis conducted by the Ministry of Environment in 2018, each Dane buys an average of 10.9 kilogrammes of clothes annually.[146] In addition to this volume of garments, another 2.3 kilogrammes of household textiles, like bed sheets and towels, contributes to a total annual consumption of 13.2 kilogrammes per capita.[147] While collection, reuse and recycling systems work relatively well, there's room for improvement: only between one-quarter and one-fifth of clothing and home textiles discarded are reused, although it's estimated that 7,600 tonnes of textiles are exchanged directly between consumers. Most discarded household textiles end up in mixed waste streams and are incinerated—resulting in a total of 421,000 tonnes of incinerated textiles each year.[148]
Even though municipalities are now being required to provide separate textile collection services, the generation of unwanted textiles outpaces sustainable methods for keeping them in the loop. Therefore, lowering consumption and decreasing textile waste must be a core strategy towards circularity. This can be achieved by forgoing fast fashion in favour of more durable, high-quality garments. Another strategy could involve reducing the overall consumption of textiles by reusing and repairing clothes and household textiles. Further, consumers should consider buying clothes made of recycled fibres, using clothes longer, and donating or recycling old clothes. Clothing rental services and clothing libraries can further reduce the demand for new garments.

Shifting away from consumer culture towards more community-oriented lifestyles and opting for circular solutions from businesses supplying sharing platforms, repair and reuse options will be a key strategy for Denmark to change its consumption habits. This could, for example, manifest as the direct peer-to-peer trading of goods and services, renting clothing or buying refurbished appliances. In a community-centric culture, residents enjoy more home-based activities and local cultural organisations. Instead of travelling long distances for cultural experiences, citizens invest in enriching the local community. Circular strategies like these serve to promote societal wellbeing within the planet's safe limits.

To model the shift towards a culture of repair and maintenance marked by a 'sufficiency' mindset, we assumed a reduction in clothing purchases. A net reduction of 80% in clothing consumption is assumed as a reference but applied differently across textile and clothing products.[149] For example, consumption of finished products (textiles and clothing) are reduced by between 17% and 45%, meanwhile 20% of spending on textile materials (fibres and wool) and leather is substituted.[150] What's more, the purchase of textiles in general is reduced by 20% due to increased recycling, consumers swap petroleum-based fabrics for natural ones. As for household consumer items, it is assumed that use of furniture, home appliances and electronics such as mobiles and computers is minimal. Items such as desks, office chairs and sofas are reused, and repaired by consumers themselves. Product lifetimes are thus extended, resulting in an 80% reduction in the consumption of new products. In terms of services, we assume the use of commercial services is reduced by a net 26%, as consumers become highly dependent on inter-community exchange. Home-based activities and consumption of media increase while long-distance travel is decreased.

Impact on Denmark's circularity: Second to transforming the built environment, this scenario yields the highest material footprint reduction, especially by implementing community-based strategies. By buying less, buying used and buying better—while extending the lifetime of goods—Denmark could cut its material footprint by 9.1%, lowering it from 142.2 million tonnes to 129.2 million tonnes. Community-based strategies alone contribute the most to potential material footprint reduction: 6.1%. The carbon footprint could be reduced by 10.8%, from 61.8 million tonnes of CO_2e to 55.1 million tonnes of CO_2e, with 7.7% accounted for by community-based strategies, while the Metric could rise by 0.4 percentage points, up to 4.4%. This scenario could also bring a range of **co-benefits**: supporting local businesses with a specialisation in restoring goods, reducing waste and tackling the cost of living crisis by reducing consumption of goods which do not enhance the quality of life or wellbeing of residents and thus saving money.

DANISH INITIATIVES FACILITATE CIRCULAR CONSUMPTION

- Across the country, Repair Cafe Danmark facilitates and motivates volunteers, consumers, associations and municipalities to participate in 'Repair Cafes'. In doing so, participants can reduce waste, change their consumption patterns and build up the needed knowledge and motivation to 'go green'.[151] By enabling the continued use of household goods, Repair Cafe Danmark **slows** flows, and **narrows** flows by reducing the consumption of new goods.
- In the world of textiles, Denmark's *Voluntary Sector Cooperation on Textiles*[152] and *Action Plan 2030* are ahead of the curve, including a public-private textile sector collaboration. Participation is voluntary and more than 60% of the Danish textile industry has already joined. This initiative facilitates the circular transition by measuring circularity in fashion and textile companies, fostering the sharing of best practices, practical collaboration, and setting goals across the sector for shifting away from textile-related resource consumption in Denmark. The plan aims to **regenerate** flows by producing clothing and textiles from a minimum of 40% recycled textiles by 2030. The collaboration will also work to **narrow** and **slow** flows by keeping textiles in the loop for longer through reuse and resale.
- In line with Denmark's ambitious goals, Sheworks Atelier is another initiative aiming to transform textile waste. The award-winning textile design studio specialises in bespoke products made from surplus and waste textiles. Sheworks Atelier makes all of its products locally, employing women on the margins of the Danish labour market.[153] Ordering decor from this studio helps **cycle** flows while **narrowing** flows of virgin materials due to reducing the purchase of new products.
- Danish brand Rentista is also exploring circular business opportunities, consisting of a vintage shop and a rental service. To date, Rentista has facilitated over 1,000 clothing rentals,[154] reducing the consumption of new clothing and thus **narrowing** flows. It also promotes demand for higher quality, more durable clothing that can be used longer, thus **slowing** flows.

** Smaller activities and case studies are plentiful, but there's still a large gap to be bridged—such initiatives must be scaled up across sectors to maximise Denmark's circular impact.*

3. RETHINK TRANSPORT & MOBILITY

Transporting people and products from A to B consumes vast quantities of materials and releases emissions—and yet we're dependent on transport for everyday commuting, travel and freight shipping. The Danish government plans to tackle this with *Denmark Forward*, an initiative to invest kr. 161 billion (€21.6 billion) in infrastructure by 2035. The plan prioritises new investments in road networks, public transport, cycling and an overall green transformation of the transport sector. Seven benchmarks—such as making public transport more attractive, encouraging bicycle use, maximising the convenience of electric vehicles and overall greener transport—should, in theory, guide new investments.[155] However, a large portion of the project's financing is directed towards new highways, and the seven benchmarks need more weight behind them to succeed in reality. Future policy and action should strive further to enable behavioural change through infrastructure and urban planning. Ultimately, a circular shift will allow the country to transition to a lifestyle less dependent on private vehicles.

This 'what if' scenario reimagines Danish mobility, modelling six interventions to cut the material and carbon footprint whilst boosting circularity. The scenario includes strategies that reduce reliance on private vehicles, encourage a modal shift and supporting flex work, and decarbonise the vehicle fleet with electric vehicles. Some of these strategies can be actively pursued on a city and national level; however, a strategy like lightweighting vehicles is a change that must be pursued on a sectoral level, going beyond Danish borders. Nevertheless, when purchasing a car is inevitable, Danish consumers can opt for smaller cars that require less materials and less energy to move around, thus reducing the material footprint through thoughtful purchasing choices.

3.1 REDUCE RELIANCE ON PRIVATE VEHICLES

This scenario's first intervention imagines a modal shift among Danish residents, illustrating the potential benefits of reducing the overall use of cars as much as possible. This could cut the need for private car ownership and fuel consumption, both serving to **narrow** flows.

In Denmark, private cars and small vans accounted for 75% of total passenger kilometres travelled in 2021, increasing by around 12% over the last ten years.[156] This increase mirrors the number of newly registered household passenger cars, which was around 220,000 in 2011 and increased to 240,000 in 2021.[157] That being said, the modal split in Copenhagen is very different from national averages owing to the fact that it is one of the world's most bicycle-friendly cities and has an extensive and well-integrated public transport system. For all trips in, to and from Copenhagen, 28% of people travel by bicycle, 19% by public transport, 32% by car and 21% by foot. There has been a steady increase in the use of bicycles and decrease in the use of passenger cars over the last ten years.[158] While there are challenges to implementing certain infrastructure—bike lanes, pavements and well-connected public transportation—in less urban areas, there are still lessons to be learnt from such a huge success in shifting away from private vehicle use. This can be further incentivised by ensuring car sharing is easily accessible, such as by providing low-cost parking permits for privately shared cars or making parking permits available for shared commercial cars. Providing tax breaks for cars purchased or leased for sharing may also prompt a modal shift, as could ensuring cycling infrastructure is as safe and efficient as possible.

Strategies for this intervention include replacing private car travel with bicycles, e-bikes, walking and car sharing. In modelling this strategy, it is assumed that 25% of mobility needs are either eliminated or replaced by bike or foot, with the remaining 75% of travel being covered by car sharing. In this scenario, the reduction of mobility inputs results from the increased average vehicle occupancy (from 1.3[159] up to 2.5) and is partially mitigated by the higher 'wear and tear' of vehicles due to increased utilisation (+25%). In the medium term, this intervention is assumed to reduce the need for private vehicles while potentially replacing the land used for parking with bicycle and pedestrian infrastructure. This strategy is further modelled by looking at the impact of different parts of the population being less reliant on cars—divided between urban (88%) and rural (12%)[160] due to the differing car use in the two contexts. It is assumed that 100% of the urban and 50% of the rural population rely on modes of transport other than cars. It is also assumed that the elimination of private cars in the urban population also eliminates the demand for car manufacture and sale and the related fossil fuel use. Ultimately, by reducing the reliance on private vehicles, Denmark could cut its material footprint by 1.7%, down to 139.7 million tonnes, and its carbon footprint by 5.2%, down to 58.6 million tonnes. The Metric would grow by 0.07 percentage points to 4.07%.

3.2 EMBRACE FLEX WORK

The covid-19 pandemic created a 'new normal' for workers around the world—and even as many of us have shifted back to business-as-usual, trends indicate that flex work might be here to stay. This intervention examines how continuing to work from home, where possible, could impact Denmark's circularity, as doing so would cut the need for transport for workers' commutes, thereby **narrowing** flows.

The Danish Chamber of Commerce reports that in an average company, 16% of working hours are now completed at home, as opposed to 8% before the pandemic.[161] This is favourable to many Danish workers, as around one-third of employees have to travel over 20 kilometres to reach their workspaces,[162] with an average commuting distance of 22 kilometres in 2020.[163] What's more, 58% of commuter journeys are taken by car.[164] Therefore, this strategy drastically reduces the need for private mobility by working from home, especially for hires living far from work. Employer policies that support home-working, as well as tax breaks on office equipment for remote workers, could help make this intervention a reality. However, this intervention's potential impact on public transport must also be considered: the lowered demand for public transport must be factored into future plans to ensure profitable operations and job security in the future.

To model this intervention, we assume a 50% boost in work-from-home applied to 35% of the workforce—the portion deemed eligible for home working.[165] This is matched with an equal reduction in kilometres travelled for commuting across transport modes, assuming a commuting modal shift of 67% for cars, 23% for buses and 10% for trains. We also estimate lessened demand for commercial real estate, as required office capacity will decrease as more workers stay home. It's worth noting that work-from-home could result in increased leisure trips that may counteract benefits from decreased commuting trips. This has not been reflected in the modelling. By embracing this intervention, Denmark could usher in a 2.1% reduction in the material footprint, bringing it down to 139.1 million tonnes, and decrease the carbon footprint by 1.5%, bringing it down to 60.9 million tonnes. The Metric would grow by 0.08 percentage points to 4.08%.

3.3 PURSUE A MODAL SHIFT FOR TRANSPORT

While this scenario's first intervention explored a sharp reduction in private car ownership and use, this intervention examines the impact of a modal shift, considering the untapped potential of public transport. Dane's opting to take the train or bus for more of their journeys would effectively **narrow** flows by reducing the number of private vehicles on the road and lowering fuel consumption.

Due to the rising use of private vehicles, Denmark has seen a decrease in public transport use. In 2021, 13% of total passenger kilometres travelled was done by public transport, compared to 20% in 2011. While low, this rate is in line with EU averages.[166] In terms of modal shift, the main options included in this strategy are buses and trains, representing a relevant share of urban and extra-urban public transport. The shift from private to public transport can reduce overall kilometres travelled by car and, therefore, direct tailpipe emissions. Realising this scenario will require developing more and better public transport infrastructure nationwide. By ensuring an affordable and accessible public transport system and good interconnectivity between transport types—such as bicycles, buses and trains—Denmark can encourage more residents to shift away from predominantly relying on private vehicle use.

In modelling this intervention, we consider private mobility demand in terms of passenger-kilometres travelled, and, thus, the possibility of replacing it with public mobility. We model an increase in the occupancy of buses and trains without exceeding the maximum capacity that would imply additional investments in public transport vehicles. In this calculation, we include the reduction in spending on private vehicles (sales, repair and maintenance), the reduced need for fuel and the monetary value of the shift towards public transport services. By implementing this strategy, Denmark could cut its material footprint by 1.1%, down to 140.5 million tonnes, and its carbon footprint by 3.1%, down to 60 million tonnes. The Metric would grow by 0.4 percentage points to 4.4%.

3.4 ELECTRIFY THE VEHICLE FLEET

While shifting mobility—especially reducing car use—should be Denmark's top priority, cleaner mobility should follow. This intervention offers strategies that tackle vehicles' use phase by electrifying Denmark's vehicle fleet. This will **narrow** resource flows (by cutting fuel use) while also **regenerating** flows by powering all additional electricity demand with renewable energy.

Denmark boasts one of the highest shares of electric vehicles in Europe. In 2021, around 35% of newly registered cars were electric.[167] However, the overall share of electric and hybrid cars was still only 7% of total registered vehicles at the end of 2022,[168] revealing a way to go in electrifying the private vehicle fleet. Regarding public transport, Denmark has the most zero-emission urban buses on the roads in Europe, with electric buses making up 78% of its new vehicles.[169] Banedanmark's *Electrification Programme* is set to electrify the majority of the Danish state railway network by 2027. Today, nearly two thousand kilometres of railway have been electrified.[170] Meanwhile, Copenhagen plans to pilot zero-emission zones for passenger and delivery vehicles in some central urban areas to reduce traffic and pollution.[171] While Denmark has a way to go in phasing out registrations of combustion engine vehicles, the overall transport policy environment within the country represents a shift in the right direction: the country must continue building on this momentum. Further policy drivers to stimulate the needed changes could include sound fiscal incentives (such as levies on emissions and vehicle weight) and tighter fuel economy and emissions standards, subsidies for the purchase of more sustainable (private and commercial) alternatives, and investments in the deployment of a reliable and affordable charging network (cities play a key role here), for example.[172]

In modelling this intervention, we assume that the entire bus fleet and road freight and half of car mobility are electrically powered—keeping the demand for transportation constant.[173] By creating a fleet of electric vehicles, Denmark could cut its material footprint by 2.5%, bringing it down to 138.6 million tonnes. The carbon footprint would decrease by 5.9%. Overall, the Metric could increase by 0.1 percentage points, reaching 4.1%.

3.5 LIGHTWEIGHT THE VEHICLE FLEET

Denmark can **narrow** material flows by prioritising small(er), more lightweight, energy-efficient vehicles, thereby cutting material and fuel use. This could include private cars, public transport vehicles and freight transport. As Denmark is not a producer of vehicles, this intervention focuses on the demand side: reducing the demand for larger, heavier vehicles will reduce the materials required for production and fuel. It's worth noting that currently, electric vehicles are generally heavier than their fossil fuel counterparts, mostly due to the battery weight. This stresses the need to lightweight the remainder of the car's body by prioritising smaller vehicles. R&D efforts should also endeavour to produce more efficient, lighter batteries to cut vehicles' weights.

In Denmark, more expensive cars are taxed at a much higher rate than cheaper ones[174]—meaning that small and compact vehicles may be more common in the country compared to the rest of Scandinavia.[175] While this policy is a step in the right direction, taxing cars based on actual weight could go further in reducing demand for larger, less fuel-efficient vehicles—especially as the size and weight of cars has risen substantially over the last two decades.[176] While Denmark should prioritise buying smaller and, ideally, electric cars, electric vehicles are often heavier than combustion vehicles. However, this weight is offset by the fact that electric cars do not consume fossil fuels. Another conflict, and a recent trend, in lightweight vehicles is the use of plastic, which has a lower recycling rate than metals. However, EU legislation is aiming to tackle this by setting minimum requirements of recycled content within new vehicles.[177] Still, the emphasis for Dane's should be on buying small, electric vehicles that take advantage of sustainable, lightweight materials to reduce fuel consumption and tailpipe emissions as much as possible. The current tax exemption, which doesn't consider the weight or size of electric or hybrid vehicles, could also shift to reflect this.

Lightweighting of vehicles could reduce material demand by 17% to 50% (mainly of aluminium, copper and steel, but also fuel) for cars and public transport vehicles. By encouraging the further adoption of small, lightweight electric vehicles, Denmark could cut its material footprint by 1.4%, bringing it down to 140.1 million tonnes. The carbon footprint would decrease by 4.4%. Overall, the Metric could increase by 0.05 percentage points, reaching 4.05%.

3.6 REDUCE AIR TRAVEL

The aviation sector relies heavily on fossil fuels, making air travel a highly polluting mode of transport—an aeroplane's emissions per kilometre travelled are much higher than a bus or train, for example.[178] Material flows in this intervention can be **narrowed** by slashing demand: this will reduce the materials used to produce aeroplanes while also lowering their associated fuel use. Given that the aviation sector is a notoriously difficult and slow sector to decarbonise, reducing demand is key.

Passengers departing and arriving at Danish airports have increased from 28 million in 2011 to 36 million in 2019.[179] Moreover, the number of passengers travelling by air for distances less than one thousand kilometres increased in tandem.[180] To combat the impacts of this carbon-heavy sector, the Danish government aims to make domestic flights fossil-fuel-free by 2030.[181] On the industry level, Dansk Luftfart, the trade association of the Danish aviation sector, is proposing a number of new, targeted initiatives to achieve climate neutrality no later than 2050. Its plan lays out the various steps for technology, financing and regulation, yet fails to reduce the need for air travel in the first place.[182] In a small country with a well-connected train system, the need for flying domestically should be vastly reduced—if not eliminated. A 2021 survey found that 83% of Danes want to replace short-distance flights with fast, low-polluting trains in collaboration with neighbouring countries.[183] Promoting alternative modes of transport and boosting local tourism could slow the exponentially growing rates of air travel, as could incorporating environmental costs in flight tickets. Certain strategies—such as improving and expanding the railway system, or the use of e-fuel for aviation—will be material-intensive but can be optimised to provide positive outcomes in the long-term.

In modelling this intervention, we assume household demand for air mobility services falls by capping the number of trips per capita per year from 2.6[184] to 2 for a net reduction of 24%. By reducing air travel, Denmark could see a 0.2% reduction in its material footprint and a 0.3% reduction in its carbon footprint, lowering them to 141.8 million tonnes and 61.7 million tonnes, respectively. The Metric would rise by 0.01 percentage points to 4.01%.

Impact on Denmark's circularity: Due to the Danish mobility system's dependence on fossil fuels, this scenario has the greatest potential to reduce the country's carbon emissions. By combining six mobility-related interventions, Denmark can substantially cut its material footprint, bringing it down to 132.5 million tonnes—a 6.8% reduction. It could also lower its carbon footprint by 15.1%—down to 52.5 million tonnes of CO_2e—while bumping up its Metric by 0.28 percentage points to 4.28%. Denmark would also likely enjoy a range of other environmental, social and economic **co-benefits** from implementing these strategies: less harmful air pollution, lighter congestion in busy cities, less noise, and increased room for green spaces, for example.

CIRCULAR PLATFORMS AND POLICIES REDUCE RELIANCE ON PRIVATE VEHICLES

- The Danish digital sharing platform GoMore enables people to share their cars or seats on a planned trip through private car rental, shareable leasing and ridesharing. The platform now has 2.7 million members across Denmark, Sweden, Finland and Spain, leading the way for private car sharing. In 2020, around 33,000 unique Danish users rented a car on GoMore, totalling 65,000 rentals. Since the platform was established in 2005, more than 2.3 million rideshares have been sold in Denmark alone.[185]
- GreenMobility[186] and SHARE NOW[187] are two other Danish services with options for shared vehicles, including electric options. These platforms are working to **narrow** and **regenerate** flows by cutting the material demand of private car use while also promoting electrification.
- The Danish government is also playing its part in reducing private vehicle use, thus **narrowing** flows. As of 2021, diesel cars will be taxed based on CO_2 emissions rather than fuel efficiency. Further, electric vehicles worth up to kr. 500,000 (€67,125), along with privately installed charging stations, are exempt from taxation.[188] In Copenhagen, bikes have been allowed to ride for free on the regional S-train line since 2010. This has had a major impact: today, around 14% of all S-train travellers and 20% of Copenhagen residents commuting in and out of the city by train use a bicycle at their destination.[189]

** Smaller activities and case studies are plentiful, but there's still a large gap to be bridged—such initiatives must be scaled up across sectors to maximise Denmark's circular impact.*

4. NURTURE A CIRCULAR FOOD SYSTEM

Danish agricultural practices—from growing crops and feed to livestock—have a substantial environmental impact. Such practices claim around 63.7% of the country's land, making Denmark among Europe's most intensively cultivated countries.[190] This cultivation level makes agriculture a key economic sector, as 24% of Denmark's export value comes from agricultural products.[191] That being said, Danish agriculture puts increasing pressure on the country's natural landscapes: biodiversity is on the decline, specifically amongst pollinating insects, while soil degradation threatens Danish subsoils.[192] Due to the national decline in pollinating insects, new allocations are being invested in projects to restore, preserve and enhance local ecosystems. The *Rural Development Programme for Denmark* supports better management of natural resources and ecosystem services such as replanting hedges, enforcing field boundaries and restoring small lakes.[193] Regenerative agriculture is also receiving more attention. Regenerative agriculture is often defined by multiple agricultural practices—use of cover crops, crop rotation, livestock integration, maximising farm input and reducing tillage, for example. Many of these practices, such as reduced tillage and cover crops, have already been integrated in Denmark.[194] Cover crops (or 'catch crops'), for one, have been mandatory since 1999. Farmers must allocate at least 10% of farmable land to cover crops to prevent leakage of nutrients, especially nitrogen, to the surrounding environment.[195] In terms of particulate pollution, agriculture contributes to 13% of Denmark's total domestic GHG emissions, equating to 13 million tonnes of CO_2e pollution from agriculture, forestry and fishing combined.[196] Denmark's *CAP Strategic Plan* aims to cut this figure in half by 2030.[197] Our circular interventions for this scenario pave the way to reaching these targets.

Realising Denmark's goals will require both supply and demand side measures, ranging from more sustainable, regenerative farming methods to shifting the dietary habits of Denmark's residents. A circular food system is one where agricultural production optimises the use of all biomass, waste is minimised by closing nutrient loops, and soil health and biodiversity are enhanced. It is also one where sustainable diets that avoid waste are the norm. To this end, this scenario proposes three circular interventions to cut the Danish food system's impacts: endorse a more balanced diet, reduce food surplus and waste and shift to more sustainable food production. Many more solutions are relevant in the Danish context, from biomass cascading to industrial symbiosis, although these are currently not possible to model with our current methodology.

For biomass to be considered circular, both carbon and nutrients, such as nitrogen and phosphorus, must be fully circulated back into the local environment. As of yet, there are methodological limitations to guarantee nutrient cycling. To this end, in line with past *Circularity Gap Reports*, we have excluded ecological cycling in our calculation of Denmark's Circularity Metric, **even though this could potentially boost the country's circularity rate to just over 30%**.

The potential for ecological cycling is massive, and thus an important path to investigate in Denmark. Researchers and industry within Denmark's agrifood sector have developed a roadmap for the *Sustainable Transformation of the Danish Agrifood System*. Four major tracks have been selected to contribute to the 2030 and 2050 climate goals and visions. One of these is using biotechnology to produce alternative, plant-derived proteins. Biorefineries will be required to produce the plant-derived components from sustainably sourced raw materials and from residual biomass flows.[198]

Our methodology excludes biological materials that are ecologically cycled from the Circularity Metric, but includes a small fraction of biological materials that are 'technically' cycled, such as processed wood. These biological materials excluded from the Circularity Metric still contribute significantly to the overall material footprint. By lowering the material footprint, the strategies explored in this scenario will thus indirectly serve to increase the Circularity Metric.

4.1 ENDORSE A BALANCED DIET

This intervention centres on food consumption: capping caloric intake at 2,700 per day and favouring plant-based foods to **narrow** and **regenerate** resource flows. By limiting caloric intake to a sufficiency level, residents can reduce waste along the value chain that was not necessary in the first place—subsequently **narrowing** flows.

Dietary choices substantially impact human health[199] and the environment,[200] with research showing that the healthiest diet for the planet and people is very low in meat and high in plant-based protein and whole grains.[201] An analysis of Danish meat consumption revealed that between 8 and 12% of Danes follow a 'flexitarian' diet—opting to reduce their meat consumption versus eliminating it entirely.[202] Nonetheless, the average Dane consumes about 62 kilogrammes of meat a year,[203] far surpassing the recommended 15.6 kilogrammes that are considered part of a healthy and sustainable diet.[204] Overweight and obesity figures are also relatively high in Denmark. According to the Danish Ministry of Health, 18.6% of Danes were obese in 2021[205]—in line with EU averages.[206] Changes in dietary habits—reducing meat and dairy consumption, for example—could be encouraged through the use of the Danish Veterinary and Food Administration's climate-friendly dietary advice.[207] Plans to introduce climate labelling are also now in the works, and further measures, such as carbon- or health-based tax incentives could also be introduced to make sustainable food more affordable.[208] Other policy instruments, such as grants for dietary advice, and the wider provision of personalised nutrition advice through the healthcare system could also be used to support dietary changes. In this sense, policy carbon and health taxes are most effective in designing sustainable food policies when combined.[209]

For this strategy, adopting a balanced diet was modelled by reducing the total caloric intake per capita towards the average sufficiency level for European populations. This would result in a decrease from 3,434 calories per capita per day to 2,700 calories per capita per day.[210] Modelling a diet based on the Danish Official Dietary Guidelines, as well as vegetarian and vegan diets involved both reducing the caloric intake as well as shifting the nutritional profile to substitute certain food groups for other foods to maintain basic nutritional requirements. Our base strategy—caloric intake limits—could cut the material footprint by 2.2%, bringing it down to 138.9 million tonnes, and decrease the carbon footprint by 1.7%, bringing it down to 60.8 million tonnes of CO_2e. The Metric could increase by 0.1 percentage points, up to 4.1%. Embracing a diet aligned with the Danish Official Dietary Guidelines would bring substantial benefits: the material footprint would drop by 3.8%, and the carbon footprint by 2.9%. The Metric would also benefit substantially, growing by 0.15 percentage points to 4.15%. For our second demand-side strategy, we assume Denmark's residents transition to a vegetarian diet: this strategy would have an even larger impact on both the material and carbon footprints, reducing them by 4.1% and 4.2%, respectively. The Metric could swell by 0.16 percentage points to 4.16%. If each Danish resident were to embrace a vegan diet—with otherwise similar assumptions to the previous strategy—the material and carbon footprints would decrease by 3.8% and 6.5%, respectively, with the Metric growing 0.15 percentage points.

4.2 REDUCE FOOD WASTE

This intervention revolves around cutting household-level organic waste. Preventable food waste—that which has spoiled in the refrigerator and been binned, or food bought in surplus only to be discarded—is limited, **narrowing** flows. Under this intervention, unavoidable food waste such as bones, peels, shells or other inedible components should be **cycled**.

Every year, 814,000 tonnes of edible food is wasted in Denmark. Avoidable food waste is created throughout all parts of the value chain, with households playing an especially significant role.[211] To combat food waste, the *Denmark Action Plan for the Circular Economy* will, among other things, provide assistance to reduce food waste in retail, create financial incentives for recycling sewage and implement measures to reduce the GHG emissions from treatment of garden waste.[212] Additionally, *Denmark Against Food Waste* is a voluntary agreement that unites 25+ food producers and retailers behind the shared mission to halve food waste by 2030. The signatories to the Agreement develop and test metrics to measure food waste.[213] In Denmark, separating the collection of food waste is mandatory, although this still doesn't happen consistently across municipalities. Nonetheless, in 2020, 348,000 tonnes of food waste from businesses and households were collected separately. The waste was treated in biogas plants with manure and other organic residues for energy production, and the 'digestate' was applied to farmland.[214, 215] Still, in economic terms, an average Danish family wastes kr. 3,000 worth (around €400) of food a year.[216] By promoting healthier and more sustainable diets—namely by limiting overall caloric intake—Denmark can decrease purchases of food products by households that lead to an excess of post-consumer waste.

In modelling this intervention, we assume that avoidable post-consumer food waste is halved—guided by official targets in line with Sustainable Development Goal 12.3.[217, 218, 219] We implicitly assume that this avoided waste is recycled—whether as a substitution for fodder crops, compost for nutrient recycling or through anaerobic digestion. By halving all the avoidable post-consumer organic waste, Denmark could cut its material footprint by 1.2%—bringing it down to 140.4 million tonnes and its carbon footprint by 0.6%, from 61.8 million tonnes to 61.5 million tonnes. The Metric could increase by 0.6 percentage points to 4.6%.

4.3 SHIFT TO MORE SUSTAINABLE FOOD PRODUCTION

This scenario's first intervention tackles food production. We explore the impact of a shift to low-fertiliser, local and seasonal food production—strategies that will **regenerate** and **narrow** flows by reducing the need for synthetic fertilisers, lowering transport distances and lessening dependence on greenhouse-grown foods (and thus reducing fuel consumption for heating them). We can envision a food production system as sustainable and low-waste as possible—one that works alongside nature, protects biodiversity and cuts emissions and chemical inputs.

Today, around 12% of Danish farmland is cultivated organically, and Danish consumers buy more organic food items than any other Europeans.[220] With this in mind, Denmark aims to double its current land area for organic farming to 403,000 hectares by 2030.[221] This will require farmers to use less synthetic nitrogen and phosphorus fertilisers, which have been on the rise between 2010 and 2020.[222] To counteract this, subsidies as part of the newest agricultural reform will support farmers who voluntarily implement sustainable farming practices.[223] Additional regulation is already in place to optimise the nitrogen and phosphorus cycle within Danish food production. These regulations aim to increase the efficiency of (re)using nutrients from organic sources, like animal slurry, and limit chemical fertiliser use while reducing losses from the system.[224] This intervention promotes holistic regenerative farming alongside local and seasonal food production. Although Denmark is self-sufficient in some animal products, such as pork, it relies on imports for many of its foodstuffs.[225] The issue with imported food items is the associated 'food miles'—the distance the food must travel from the farm to the consumption point. We know that transport makes up a significant share of the GHG emissions of the global food system,[226] and this is likely also the case for Denmark given its reliance on imports. However, it must be noted that localising food production requires constructing certain infrastructure, like greenhouses, which come with their own material and carbon footprint, given that this is typically an intensive form of food production.

Policy instruments that provide needed economic benefits, such as tax incentives, could be used to promote sustainable farming practices: taxes on chemical fertilisers and pesticides, and more subsidies and grants for switching to more sustainable agricultural practices, for example. But getting there will require robust farm-level support, extension services and technical advice: direct payments that support innovation, for example, or training for farmers.[227] Denmark is already exploring new ways to aid farmers in reducing external inputs, such as chemical fertilisers and pesticides, using precision farming techniques. Precision agriculture uses satellite images, drones, GPS and various technical equipment to control land seeding, fertilisation, pesticide application and harvest as precisely as possible. In this way, farmers can have higher yields while saving on fuel, fertiliser, pesticides and time.[228, 229] This will be further supported by increased circularity in biomass use and nutrient cycling at farm, landscape and societal scales, lowering the need for external inputs.[230]

To assess this intervention's impact, we assume that synthetic fertiliser use is eliminated. In practice, new technologies (such as nano fertilisers and precision farming) can be used to counteract the lower yields that could arise from this shift. Further, we could not account for the rebound effects of food production localisation; thus, this would have to be carefully considered on a case-by-case basis when considering the practical implementation. In this scenario, the need for chemical fertilisers and pesticides is eliminated through organic food production and new technologies, as is the hot-housing of fruit and vegetables due to shifting consumer preference towards seasonal produce.[231] We modelled a 50% reduction in the transportation of selected food products due to the assumption of increased preference for local products and products sourced from countries closer to Denmark—but do not account for potential rebound effects, such as localised food production requiring more greenhouses or special infrastructure. This intervention results in a 30% reduction in fossil fuel and electricity use by the fruit and vegetable sectors. If Denmark embraced these strategies, it could reduce its material footprint by a modest 0.6%, bringing it down to 141.2 million tonnes. The carbon footprint could shrink by 0.5% to 61.5 million tonnes of CO_2e, and the Metric could increase by a slight 0.02 percentage points to 4.02%.

Impact on Denmark's circularity: Of the three interventions included in this scenario, changing diet and reducing waste have the greatest impact on Denmark's Circularity Metric. In total, it could grow by 0.82 percentage points to 4.82%. Altogether, this scenario could bring substantial benefits: Denmark's material footprint could drop by 6%, bringing it from 142.2 million tonnes to 133.6 million tonnes, while the carbon footprint could drop by 8%, lowering it from 61.8 million tonnes of CO_2e to 56.9 million tonnes of CO_2e. Although these impacts are modest compared to the other scenarios, their importance should not be overlooked. Embracing a circular food system could also bring a range of **co-benefits** to Denmark, from the improved health of its residents to lower air pollution to healthier soil and flourishing biodiversity. Preventing food waste—in addition to helping the country meet its goal of halving it by 2030—will also benefit residents financially: after all, wasted food is wasted money. Producing food sustainably and locally could also help ensure greater resilience, protecting against future shocks—whether geopolitical, economic or health-related—while reducing import costs for import-dependent food groups. This scenario can also help to stimulate new business models which capitalise on food waste, creating new employment opportunities and allowing for more collaboration with local farmers to increase the quality of their soil, provide biogas for energy and decrease dependency on imported fertilisers.

DENMARK PAVES THE WAY TOWARDS A MORE CIRCULAR FOOD SYSTEM

- Denmark is beginning to embrace circular ideas regarding food consumption and is investing in higher-quality, sustainable diets, serving to **narrow** flows. For example, the Danish government has announced over kr. 1.25 billion (around €168 million) in funding to advance plant-based foods as part of an unprecedented climate agreement for food and agriculture. Under the new agreement, Denmark will create a Fund for Plant-based Food Products, providing kr. 675 million (around €90.6 million) over nine years to support product development and promotion. For farmers, a five-year plant-based eco-scheme will pay kr. 580 million (around €77.9 million) in bonuses to those who grow plant-based protein crops for human consumption.[232]
- Another groundbreaking circular advancement comes in the form of a 'nano fertiliser'. This new product, developed by Innovation Fund Denmark and Copenhagen University's Department of Plant and Environmental Sciences, should be able to reduce the consumption of phosphate in the agricultural sector by 70 to 75%,[233] leading to more **regenerative** flows.
- In an effort to **cycle** flows and reduce food waste, Agrain is upcycling brewer's spent grain from beer and whisky production. Agrain gives malted and mash grains a new life, helping to reduce food waste by offering Danish customers tasty, new everyday products like flour and granola.[234]

** Smaller activities and case studies are plentiful, but there's still a large gap to be bridged—such initiatives must be scaled up across sectors to maximise Denmark's circular impact.*

5. ADVANCE CIRCULAR MANUFACTURING

Manufacturing is a broad sector encompassing a variety of industries, from petroleum refinery to the manufacturing of vehicles, machinery, equipment, transport equipment and even furniture and clothing (for more examples, see Appendix F on page 121). Denmark boasts ambitious goals for its manufacturing sector: the country aims to have the world's first climate-neutral production industry by 2030.[235] Danish manufacturing is well known for being one of the world's most innovative industries, namely in automation and robotics. It is the country's most internationally integrated sector, with 65% of sales being exported and an annual turnover of around kr. 230 billion (around €31 billion).[236] Manufacturing is a crucial facet of Denmark's environmental strategy due to its strong culture of collaboration,[237] giving it the potential to be a key driver for a prosperous and sustainable future. The manufacturing sector and the *Climate Partnership for the Manufacturing Industry* are already collaborating with the government to find solutions for cutting carbon emissions by 70% by 2030.[238] Across the industry, targets have been set to use resources more efficiently, cut carbon emissions, reduce energy use and waste and embrace industrial symbiosis.

We envision a circular manufacturing sector for Denmark, in which products and parts are reused at their highest value, design optimises product lifetimes, and current modes of production and sales are radically changed. To this end, this 'what if' scenario for Denmark's manufacturing industry outlines opportunities to pivot away from linearity: we highlight how to advance resource efficiency by making better use of waste in industrial processes and how to extend product lifetimes through various R-strategies (see text box on page 75), from remanufacturing and refurbishment to repair and reuse. This scenario is closely linked to Scenario two, Embrace a circular lifestyle. While Scenario two shifts behaviour on the demand side (also entailing a shift in business models to make it possible for consumers to make more circular and sustainable choices), this scenario tackles the supply side of industrial commodities and consumer goods. However, there are some overlaps between the scenarios: for example, whether goods are repaired commercially or by households themselves. We see measures at both the supply and demand side as important, and thus both are modelled. Any possible overlaps are removed when the scenarios are combined (see 'Combined interventions' on page 78).

5.1 IMPLEMENT RESOURCE-EFFICIENT, SYMBIOTIC MANUFACTURING

A circular approach to manufacturing revolves around eliminating 'waste' as we know it, improving manufacturing processes to cut material losses, and championing industrial symbiosis in which the waste or byproducts of one industry become raw materials for another.[239] This intervention offers strategies to improve resource efficiency in Danish manufacturing. Gains in material efficiency should be integrated into the early stages: cutting yield losses involves making the most of technological advances to get more from less. Further along the value chain, where metals will be used to make machinery or vehicles, for example, process improvements will bring similar benefits. Reducing scrap material—a byproduct of standard procedure—would also boost efficiency and reduce the need for virgin material inputs, further **narrowing** flows. All unavoidable scrap can also be reused, **cycling** flows.

When it comes to metals, Denmark relies heavily on imports. The country does not extract metal ores nor produce primary steel domestically.[240] Instead, it relies on metal imports primarily from Germany, Sweden and Russia,[241] making the industry vulnerable to external market instabilities. In addition to its lack of domestic metal extraction and production, Denmark doesn't have domestic facilities for recycling its steel.[242] Denmark's lack of recycling facilities for steel—a commonly used material—restricts the country's Circularity Metric, which only accounts for secondary material use in Denmark and does not account for recycling conducted abroad. However, it is worth noting that Denmark is a small country and is well-connected to other countries' metal recycling facilities, so there is often no advantage for Denmark to recycle metal domestically. That being said, to boost its Metric, Denmark can increase the efficiency of domestic metal processing operations so that less metal is required and less waste is produced.

Denmark can consider implementing technical improvements, such as more additive manufacturing (AM) practices to end its reliance on foreign metals and boost overall circularity in manufacturing. Technically, AM can refer to any process where a product is created by adding material to build something up (versus subtracting material), but it typically refers to 3D printing.[243] AM is a resourceful method of manufacturing that eliminates metal scrap and waste and is already in use by one-third of Danish manufacturers.[244] However, AM's sustainability has been called into question, and should not be treated as a silver bullet. Improving biotechnological upcycling, focusing on the development and use of new materials and seeking out digital opportunities will also prove useful to achieve manufacturing's circularity.

To model this scenario, we consider the implementation of both process improvements and industrial symbiosis. Process improvements refer to the reduction of raw materials needed to make finished products. We modelled a 28% reduction of aluminium and steel used in specific products.[245] Similar changes are extended to all metals, chemicals and wood, ranging from reductions of 7% to 28% for material categories apart from aluminium and steel. Industrial symbiosis is limited to metals in this specific case and it consists of scrap diversion and reducing yield losses. Scrap diversion is assumed to apply to selected sectors because scrap reduction concerns the production of manufactured products for specific industries. Meanwhile, yield losses are assumed to apply to all the sectors based on the fact that the reduction of yield losses concerns specifically the production of semi-manufactured products for many industries. By implementing interventions that cycle flows and boost resource efficiency in manufacturing, Denmark could cut its material footprint by 0.4%, lowering it from 142.2 million tonnes to 141.5 million tonnes. The carbon footprint can be reduced by 0.4%, from 61.8 million tonnes to 61.6 million tonnes of CO_2e; while the Metric could grow by 0.01 percentage points up to 4.01%.

5.2 EMPLOY R-STRATEGIES FOR MACHINERY, EQUIPMENT AND VEHICLES

The industrialisation of production and an economic model focused on profit encourages businesses to sell more and more goods. At the same time, product users quickly replace items when they break, as goods can be costly to repair or are no longer wanted as trends shift. Fortunately, it seems the tide is turning, with new EU regulations rolling out to ban planned obsolescence,[246] and to ensure products are designed to last with the potential for repair, reuse and recycling.[247] Essentially, both users and manufacturers will have to shift away from quantity towards quality by embracing activities that can extend the life of both industrial and consumer goods. This scenario's second intervention employs various R-strategies (see text box on page 75) for manufacturing machinery, and equipment and vehicles. Strategies such as remanufacturing, refurbishment and repair can be leveraged to stretch product lifetimes, **slowing** flows and lowering the need for new products, resulting in an overall **narrowing** of flows.

Denmark is already adopting certain R-strategies to keep resources in the loop. For example, Danish company Borg Automotive is among Europe's largest, most skilled and most experienced companies in the automotive parts remanufacturing industry.[248] A study by the Ellen MacArthur Foundation finds that remanufacturing and new business models based on performance contracts and reverse logistics could lead to net value creation of €150–250 million (kr. 1.1–1.8 billion)[249] per year by 2035.[250] Therefore, remanufacturing can provide a promising circular opportunity for Denmark to continue investing in. Through implementing more remanufacturing, Denmark can produce the same volume of products while reducing the need for virgin materials. However, barriers remain: in the machinery sector, for example, more than 95% of its most important material (steel) is recycled, yet less than 1% is remanufactured.[251] This is largely due to barriers in logistics, financing, policy and public perception of remanufactured goods. This was illustrated by a 2015 market study, in which several companies highlighted concern that customers would perceive remanufactured products as being of lower quality than new products and pointed to the fact that Danish authorities do not demand remanufactured products in public procurement.[252] This represents a missed opportunity for Denmark, as remanufacturing is a more labour and energy-efficient strategy than recycling, for example.

Beyond remanufacturing, other R-strategies (refurbishment, repair, reuse) can be capitalised on, given Denmark's impressive innovation levels, skilled workforce and connected industry. Like remanufacturing, refurbishment focuses on extending and renewing the life cycles of goods. It entails improving the quality of used goods to increase their usable lifetimes and is largely carried out on an industry level. Meanwhile, repair can be performed by both households and companies. Repair and maintenance performed at the inter-industry level may be carried out by repair companies. Lastly, increased reuse also leads to an extension of the lifetimes of products without the need for additional repair and maintenance. By reusing products, there is less demand for production—and therefore material extraction—in the first place.

To fully reap the benefits of R-strategies, Denmark should continue working with producers to ensure they can create products with longer life spans. For example, ensuring that business models incorporating R-strategies can compete with business models selling new products. This could involve incorporating the environmental impacts of making new products into the final price. Denmark could also benefit from a shift to more circular supply chains, using leasing or other Product-as-a-Service (PaaS) systems as an alternative to ownership-based models. Attention must also be given to consumers so that they have the means and incentives to keep their belongings in use for as long as possible. For example, if a consumer wants to repair an item, it must be as easy as buying a new product in addition to being financially advantageous. This could involve mandating that all manufacturers are obliged to repair their products or provide repair advice to consumers while ensuring that spare parts are readily available. Political action is already taking place at the EU level to support this, with the European Commission adopting a new proposal on common rules for the repair of goods in March 2023.

To model this intervention, we make a number of assumptions related to remanufacturing, refurbishment, repair and maintenance, and reuse. Remanufacturing and refurbishment is modelled using a fixed sales assumption. This means that the overall volume of sales stays the same due to the redistribution and reselling of remanufactured and refurbished products. Displacement of new sales is therefore modelled as a net reduction in the inputs needed to produce the same volume of products. The intervention is modelled as an increase in repairing services at the interindustry transactions level in proportion to level of the repair. All primary raw materials or semi-manufactured product inputs then decrease in proportion to the lifetime increase. Repair, maintenance and reuse is also modelled through a reduced sales assumption: the overall volume of sales decreases because of the extended lifetime of the repaired product. The displacement of new sales is then modelled directly as a reduction in the volume of product output. Combined, these lead to reduced consumption of selected finished products for households and machinery and equipment for industries. The net reductions modelled in the consumption of durable products range from 2.5% to 12.5% for motorised vehicles, and between 2.5% and 45% for all other machinery and equipment consumed by industries. All together, this intervention could cut the material footprint by 0.8%, lowering it to 141 million tonnes, and the carbon footprint by 0.9%, bringing it down to 61.3 million tonnes of CO_2e. The Metric could be boosted by 0.03 percentage points, reaching 4.03%.

Impact on Denmark's circularity: By boosting resource efficiency in manufacturing, Denmark could cut its material footprint by 1.2%, lowering it from 142.2 million tonnes to 140.4 million tonnes. The carbon footprint could be reduced by 1.3%, from 61.8 million tonnes of CO_2e to 60.8 million tonnes of CO_2e, while the Metric could grow by 0.04 percentage points, up to 4.04%. **Co-benefits** are also plentiful: the country could boost its supply chain resilience against disruptions and volatility, reduce energy consumption from efficiency gains and cut waste generation. In also diverting waste from landfills, more value can be generated from the waste by using it elsewhere, and also in skipping the typical disposal/management costs associated with sending waste to landfill.

The modelling results of this scenario show a relatively low impact, especially compared to that of Scenario two, which takes a demand perspective to improve the resource efficiency of producing and consuming goods, rather than a supply perspective. However, it should not be concluded that all of the responsibility lies with the final consumer, as opposed to industry and businesses. Methodological limitations for the modelling of this scenario mean that we could expect the actual impact of circular manufacturing to be much higher—but more granular modelling would need to be undertaken to discern the extent of this.

WHICH R-STRATEGIES DO WE CONSIDER—AND WHAT DO THEY MEAN?

- We understand **remanufacturing** as a procedure in which all components of a product are completely disassembled down to their smallest parts, are fully inspected and then reused for an entirely new life cycle.
- We understand **refurbishment** as a procedure to improve the quality of a product up to a specified quality.
- We understand **repair** as the reparation of the parts that limit the performance of a product and the maintenance of parts that can help to prolong the useful life. This can happen at the inter-industry level or be performed after consumers purchase a good. Similarly, upgrades can be carried out to improve a product's functionality and extend its useful lifetime: this goes beyond repair and implies an improvement to a product, for example, by increasing mechanical-, electrical- or ICT-related inputs, depending on the product.
- We understand **reuse** to mean an extension of a product's lifetime, therefore displacing the sale of new goods. This assumption stems from the fact that products are often still usable—even without additional repair and maintenance—but reach their end-of-use early due to consumer attitudes and behaviours.

DANISH PRODUCERS ARE MAKING THE MOST OF R-STRATEGIES

- Vestas is a Danish manufacturer, seller, installer and servicer of wind turbines. Its chemical technology will allow turbines to be recycled instead of landfilled. Through a newly established value chain, supported by Nordic recycling leader Stena Recycling and global epoxy manufacturer Olin, Vestas is scaling up its chemical disassembly process into a commercially available solution.[253] This initiative focuses on **cycling** flows, with the aim to **narrow** the use of virgin materials in the wind turbine manufacturing industry.
- Danish company Refurb is also doing its part to **cycle** flows of electronic waste: it buys, refurbishes and sells used electronic equipment to public and private customers online. With a focus on value recovery, Refurb extends the life of computers, tablets and smartphones.[254]
- Another manufacturer tackling electronic waste is Danfoss, which is going circular by rethinking product design, reducing waste and recirculating products and parts. Danfoss provides equipment and services across industries like refrigeration and cooling, manufacturing equipment and automotive.[255] The company is **narrowing** flows through smart design, allowing individual components to be removed and reused in other products. Flows are **slowed** and **recycled** by refurbishing products to make them last longer.

** Smaller activities and case studies are plentiful, but there's still a large gap to be bridged—such initiatives must be scaled up across sectors to maximise Denmark's circular impact.*

COMBINED INTERVENTIONS

Individual interventions—summarised on pages 80–82—have a limited impact on the Circularity Metric and the material and carbon footprints. When combined, however, the interventions could bring substantial impact. If we harness the cross-intervention synergies in our broad 'what-if' image for the economy, Denmark's material footprint of consumption is lowered by a remarkable 38.9%, from 142.2 million tonnes to a mere **86.8 million tonnes**. On a per capita basis, the material footprint could be reduced from 24.5 tonnes to around 15 tonnes per year, bringing the figure close(r) to what is suggested a sustainable level (8 tonnes per person per year[256, 257]) and below the EU average. The combined scenarios also offer deep emissions reductions: the carbon footprint could be decreased by 42.2%, bringing it from 61.8 million tonnes of CO_2e down to 35.7 million tonnes of CO_2e. At the same time, the Circularity Metric could swell by 3.6 percentage points, increasing from 4% to 7.6%.[258] These impacts are illustrated by Figure five on page 79.

This said, it is important to note the difference in relative impacts between the material and carbon footprint reduction and the increases in the Circularity Metric. Firstly, as noted in Chapter two, the material and carbon footprints are absolute figures, while the Circularity Metric is relative. Secondly, because material consumption and GHG emissions are good proxies for environmental degradation, reducing them are primary goals for reducing environmental pressures. On the other hand, increasing the Circularity Metric is a means to lower material consumption and GHG emissions. Increasing circularity by replacing virgin materials with secondary materials is just one way to reduce the overall material and carbon footprint (and thus environmental impacts). However, constraining the overall demand for materials has a much more significant effect on lowering the material and carbon footprints, with fewer interventions needed. In this sense, the scenario analysis does well at exemplifying the limits to cycling relative to a reduction of (material) consumption.

What's more: overlaps between and the sequentiality of interventions mean that our combined intervention and scenario calculations yield different results than simply adding up the impacts of individually modelled strategies and interventions. In particular, the scenarios on repair, recycling, as well as fossil resource consumption, are applied across sectors, thereby influencing the industry specific interventions on agriculture and construction. Therefore, we prioritise interventions according to principles of the circular economy. We begin with strategies that aim to reduce inputs, secondly applying repair and reuse focused scenarios and only lastly applying those focused on recycling. We rather look at overlaps in terms of coherence, meaning that we exclude interventions that explicitly contradict each other. We also do not take into account the anti-synergic effects—for instance, the reduced availability of waste for recycling stemming from increased manufacturing efficiency. The sequential application of interventions means that those applied further down will have a lower impact than earlier ones, when they target the same transactions between economic actors. By way of example: let's assume we model two interventions targeting investments in the construction services sector. The share of the investment to be reduced—as specified in the first intervention—will be applied to the original investment figures, while the second intervention will be applied to the reduced investment figure that has resulted from the application of the first intervention.

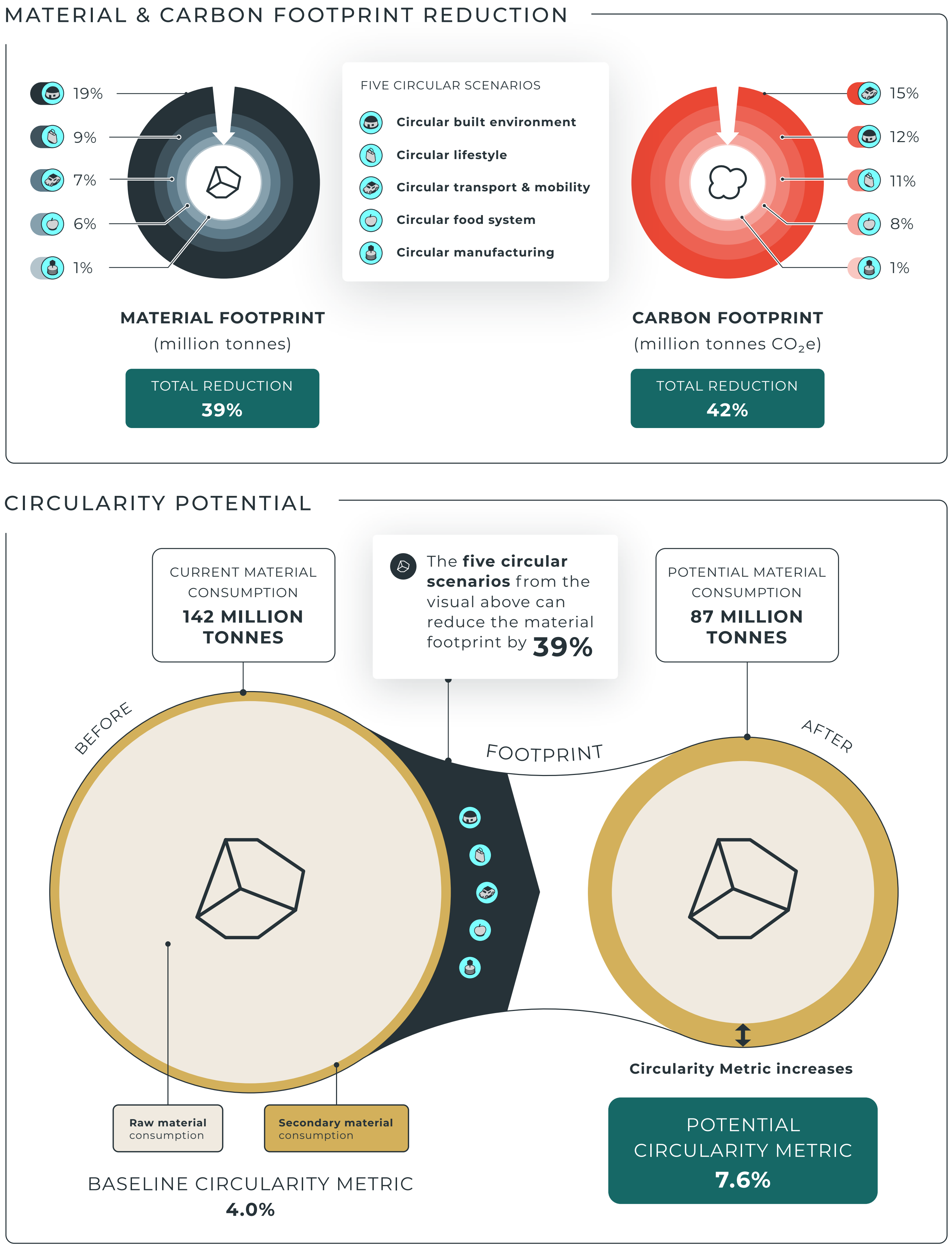


Figure five shows a summary of the material and carbon footprint reductions made possible by applying the five circular scenarios, as well as the scenarios' combined impact on the Circularity Metric.

SCENARIO ONE

BUILD A CIRCULAR BUILT ENVIRONMENT

1.1 Optimise housing stock expansion

- Cycle construction and demolition waste
- Decrease virgin material use for residential construction

1.2 Ensure an energy- efficient housing stock

- Carry out deep retrofits
- Prioritise secondary, non-toxic materials for retrofitting
- Make behavioural changes in homes, like fewer and more efficient appliances

1.3 Create a low-carbon and resource-efficient building stock

- Choose lightweight building materials
- Increase the lifetime of bearing elements
- Prioritise modular and off-site construction
- Keep supply chains as local as possible

1.4 Increase occupancy, cohousing & multifunctional buildings

- Enforce incentives for cohousing and multifunctional spaces
- Increase occupancy by taxing unoccupied spaces

IMPACT SCENARIO ONE

- Reduction of material footprint by **19.2%**, decrease from 142.2 to **114.8 million tonnes**.
- Reduction of carbon footprint by **11.9%**, decrease from 61.8 to **54.5 million tonnes** of CO_2e.
- Circularity rises from 4% to **5.2%**.
- **Co-benefits:** Higher awareness of energy consumption among consumers and new business and employment opportunities.

SCENARIO TWO

EMBRACE A CIRCULAR LIFESTYLE

2.1 Promote a material sufficiency lifestyle

- Minimise consumption of electronics, appliances, furniture and textiles
- Encourage product repairs
- Boost community services

IMPACT SCENARIO TWO

- Reduction of material footprint by **9.1%**, decrease from 142.2 to **129.2 million tonnes**.
- Reduction of carbon footprint by **10.8%**, decrease from 61.8 to **55.1 million tonnes** of CO_2e.
- Circularity rises from 4% to **4.4%**.
- **Co-benefits:** Support for local businesses, lowering the consumption of goods which don't enhance quality of life, improved wellbeing, cost savings.

SCENARIO THREE

RETHINK TRANSPORT & MOBILITY

3.1 Reduce reliance on private vehicles

- Reduce car use and private ownership

3.2 Embrace flex work

- Prioritise work-from-home to decrease commuter transport

3.3 Pursue a modal shift for transport

- Increase journeys by bus and train to cut car use

3.4 Electrify the vehicle fleet

- Electrify the bus and car fleet
- Power electricity through renewable sources

3.5 Lightweight the vehicle fleet

- Prioritise small, lightweight, fuel-efficient vehicles

3.6 Reduce air travel

- Reduce passenger air travel

IMPACT SCENARIO THREE

- Reduction of material footprint by **6.8%**, decrease from 142.2 to **132.5 million tonnes**.
- Reduction of carbon footprint by **15.1%**, decrease from 61.8 to **52.5 million tonnes** of CO_2e.
- Circularity rises from 4% to **4.28%**.
- **Co-benefits:** Decrease in harmful air pollution, less congestion in busy cities, more green spaces.

SCENARIO FOUR

NURTURE A CIRCULAR FOOD SYSTEM

4.1 Endorse a balanced diet

- Shift to a plant-based diet or one low in animal products

4.2 Reduce food waste

- Cut household-level organic waste
- Cycle unavoidable food waste

4.3 Shift to more sustainable food production

- Prioritise local, seasonal food production
- Decrease synthetic fertiliser use

IMPACT SCENARIO FOUR

- Reduction of material footprint by **6%**, decrease from 142.2 to **133.6 million tonnes**.
- Reduction of carbon footprint by **8%**, decrease from 61.8 to **56.9 million tonnes** of CO_2e.
- Circularity rises from 4% to **4.82%**.
- **Co-benefits:** Improved health among residents, lower air pollution, healthier soil.

SCENARIO FIVE

ADVANCE CIRCULAR MANUFACTURING

5.1 Implement resource-efficient, symbiotic manufacturing

- Improve industrial processes to reduce virgin inputs for key manufacturing industries
- Reduce yield losses
- Divert scraps

5.2 Employ R-strategies for machinery, equipment and vehicles

- Increase the lifetime of machinery, equipment, and vehicles
- Increase in remanufacturing, refurbishment, repair and maintenance, upgrade, and reuse services

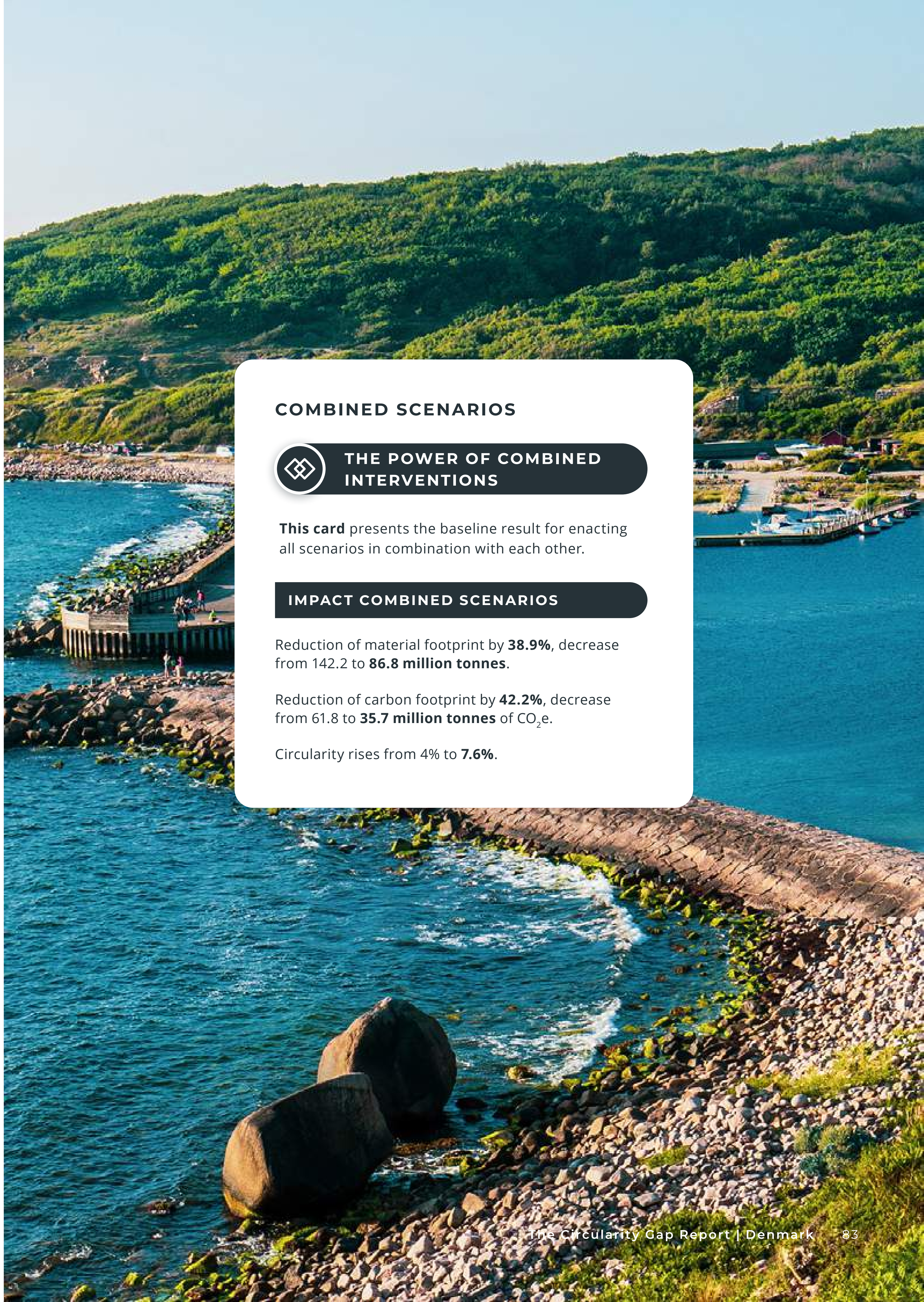
IMPACT SCENARIO FIVE

Reduction of material footprint by **1.2%**, decrease from 142.2 to **140.4 million tonnes**.

Reduction of carbon footprint by **1.3%**, decrease from 61.8 to **60.8 million tonnes** of CO_2e.

Circularity rises from 4% to **4.04%**.

Co-benefits: Improved supply chain resilience, lower energy consumption from efficiency gains, less waste generation.



COMBINED SCENARIOS

THE POWER OF COMBINED INTERVENTIONS

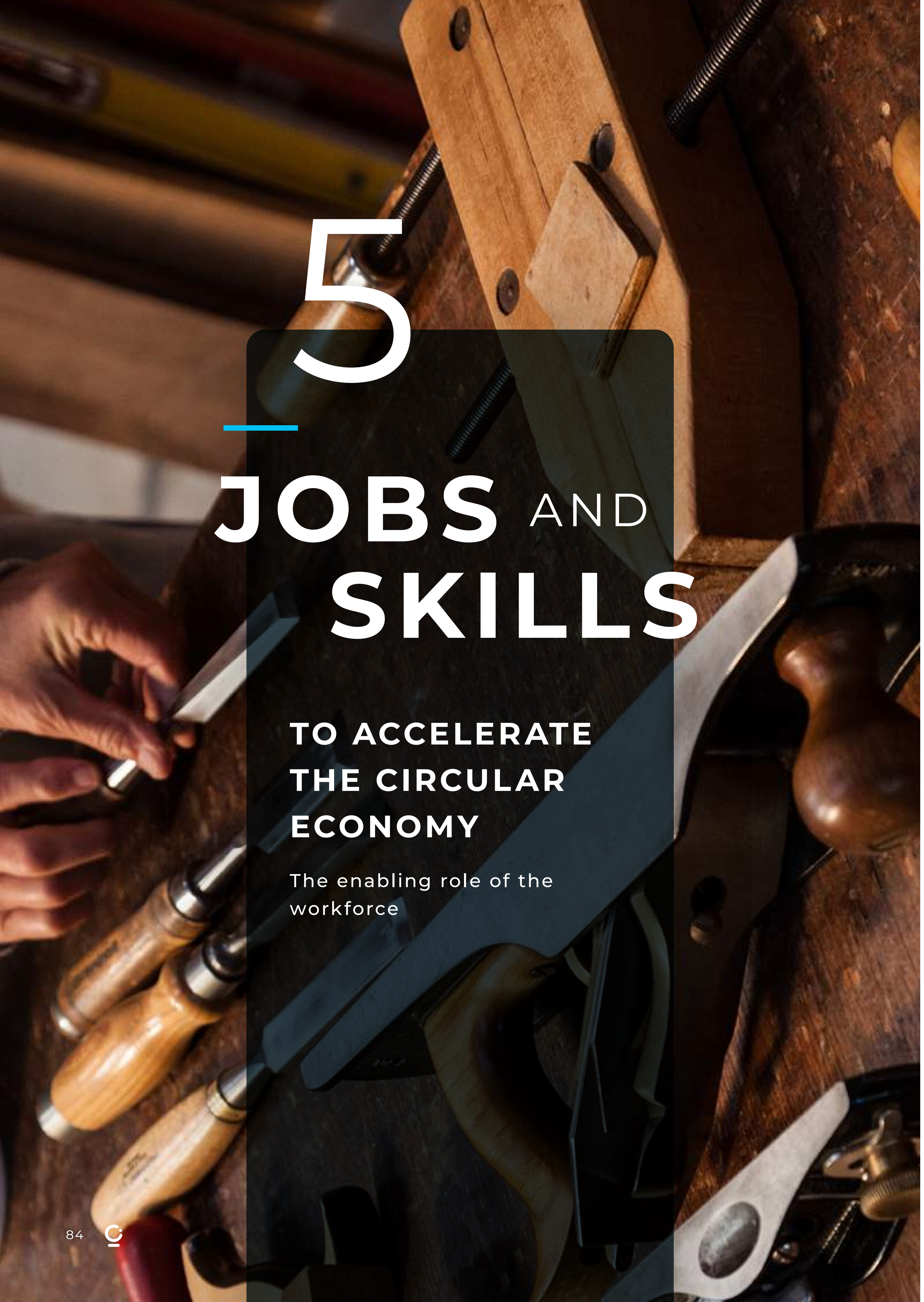
This card presents the baseline result for enacting all scenarios in combination with each other.

IMPACT COMBINED SCENARIOS

Reduction of material footprint by **38.9%**, decrease from 142.2 to **86.8 million tonnes**.

Reduction of carbon footprint by **42.2%**, decrease from 61.8 to **35.7 million tonnes** of CO_2e.

Circularity rises from 4% to **7.6%**.



5 JOBS AND SKILLS

TO ACCELERATE THE CIRCULAR ECONOMY

The enabling role of the workforce

The previous chapter outlined the impact a transition to a circular economy could have on Denmark's Circularity Metric and material footprint—but what about the role of people and their skills? A labour market that anticipates and plans for the transition to circularity can help accelerate it while safeguarding jobs. A baseline assessment of employment in Denmark generated by current circular economy activities found that 9.6% of jobs in Denmark (approximately 280 thousand jobs) are currently contributing to the circular economy, either directly or indirectly. Based on qualitative data from a review of existing research and policy strategies and 15 expert interviews with stakeholders in Denmark,[259] this chapter explores the jobs and skills necessary to realise the scenarios put forward in the previous chapter to close the country's Circularity Gap equitably: one that future proofs Denmark's labour market and benefits work and workers.

JOBS AND SKILLS IN THE CIRCULAR ECONOMY

Businesses, government and the people working within them and across sectors in Denmark all have a vital role in seizing the opportunities the circular economy presents. They also have a role to play in ensuring a just transition to a circular economy that is positive for people and the planet in the long term. Collaboration and investment in career development and skills pathways will help ensure decent and inclusive job opportunities are available to workers across sectors and with varying skill levels; it will also spur the adoption of circular business models, which may require new and different job roles and ways of working.

The transition to a circular economy will likely require workers to undergo training to keep their skills up-to-date and upskill across occupations:[260] as they deviate from traditional practices, circular jobs require significantly more work experience and on-the-job training than traditional 'linear' jobs.[261] They also require two types of skills: **deep skills**, or specialist skills needed by employees working in specific industries, and **transversal skills**, or those applicable across a range of tasks, occupations and industries.[262] For a circular job, deep skills may include technical skills in modular design or special materials, for example, while transversal skills in collaboration may be particularly useful.

CIRCULAR ECONOMY IN THE DANISH LABOUR MARKET

MEASURING EMPLOYMENT THAT CONTRIBUTES TO CIRCULARITY

Our analysis, the Circular Jobs Methodology, follows an international standard developed in collaboration with the UN Environment Programme,[263] and defines circular jobs as those that contribute to one of the strategies laid out by Circle Economy's Key Elements framework (see Figure six on pages 88–89). This analysis demonstrates the breadth of the circular labour market, encompassing sectors ranging from waste management to the creative industries. Circular jobs can be those in research, policy writing, consulting; they may also include entrepreneurs and craftspeople. Everyone, from academics to vocational professionals, can have a role in the circular labour market. Jobs in sectors that are a core part of the circular economy—based on sector classifications—provide an input to our calculation of circular jobs.

- **Core circular jobs** are all jobs that ensure the closure of raw material cycles, including jobs in repair, renewable energy, and waste and resource management. They form the 'core' of the circular economy—and are often what people would think of when they hear 'circular jobs'.
- **Enabling circular jobs** are jobs that remove barriers to and enable the acceleration and upscaling of core circular activities. These may arise in leasing, education, design and digital technology, for example. They form the supporting shell of the circular economy: without these, core circular jobs will be less likely to flourish.
- **Indirectly circular jobs** are jobs that indirectly uphold the circular economy by using core circular products and services.

RESULTS OF THE CIRCULAR JOBS CALCULATION

Almost one-tenth of jobs in Denmark (9.6% or 279,755) contribute to the circular economy, either directly or indirectly. The other 90.4% of the workforce is still operating in a linear economy: the present take-make-waste paradigm. The number of jobs in sectors, local authority areas and regions of Denmark can also be explored on the Circular Jobs Monitor.[264] The results of the analysis are also displayed in Figure six on pages 88–89, while circular jobs by sector are illustrated in Figure seven on pages 90-91.

Core circular jobs (32,360 workers, or 11.6% of total circular jobs)

- **2,682 jobs** fall under recycling, materials and waste recovery. 37.9% (1,016 jobs) of these jobs are found in the waste sector alone. This is because only a limited share of high-volume waste materials—such as demolition and industrial waste—are cycled back into use.
- The majority of core circular jobs, **28,196 jobs** (10.1% of circular jobs) stretch the lifetime of products and equipment through repair and maintenance.
- The renewable energy sector has only **1,481 circular jobs** (0.5% of circular jobs), showing that the potential for renewable energy production is largely unexploited. This does not correlate to the size of the sector itself, but points to the fact that Denmark could diversify jobs in the renewable energy sector, going beyond wind power.

Enabling circular jobs (27,764 workers, or 9.9% of total circular jobs)

- Due to its role in servicing other sectors, the digital technology sector generates **6,280 circular jobs** in Denmark.
- A further **9,060 jobs** (3.2% of circular jobs) are related to circular business models (3.2% of circular jobs) such as leasing, rental and sharing products as services (Product-as-a-Service) to use instead of goods to own.
- **8,242 circular jobs** (3% of circular jobs) serve to strengthen and advance knowledge by providing training and know-how to businesses within the core circular sectors.
- Only **2,924 jobs** (1%) service core circular sectors through design, revealing untapped potential for circular design activities.
- Another **1,257 jobs** (0.4%) aid core circular sectors in collaborating with other organisations, in order to improve their processes and employee administration.

Indirectly circular jobs (219,631 workers, or 78.5% of total circular jobs)

- The vast majority of circular jobs are generated by sectors indirectly supporting the circular economy, accounting for more than three-quarters of all circular jobs. This shows the important role that jobs across all sectors in Denmark can play in supporting the circular economy.
- These jobs are mainly generated through demand for core circular products or services by the manufacturing (**19,506 circular jobs**), health and social work (**60,677 circular jobs**), administrative services (**14,754 circular jobs**) and construction sectors (**9,127 circular jobs**). In the case of administrative services this includes, for example, purchasing officers for a call centre that buy second-hand or refurbished equipment, therefore indirectly contributing to the circular economy.

Total circular jobs	Total circular jobs as a % of total
279,755	9.57%

Circular jobs breakdown:

CORE

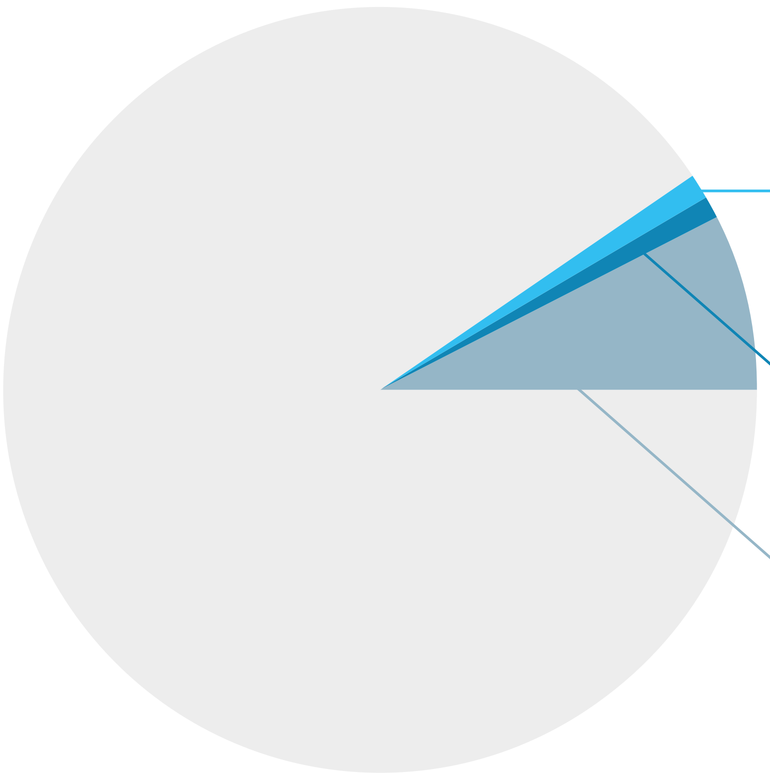
- **Prioritise** regenerative resources
- **Stretch** the lifetime
- **Use** waste as a resource

ENABLING

- **Design** for the future
- **Rethink** the business model
- **Incorporate** digital technology
- **Team up** to create joint value
- **Strengthen and advance** knowledge

INDIRECT

Jobs that indirectly uphold the circular economy. These jobs occur in sectors that do not play a direct role in furthering the transition to the circular economy but can still adopt circular strategies.



CORE circular jobs	32,360	
CORE circular jobs as a % of total circular jobs	11.57%	
ENABLING circular jobs	27,764	
ENABLING circular jobs as a % of total circular jobs	9.92%	
INDIRECT circular jobs	219,631	
INDIRECT circular jobs as a % of total circular jobs	78.51%	

Figure six shows the baseline assessment of the number of jobs generated by circular economy activities across sectors.

Baseline year: 2019

	Sector	Total circular jobs	CORE circular jobs	ENABLING circular jobs	INDIRECT circular jobs
A	Agriculture, forestry and fishing	3,275			100%
B	Mining and quarrying	499			100%
C	Manufacturing	28,274	3.4%		96.6%
D	Electricity supply	2,275	25.8%		74.2%
E	Waste	1,016	100%		
F	Construction	11,689	0.8%	13.9%	85.3%
G	Wholesale and retail	63,405	4.5%	6.3%	89.2%
H	Transport and storage	13,052		43.2%	56.8%
I	Accommodation	7,042			100%
J	Information and communication	9,868		82.1%	17.9%
K	Financial and insurance	7,824			100%
L	Real estate	4,608			100%
M	Professional services	14,085		39.1%	60.9%
N	Administrative services	15,105		3.8%	96.2%
O	Public administration	10,883		49.1%	50.9%
P	Education	9,040		89.1%	10.9%
Q	Human health and social work	60,677			100%
R	Arts, entertainment and recreation	7,039			100%
S	Other services activities	9,904	5.9%	28.3%	65.8%

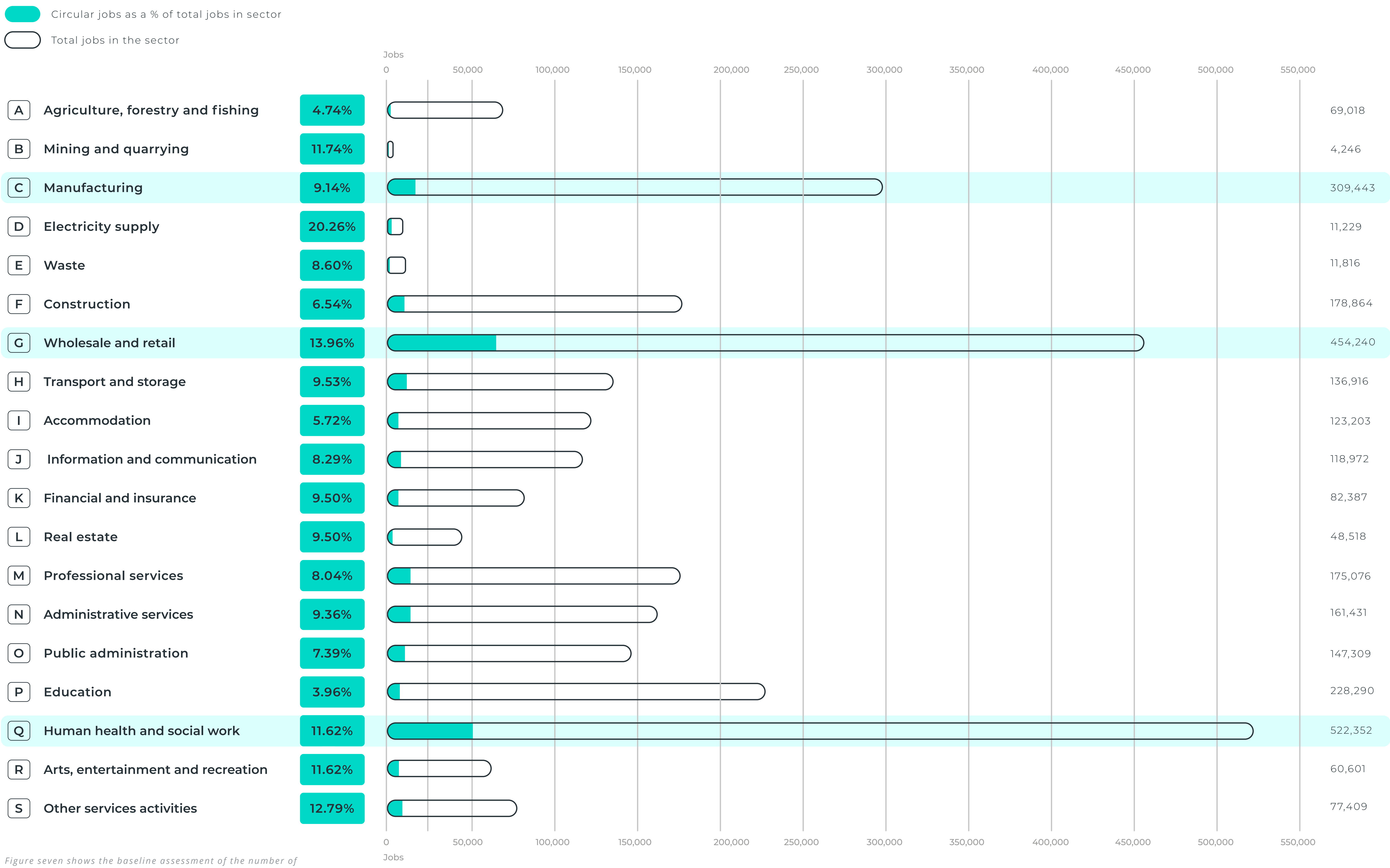


Figure seven shows the baseline assessment of the number of jobs generated by circular economy activities across sectors.

SHAPING A CIRCULAR LABOUR MARKET IN DENMARK: ENABLERS, BARRIERS AND RECOMMENDATIONS

ENABLING FACTORS

1. **Strong foundations have already been set for systemic transformation.** Industries are already being directed towards circularity, with social dialogue around climate policy and the energy transition already beginning in the 1970s, for example. Denmark's wind industry employs a significant 31,251 people, and has become a highly productive and expanding sector, delivering substantial employment and economic returns.[265, 266] What's more, one-fifth (20.3%) of jobs in the Electricity, gas, steam and air conditioning supply sector contribute to the circular transition—with 25.8% of these being core circular jobs. Unions are also notably pro-wind energy and pro-climate policy, recognising the green transition as a significant driver for job creation. Unions often call for heightened ambition on climate and energy targets—while providing commentary on the implications for decent job creation.
2. **There is a high concentration of small and medium-sized enterprises with few large enterprises.** The bulk of Denmark's business community is made up of small and medium-sized enterprises (SMEs): these companies, and especially those among them that are export-oriented, are likely to be quick in adapting to and accepting change, especially if supported in doing so. This makes them key players in the transition. While they make up a comparatively small portion of the total, large companies are also often key industry players, as they have the flexibility to adapt to new legislation and requirements: the upcoming EU *Corporate Sustainability Reporting Directive* (CSRD), for example. These companies boast the in-house training capabilities and expertise needed to attract and retain in-demand workers with the right skills and competencies—and can act as a 'lighthouse' for business clusters, at times entering a symbiotic relationship.
3. **The country is characterised by its strong flexicurity system and low unemployment.** First coined by a Danish Prime Minister, 'flexicurity' refers to a welfare state model characterised by high mobility between jobs, a strong income safety net and a pro-active labour market policy: the unemployed are supported with a high proportion of their lost income, yet must actively continue searching for work. Skills training is a central component of the country's labour market policy: workers are supported in re- and upskilling to return to work, resulting in the highest re-employment rate in the EU.
4. **Denmark boasts strong pathways for skills development.** The Danish labour market consists of nearly three million workers, almost evenly split between unskilled workers, skilled workers[267] and those with medium or higher qualifications.[268] It's expected that the level of highly-skilled workers will increase, as highly-educated younger generations gradually replace older generations, who, on average, have a lower education and skills levels.[269] While a skills gap can be expected in the years to come, Denmark does boast strong pathways for skills development:[270] reskilling and upskilling, for example, are highly-intertwined with the active labour market policy, and are available for both the unemployed and employed. Emphasis on skills development for low-skilled workers has also grown over the last decade, with participation in adult education among low-skilled workers ranking second in the EU. For all education levels, participation in adult education and continuing training is the highest in the EU.[271] In this way, the country is well-poised to spearhead the needed skills shift that the circular economy transition will call for. However, finding time and financing for further education remains difficult, despite Denmark ranking above other countries. This is expanded upon in the following section.

BARRIERS TO THE CIRCULAR TRANSITION

1. **The circular economy ecosystem is not yet mature.** Historically, the green energy transition has taken centre stage in Denmark—yet the country has not yet secured a position as a leading player in the transition to a circular economy. In contrast to neighbouring countries, the circular economy has not yet permeated the policy landscape: Denmark has not yet formulated a circular economy roadmap that lays out clear targets, creating the necessary political commitment. While the *Action Plan for Circular Economy—National Plan for Prevention and Management of Waste 2020-2032*[272]—the latest national waste strategy—marks a step in the right direction, the circular economy encompasses far more than waste management. Although many circular initiatives have cropped up in recent years—in the design, construction and industrial sectors, for example—these often operate in isolation, with little collaboration.
2. **Awareness of what the circular economy entails for various labour market stakeholders is lacking and prevailing attitudes are not entirely supportive.** The circular transition will challenge traditional competencies and cultures. To adapt to new demands, a common language for discussing circular principles, indicators and skills will be needed. A mindset shift will also be crucial: the success of the circular transition will hinge on local support, as circular interventions largely rely on locally-embedded strategies and ecosystems. This will be especially relevant for SMEs, some of which may see circularity and sustainability more broadly as a barrier to growth.
3. **The lack of unions and collective agreements in circular sectors may hinder job quality.** Denmark's unionisation rate is among the highest in the world, with around two-thirds of workers belonging to a union. In a unique approach that distinguishes Denmark from many EU countries, there are no legal regulations on minimum wage, working hours, or pension contributions: these aspects are adeptly handled through collective sectoral or company-level agreements. As the country transitions to a circular economy, it will be important to recognise that traditional sectors have benefited from well-structured collective bargaining agreements. Emerging circular sectors, such as repair, must adopt similar frameworks and ensure that they provide good working conditions, at least on par with their linear counterparts.[273]
4. **SMEs comprise most of the Danish labour market but are not yet prepared for circularity.** While SMEs are often highly innovative, limited time and financial resources to upskill employees, as well as difficulties coordinating activities and relying upon external actors throughout their respective value chains, may prove challenging in fostering greater circularity. It is challenging for these companies to expand beyond their core business operations and prioritise the circular transition. This is exacerbated by how most pressure for circularity is external, leaving most businesses unprepared to report on key circular indicators—an important consideration for CSRD reporting and for eco-design requirements across sectors.

5. **Highly-skilled workers are lacking, as is a focus on circularity in higher education.** Denmark experiences a deficit of highly-skilled workers like engineers, highly-qualified IT professionals, and doctors, which poses a particular challenge for the transition to a circular economy. The shortage of engineers will be particularly challenging for the circular transition: technical expertise is needed to develop and implement technical solutions, such as design for repair, as well as to develop more efficient waste management systems and implement new business models reliant on new technologies. Beyond technical skills, higher education often overlooks transversal skill development, such as digital literacy, and embedding circular knowledge into traditional curricula. Additionally, there's a shortage of data-related skills, data sharing skills, and sustainability reporting knowledge that drive circular innovation and will become increasingly crucial with new EU regulations like the CSRD. Universities of applied sciences, which can be more flexible and agile in terms of updating their curricula, represent a solid avenue through which to further circular skills development—yet are often overlooked. It should be noted that this pattern goes both ways: although many higher education courses don't integrate circularity, students in those that do feel a mismatch with the labour market, and express concern at finding suitable jobs in Danish businesses. The cultural uptake of circular principles therefore must permeate companies as well as educational institutions To address these issues, Denmark must incentivise more students towards needed professions, enhance the integration of circularity and transversal skills in curricula, and attract foreign talent through a comprehensive national campaign promoting the country's appeal.

6. **Vocational education and training is key for the circular transition, but it is on the decline.** Although labour-intensive sectors are the most in demand, the number of vocational education and training (VET) learners is decreasing: 70% of such learners are high schoolers who are not ready to be 'locked in' to a profession. While VET professions benefit from competitive salaries, the perception that higher education can lead to better career pathways and salaries is prevalent—and an effective strategy to tackle this issue and train employees in much-needed sectors is lacking. VET will be crucial to effectively redeploy and reskill workers to prepare them for new professions.

7. **Participation in life-long adult education is difficult for workers in vocational professions.** Life-long adult education is becoming increasingly fragmented, making it hard to argue for a substantive curriculum change that centres around the circular economy. This also makes it challenging to ensure various vocations are educated in circular principles, further compounded by limited resources to pay for further education, time constraints as workers don't follow traditional nine-to-five schedules, limited availability of specialised programmes,[274] geographical distance from training providers, potential language barriers and an aversion to returning to 'formal education'. What's more, AMU programmes related to circular skills are not in demand: in general, employers do not see the need for upskilling, and workers don't want to take on the risk of upskilling themselves, while training suppliers may find it difficult to market their courses to relevant employers and employees.

RECOMMENDATIONS

1. **Foster awareness of the circular economy and frame it as a means to improve competitiveness and resilience while reaching vital climate targets.** The pandemic and Russia's invasion of Ukraine have sparked a heightened desire for resilience: shifting to a circular economy can help achieve this, and it should be positioned as such. It will be especially important to raise awareness of the circular economy's benefits among SMEs, and stimulate demand for circular products and skills, thus inspiring SMEs to change. This can be done by raising public awareness for circular business models, embedding circular requirements in public procurement, subsidising circular production processes and rolling out legally-binding circular requirements, for example. SMEs may also be encouraged to cooperate and explore synergies with each other: this will be particularly important for circular business models that use reverse logistics or take-back or repair schemes, for example.

2. **Establish a competence centre, hub or network in Denmark.** This follows from the first recommendation: a hub or network can be used to coordinate, support and inspire critical stakeholders for the transition. It may also advocate for a formal circular economy policy or roadmap, allowing stakeholders to take a mission-oriented approach towards meeting targets. For higher education institutions, such a hub could provide training courses and knowledge-sharing events targeted at both academics and educators on circular economy. Embrace Denmark's collective and collaborative nature to build communities of practice and learn by doing.

3. **Heighten the appeal of vocational education and training to the broader public.** Reshape the perception of vocational education so that students view it as a competence to be developed, rather than a 'locked-in' life option. This could also signal to other workers that reskilling and retraining are possible if they wish to switch career paths.

4. **Integrate circular knowledge and thinking in existing vocational training and adult education courses.** In 2017, the Danish Advisory Board for Circular Economy recommended that circular principles be integrated into the entire Danish educational system. The Business Development Board is also carrying out a nation-wide effort to increase circular and digital skills among managers and employees of Danish companies through internal upskilling.[275] Continue to scale these activities to push for better education opportunities in workers' agreements and ensure that circular thinking permeates curricula.

5. **National campaign to recruit international talents.** Surveys have shown that many international talents find the Danish work culture, career opportunities and work-life balance appealing.[276] However, few international talents are aware of the benefits the Danish labour market offers. A nationally-coordinated campaign to recruit international talent may be established to promote the advantages of studying and working in Denmark. Today, individual employers are left on their own in this endeavour—which is especially challenging for SMEs.

HOW THE CIRCULAR TRANSITION WILL CHANGE LABOUR ACROSS THE FIVE SCENARIOS

Chapter four dives into strategies to shift five key areas—the Built Environment, Agrifood, Mobility, Manufacturing and Lifestyle—from linear to circular. This section explores the roles and skills needed to action these strategies on-the-ground.

1. BUILD A CIRCULAR BUILT ENVIRONMENT

As of late 2022, the Danish built environment[277] represented 6.2% of total employment, with 56,480 workers employed in the construction of new buildings and a substantial 65,372 employed in repair and maintenance.[278, 279] It's expected that a net 10,000 workers will be needed each year up to 2030 to fulfil the building and construction sector's needs.[280]

According to our analysis, 6.5% of construction jobs are contributing to the circular economy, of which **0.8% are core, 13.9% are enabling,** and **85.3% are indirect**. Currently, around 9.5% of real estate activities contribute to the circular economy. The analysis has found that circular jobs in the construction sector grew by 3.3% between 2018 and 2021: this can likely be attributed due to steady growth in sustainable building practices, the increased recycling and reuse of construction materials, and the adoption of new circular technologies and practices in the sector. In the same time period, the share of **indirectly** circular jobs has decreased, replaced mainly by **enabling jobs** (such as those in 'rethinking the business model') complemented by a slight uptick in **core jobs** (largely 'using waste as a resource'). In the future, a more circular built environment would not only impact jobs and skills related to the sector itself, but also those in public administration, which would need to consider the use of space for and energy efficiency of housing and commercial buildings, as well as roles in procurement.

The way forward

The development of a sector-specific roadmap is needed to move this sector forward.[281] It will be critical to focus on the reuse of building materials and components at their end-of-life: for buildings that cannot be renovated or retrofitted, selective demolition and deconstruction must be prioritised. The development of circular skills and competencies among workers should also be spotlighted.[282] Fostering stakeholder engagement—particularly with local businesses and citizens—will be especially important to shape a shared vision and spark the implementation of circular practices.

Job opportunities

1. **Circular design:** Architects and engineers will need to be trained in circular practices, including modular construction, design for deconstruction, passive design and the selection of durable, recyclable and regenerative materials. Knowledge of building certifications, such as LEED and BREEAM, will also be important.
2. **Circular business models and project management:** Circular business models—leasing, sharing and take-back, for example—will require new roles in business model development, logistics and customer engagement.
3. **Life-cycle assessment and circular materials management:** Experts that can optimise material lifetimes, minimise waste, and promote recycling and reuse will be in high demand. They will need competencies in material flow analysis, waste management, and general circular skills like identifying and separating materials, material recycling and upcycling, and material tracking and traceability.
4. **Digitalisation and building information modelling (BIM):** Digital technology will play an increasingly important role in the built environment, so it's expected that skills in BIM, digital twins and data analysis will be desired to optimise buildings' performance, energy consumption, and resource management.
5. **Green building technologies:** Engineers, technicians and specialists with expertise in renewable energy systems, energy storage and smart building technologies will be essential for implementing sustainable solutions in the built environment.
6. **Facility management and retrofitting:** Professionals that can manage, maintain and retrofit existing buildings to improve energy efficiency and resource utilisation will be vital. They must be proficient in energy audits, building performance analysis and sustainable retrofitting strategies.
7. **Circular procurement:** Professionals identifying and selecting circular construction products and services will become essential. This will involve the procurement of recycled building materials, the use of circular service models like lighting-as-a-service and the implementation of circular supply chain management practices, for example.

2. NURTURE A CIRCULAR FOOD SYSTEM

The domestic food supply sector[283] employed around 108,000 people in Denmark in 2019, representing around 4% of Denmark's active workforce.[284] Compared to other EU Member States, this is a relatively low share[285]—but workers are notably younger than the EU average, predominantly aged 15–34 compared to 35–49. Demand for workers in the sector is forecast to fall, with around 2,000 jobs expected to be lost by 2030.[286] Implementing a full-scale bioeconomy in Denmark could lead to the creation of approximately 23,700 jobs.[287] Interestingly, about 80% of these positions are expected to be based in rural areas. This could potentially boost these areas' economies, reduce unemployment, and possibly even spur rural-urban migration by providing more local job opportunities. In addition, around half of these positions are expected to be available to workers with vocational education, driven by larger employment demand in biomass-related occupations in the agricultural, utilities and construction sectors. Overall, the bioeconomy could become a significant source of employment and economic growth, while also promoting regional development and inclusivity. A decrease in animal farming may see employees in this industry shift to other roles, while an increase in organic farming—which is less tech-intensive, smaller in size and uses fewer chemical fertilisers—would see a shift away from high-tech, intensive value chains to roles in more localised value chains.

According to our analysis, this sector is not an active player in the circular transition: only **4.7%** of jobs in the agriculture, forestry and fishing industries are contributing to the circular economy, and all are doing so **indirectly**. Indeed, circular jobs in the Agriculture, Forestry and Fishing sector decreased by around 2% between 2018 and 2021. This, however, may reflect industry trends, such as the mechanisation of agricultural processes, changes in land use and a shift in global trade dynamics.

The way forward

Implement circularity in policy and legal regulations: Danish legal requirements for catch crops,[288] for example, could be a means to promote circular economy principles. Similarly, the upcoming CO_2 tax is at the heart of sustainability discussions in the Danish agrifood sector: the circular economy must have a leading role in these conversations, particularly in re- and upskilling farmers to mitigate the expected job losses for the sector. As noted, demand for technical and digital skills will rise: farmers must be supported with financial support to invest in skills development.

Job opportunities

1. **Sustainable agriculture and farming practices:** Professionals in this field must be knowledgeable about regenerative agriculture, precision farming and agroecology to enhance soil health and boost biodiversity and ecosystem services. This may also include the development of new methods to cut waste and increase efficiency in farming and food processing.
2. **Integrated food systems and supply chain management:** Professionals that can design and manage circular food systems will be key. Roles in this arena may include developing food waste-to-energy systems, composting and anaerobic digestion systems, and promoting and distributing local food.
3. **Biorefineries and biomaterials production:** Experts in biotechnology and bioprocessing will play a crucial role in valorising waste streams, producing bio-based materials and creating added-value products from biomass. They will need skills in microbial fermentation, enzyme technology and bioconversion processes.
4. **Alternative protein sources:** Professionals specialising in the development and commercialisation of alternative protein sources, such as plant-based proteins, insects, and cultured meat, will be important for reducing the environmental footprint of food production.
5. **Circular business models and entrepreneurship:** Business professionals that can develop and implement circular business models will drive the transition. These professionals will need expertise in project management, stakeholder engagement and circular economy principles. New roles and skills in areas such as circular business model development and reverse logistics will likely arise.
6. **Digital skills:** Knowledge about the Internet of Things (IoT), machine learning and data analytics will be required, specifically skills in areas such as digitalisation, software development and data analytics.

3. RETHINK TRANSPORT & MOBILITY

Since 2019, the transportation and storage sector in Denmark has maintained steady employment figures, consistently providing jobs for 125,500 individuals.[289] A promising dynamic within this sector is the fact that it has the highest proportion of young bus and coach drivers in Europe (3% under 25 years old), well-positioning Denmark for the transport sector to adopt new technologies and foster a mindset more open to change.[290] Furthermore, employment may grow as circular business offerings—such as car sharing platforms—continue to rise in popularity: currently, Denmark hosts 75 road transport tech startups.[291]

According to our analysis, **9.5%** of jobs in the transportation and storage sector contribute to circularity. Of these, **43.2% are enabling** jobs while **56.8% are indirect** jobs. The analysis found that circular jobs in the transportation and storage sector decreased slightly by 1.2% between 2018 and 2021. In the same time period, the share of indirect circular jobs decreased, with enabling jobs (such as those in 'rethink the business model') gaining traction. In the future, a more circular mobility sector would impact many industries: transportation and storage, construction, manufacturing, electricity, gas, steam and air conditioning supply.

The way forward

Continue to focus on and invest in accessible, affordable alternative modes of transport, such as cycling, walking and public transport, while disincentivising the use of cars. Support the growth in electric vehicles with a focus on job creation and skills development in electric vehicle maintenance, as well as the recycling and remanufacturing of vehicle components. Ensure that relevant trainings are available beyond the two main urban areas of Denmark to attract a broader range of people.

Job opportunities

1. **Sustainable transport planning:** Professionals in this field should develop multimodal transportation planning, active mobility, and public transportation systems proficiently.
2. **Electric and alternative fuel vehicles:** Engineers, technicians, and specialists with expertise in electric vehicles (EVs), charging infrastructure, and alternative fuels, such as hydrogen and biofuels, will be essential for driving the transition to cleaner and more efficient mobility.
3. **Vehicle and component design:** Professionals must have knowledge of sustainable materials, design for disassembly and life-cycle assessment to design lightweight, energy-efficient and recyclable vehicles and components.
4. **Shared mobility and Mobility-as-a-Service (MaaS):** Experts who can develop and manage shared mobility solutions, including car-sharing, ride-hailing, and bike-sharing, as well as integrated MaaS platforms, will be essential for promoting a more circular mobility system.
5. **Intelligent Transformation Systems (ITS):** Experts in ITS, including traffic management systems, autonomous vehicles, and connected vehicle technologies, will be needed to enhance the efficiency and sustainability of transportation networks.
6. **Logistics and supply chain management:** Professionals with competencies in circular strategies, reverse logistics and collaborative partnerships will be needed to optimise logistics and supply chain operations.
7. **Digitalisation:** Skills in digitalisation, software development and data analytics will be needed to support new technologies, such as IoT and machine learning.
8. **Materials and resource management:** New skills and competencies related to materials and resource management, including the identification and separation of materials, materials recycling and upcycling, and materials tracking and traceability, will be crucial.
9. **Circular business models and entrepreneurship:** Business professionals will need to implement circular business models and innovate on financing schemes for the mobility sector.

4. ADVANCE CIRCULAR MANUFACTURING

In 2019, 157,300 people were employed in medium- and high-technology manufacturing and knowledge-intensive service sectors.[292] This accounted for over half, 53.3%, of all jobs in Denmark's manufacturing sector.[293]

According to our analysis, **9.1%** of the manufacturing sector's jobs contribute to the circular economy. Nearly all of these are **indirect jobs**. Between 2018 and 2021, circular jobs in the manufacturing sector increased by 4.8%: however, **core jobs**—in repair and maintenance, for example—remained static, with the growth occurring due to an increase in enabling and indirect circular jobs. In the future, a more circular manufacturing sector would have implications for waste management, arts and entertainment (for example, due to dematerialising our leisure activities) and agriculture (for example, through the use of natural fibres in textiles).

The way forward

Encourage Danish manufacturers to adopt circular principles to cut the demand for virgin materials and to minimise the material footprint of imports. Substituting high-impact imports with locally-available alternatives may also serve to boost local job creation—this should only be done, however, if the local alternative boasts a lower material footprint. Investments should be made to support knowledge and infrastructure to create digital passports for materials and products. Overall, the manufacturing sector will adapt to the circular transition more easily with clear guidance, skills training and economic incentives.

Job opportunities

1. **Sustainable and circular product design:** Professionals in this field should be proficient in design for disassembly and modularity, and Life-cycle Analysis (LCA) to incorporate circular principles in product design.
2. **Resource and waste management:** These professionals will need skills in waste management, including the identification and separation of materials, recycling and upcycling, and materials tracking and traceability. Examples of such occupations include logistics manager, waste valorisation professional, waste management trainer, technical engineer for recyclable products, and strategic waste manager.
3. **Additive manufacturing and digital fabrication:** Engineers, technicians and specialists with expertise in additive manufacturing (3D printing) and digital fabrication technologies will be crucial for enabling localised, flexible and resource-efficient production.
4. **Industrial automation and robotics:** Professionals skilled in the development and integration of automation systems, robotics and artificial intelligence in manufacturing processes will be essential for enhancing productivity, precision, and resource efficiency.
5. **Digitalisation and Industry 4.0:** Experts in digital technologies, such as the Internet of Things (IoT), big data, and advanced analytics, will be needed to optimise manufacturing operations, monitor resource usage, and improve overall sustainability and create new digital tools to enable innovation and entrepreneurship.
6. **Circular business models:** Technicians and specialists with skills in repair, refurbishment and remanufacturing will play a crucial role in the shift towards circular business models.
7. **Industrial symbiosis facilitation:** Professionals skilled in either/or traditional industrial symbiosis, circular economy strategies, supply chain management, industrial ecology and environmental engineering will be crucial for roles such as data analysts, industrial ecology

researchers, policy experts, network facilitators and educators.

5. EMBRACE A CIRCULAR LIFESTYLE

Repair, a crucial component of facilitating more circular lifestyles, plays a relatively important role in Denmark: in 2019, the percentage of full-time employees in the business-to-consumer repair sector in Denmark was the fourth highest in the EU, for example.[294]

The way forward

Introduce policies, incentives and regulations that encourage businesses to adopt more circular practices—and invest in the necessary education, vocational training and lifelong learning programmes to develop skills and competencies in eco-design, repair, refurbishment and waste management. Establish an innovation hub for circular solutions, where businesses, consumers and researchers can collaborate and learn from each other to develop new products and processes. Invest in infrastructure that supports repair skills and competencies, through local networks of community repair centres, for example.

Job opportunities

1. **Sustainable and circular product design:**[295] Professionals will need to know how to use recycled and biodegradable materials, design for disassembly and reuse and how to deploy 3D printing technology to produce customised products.
2. **Circular retails and service models:** Business professionals will require new skills in circular business model development and reverse logistics to develop circular retail and service models, with the aim of promoting sustainable consumption. These models will require expertise in online platform management, quality control and reverse logistics.
3. **Consumer engagement and education:** Professionals that can effectively communicate the benefits of a circular lifestyle and promote sustainable behaviour change will be essential. They may have expertise in marketing, communications, public relations and behavioural psychology.
4. **Sustainable fashion and textiles:** Experts in sustainable fashion and textile design will be needed to develop products made from eco-friendly materials, employ circular production methods, and promote recycling and reuse of textile waste.
5. **Sustainable food systems:** Professionals that can design and manage sustainable food systems, including circular agriculture, waste reduction, and resource-efficient food production and distribution, will be important for promoting sustainable lifestyles.
6. **Digitalisation:** Professionals with skills in digital technologies such as IoT, machine learning and data analytics, as well as the ability to use augmented and virtual reality, develop digital marketplaces and use blockchain technology to track and trace product supplies, will be important in driving more circular lifestyles.

DENMARK SCALING CIRCULARITY THROUGH JOBS IN CONSTRUCTION, AGRIFOOD AND INDUSTRY

Denmark's Roskilde municipality procured the construction and demolition of a circular parking garage as part of a pilot project: the structure was designed for disassembly and made from recycled materials. The future demolition will be spearheaded by a local non-profit that provides jobs to vulnerable citizens, who will sort, catalogue and store materials for easy access for local builders and architects.

Organic food delivery company Aarstiderne[296] is also working to provide employment opportunities to those who face barriers to entering the labour market, such as refugees or individuals with disabilities. Its aim is to cut waste and promote sustainability—all while developing training and skilling programmes for its employees and farmers to give participants hands-on experience in sustainable farming.

Pump-producer Grundfos boasts a similar aim: eliminating waste by collecting used pumps for reuse through its take-back programme. A portion of the pumps are directly reused in Grundfos' production, while another is recycled—and the sorting is carried out by employees who, for social and health reasons, have reduced ability to work.

6 THE WAY FORWARD

Denmark has the potential to transform its economy: by cutting material consumption almost in half, the nation can nearly double its Circularity Metric. This report illustrates how materials are allocated to meet Denmark's needs and wants—and lays out guidelines for how the country can drive its circularity from 4% to 7.6%. This increase may not seem significant, but by integrating circular strategies, Denmark could cut its material footprint by 39%, bringing substantial benefits for the climate, biodiversity and pollution. This could have a transformative impact: our global *Circularity Gap Report 2023*, which featured scenarios comparable to those in this report, found that a 34% reduction in the global material footprint could reverse the overshoot of five planetary boundaries and limit global warming to within 2-degrees.[297] The five scenarios presented in this report provide Denmark with an opportunity to overhaul its economy, swap out material- and emissions-intensive linear processes for ones that make the most of materials' value, minimise waste and help regenerate natural systems: a transition to a circular economy. Boosting Denmark's circularity to 7.6% should be an interim objective, and part of a larger trajectory to increasing circularity while decreasing material use and emissions to the greatest extent possible.

The transition to a circular economy will not be easy—nor will it take place overnight. While the strategies presented in Chapter four have transformative potential, their implementation will be met by numerous challenges. Adopting a circular built environment offers the greatest opportunity for material footprint reduction: by creating a more resource-efficient sector, Denmark could cut its material footprint by 15.4%. Shaping a circular built environment, through strategies such as replacing virgin construction materials with high-quality secondary materials, vastly improving energy efficiency and utilising buildings more efficiently, will require real systemic change involving the Government and business—with households even playing a small role. Meanwhile, the scenarios with the second and third highest impact—lifestyle and mobility—must also be pursued with similar commitment across stakeholders and sectors. Interventions with comparatively lesser impact, such as those for food, must not be ignored—benefits should be viewed holistically and not just in the context of reductions in the material footprint and emissions or gains for the Circularity Metric. All scenarios present their own unique co-benefits, from pollution mitigation to the protection of biodiversity to the creation of new circular jobs. There is no panacea to tackle ecological breakdown or the climate emergency, and while significant work has been done since 2019—the baseline year for this report—progress remains to be made. Everyone will have a role to play: the Government, businesses and society as a whole.

Going circular requires the continued innovative government approach already at work in Denmark. The Danish Government—across national, regional and municipal levels— is already taking steps towards circularity—but there's still more work to be done. Danish Governments must shift their focus from waste management (which has historically centred on incineration but is slowly shifting to recycling) to waste prevention. To better manage resources, big changes are needed in the waste management sector. Organisation and rules for the waste sector have shifted since the *Climate Plan for a Green Waste Sector and Circular Economy* was rolled out in 2020—for example, more uniform waste sorting processes are being implemented throughout the country to ensure that waste is transformed into recycled raw materials. Nonetheless, there is a need for more streamlined waste sorting, as well as new framework conditions that support less waste and more recycling. In order to reduce the amount of waste for incineration and ensure more recycling, it is imperative that more waste is sorted in households, public and private companies and public spaces. Many initiatives already in their infancy will be key as the transition unfolds and must be carried out to their full potential. The upcoming producer responsibility scheme for packaging, for example, will be crucial to increasing the reuse of packaging waste and reducing the amount of waste created in the first place. Green (and circular) public procurement is also currently being pursued by the government. In 2020, the *Strategy of Green Procurement for a Green Future* was launched. The strategy contains 27 initiatives, many of which contribute to promoting a circular economy—although these have yet to materialise in a meaningful way. Finally, in April 2022, the Danish Ministry of Food, Agriculture and Fisheries announced it would begin funding the development of a climate label for food, making Denmark the first country to do so—work that has already kicked off with political recommendations.[298] The country has built a solid foundation from which to go circular: the coming years will now be critical for building on this foundation and firmly positioning Denmark as a world leader in the circular economy.

Beyond recycling, going circular requires a comprehensive set of indicators and targets. A number of European and national objectives and visions have already been set, which outline the direction of Denmark's transition to a circular and climate-neutral economy.[299] However, these are still largely focused on recycling rather than reducing consumption or extending the life of products. Ingraining material footprint reduction into targets and national policy-making will be fundamental to driving change at the scale, scope and speed needed. To make the circular transition possible, the government can't act alone. Stakeholder dialogue within and across public and private entities is vital to ensure good data is available and realistic, ambitious targets are set. Denmark is already aligned with EU targets, making it a climate frontrunner among EU Member States. In 2020, its Parliament passed a climate law with a landslide majority that aims to reduce greenhouse gas emissions to 70% below 1990 levels by 2030, with net-zero emissions targeted for 2050—a goal that even surpasses EU requirements and is among the world's most ambitious.[300] However, the government has set no targets on consumption-based emissions: Denmark can move the climate discussion beyond territorial emissions and consider introducing more impactful indicators and legally binding targets to lower material use and consumption-based emissions. Monitoring and evaluating progress will also require more extensive data gathering at the sectoral and business level. In developing such targets, collaboration between countries will be crucial: Denmark can learn a lot from other countries' national journeys toward circularity and vice versa. Peer-to-peer learning and knowledge transfer will increase the pace towards global circularity.

A significant opportunity for Denmark—and the risk of missing out. While the country exhibits levels of consumption and extraction that far surpass the global average, it's well-positioned to take on the challenge of going circular. With well-formed waste management and decarbonisation goals and the circular economy increasingly accepted as means for achieving environmental aims, Denmark has already taken its first steps to leave linear behind. Proactive stakeholder engagement will be key to the transition's success—and with plenty of collaboration programmes between business and academia that span sectors, Denmark has the foundation needed for circularity to succeed. Through close collaboration and systemic changes that permeate government, the private sector and individuals, 'going circular' can become the country's new reality.

RECOMMENDATIONS AND NEXT STEPS TO BRIDGE THE CIRCULARITY GAP THROUGH LEADERSHIP AND ACTION

1. **Coordinate and collaborate to advance circularity.** Denmark benefits from a strong culture of social and business collaboration—this can be leveraged further to shape circular initiatives. Creating platforms that facilitate the exchange of knowledge, skills and resources within and between industries is key to advancing circularity. The *Climate Partnerships 2030* provides a great springboard from which to link collaboration around circular initiatives to the public sector, which can be a vital source of funding and regulatory reforms.
2. **Ensure Denmark is ready for new circular economy requirements.** The EU is rolling out policies to kickstart the circular transition across Member States—so Denmark must get ready to meet new requirements through technological advances, behavioural change and new business models. This can also help position Denmark as a frontrunner both within Europe and globally, using its innovative business sector to showcase what is possible and encourage other countries to follow suit.
3. **Create a fit-for-purpose policy framework that prioritises and facilitates smarter material use.** Ingrain reductions in the material footprint, consumption-based emissions and waste into targets and national policy-making to drive change at the scale, scope and speed needed.
4. **Support and encourage SMEs on their circular journeys.** In Denmark, the majority of businesses across most industries are SMEs. While SMEs are vital for driving the circular transition, challenges exist in terms of coordination and collaboration between so many small actors—a key component when economies of scale are not possible. Additionally, access to financing and gaining the necessary new skills can also be challenging for small players. The Government may endeavour to support SMEs with more resources, taking a different approach to the support given to larger companies.
5. **Measure, monitor and evaluate progress to capture the entire circular economy.** Create a fit-for-purpose measuring and monitoring framework that covers all elements of circularity: the narrowing, slowing, cycling and regenerating of material flows. Ensure this is directly linked to environmental goals, both domestically and abroad, and takes both a production- and consumption-based perspective. This can allow Denmark to tackle the full extent of its environmental impact, as well as better gauge how successful various policy instruments are by tracking more comprehensive and granular data.

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48. We classify backfilling as a form of technical cycling, as it substitutes demand for virgin materials. This aligns with other methodologies for measuring circularity, such as Eurostat's Circular Material Use Rate (CMUR).

49. The term 'cycled technical materials' is a simplification for visual purposes, as these materials comprise the vast majority of the Metric.

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52. The Net Extraction Abroad indicator is calculated as the difference between the Raw Material Consumption (RMC) and Domestic Material Consumption (DMC). When the difference is positive, it means that the materials extracted abroad used to satisfy domestic final demand are larger than the domestic one used to satisfy demand abroad and vice versa.

53. Countries such as the Netherlands and Norway are missing because their Indicator Sets were derived using a slightly different methodology, thus rendering comparisons with the present analysis inaccurate.

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57. Net extraction abroad equals RMC minus DMC. This yields a positive value when there is a net extraction happening abroad in a given year, considering imports and exports of raw materials.

58. Here, we consider technical recycling as that which contributes to the Circularity Metric, not including materials that are incinerated, landfilled or spread on land.

59. Recycling rates are calculated as the recycled waste divided by the total waste treated for each waste category.

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259. Among the interviewed were: Peter Andreas Norn (Concito), Markus Bjerre & Martin Koch Haagensen (Danish Business Authority), Hanne Juel (Central Denmark Region), Camilla Haustrup Hermansen (PlusPak), Ditte Lysgaard Vind (Lendager The Circular Way), Arne Remmen), Thomas Budde (Roskilde University),Birgitte Kjær (Landbrug og Fødevarer), Anders Ziegler Kusk (Industriens Fonds), Tim C. McAloone (Danmarks Tekniske Universitet), Sine Beuse Fauerby (IDA), Thomas Michael Klintefelt (Confederation of Danish Industry), Jussi-Pekka Teini (TEK – Finland), Jon Lausten Vilsen (3F), Victoria Lindhardt Zorzi (State of Green).

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265. QBIS. (2020). *The socio-economic impacts of offshore wind*. Retrieved from: QBIS website

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274. Specifically, an interviewee mentioned that 'there is not enough time to find the right course. Often if you want further education, you need to find it yourself. It can get very overwhelming.' This is further exacerbated in the niche circular economy space.

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276. Oxford Research. (2020). *The expat study 2020: An analysis of living and working in Denmark as an expat*. Retrieved from: Oxford Research website

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284. Eurostat. (2020). Employment in food supply across EU regions. Retrieved from: Eurostat website

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287. This source study was commissioned by 3F. The employment effects in Denmark’s bioeconomy were calculated using the ‘+10 million tons plan’, the Maabjerg Energy Concept Status Report, and Statistics Denmark’s data, incorporating considerations of agricultural changes, construction phase contributions, sectoral and geographical distributions of jobs, and educational levels of employment. The assumptions in the employment calculations include a successful increase in biomass production, job creation not causing losses elsewhere, consistent annual construction jobs, accurate sectoral job distribution, jobs divided into rural and urban based on sector, geographic job distribution based on current municipality sizes and bioeconomy businesses, and educational job distribution following national trends. Learn more here.

288. Referrings to crops that are grown between two main crops in order to reduce nutrient leaching and improve soil health. In Denmark, catch crops are an important component of the country’s agricultural policy, and farmers are required by law to plant catch crops on a certain percentage of their land in order to receive subsidies, as you cannot leave your soil green.

289. Eurostat. (2023). Labour force survey for Denmark – NACE Rev. 2. Retrieved from: Eurostat website

290. IRU. (2022). *Driver shortage global report 2022*. Retrieved from: IRU website

291. Tracxn. (2022). Road transport tech startups in Denmark. Retrieved from: Tracxn website

292. Many manufacturing activities rely on service activities: the sector is closely linked to maintenance and repair, training, and consulting, for example.

293. Eurostat. (2023). Employment in high- and medium-high technology manufacturing and knowledge-intensive services. Retrieved from: Eurostat website

294. Manoochehri, S., Schluep, M., Dams, Y., Mehlhart, G., Bekkevold Lingås, D., Marin, G., Nicolau, M., & Colgan, S. (2022). *An overview of Europe’s repair sector*. European Environment Agency. Retrieved from: Europa website

295. Recent research has shown that there is a shortage of circular design experts for current demand—and especially for the demand expected in the years to come. Due to this shortage, even leading companies are struggling to train their staff in this area. Source.

296. Aarstiderne. (2023). Om Aarstiderne. Retrieved from: Aarstiderne website

297. Circle Economy. (2023). *The circularity gap report 2023*. Amsterdam: Circle Economy. Retrieved from: CGRi website

298. Kjølberg, T. (2022). Voluntary climate labelling in Denmark. Retrieved from: The Daily Scandinavian website

299. Ministry of Environment for Denmark. (2021). *Action plan for the circular economy*. Retrieved from: Ministry of Environment for Denmark website

300. Batini, N. & Segoviano, M. (2021). Denmark’s ambitious green vision. Retrieved from: IMFBlog website

301. The World Bank. (2022). Trade (% of GDP) - Denmark. Retrieved from: The World Bank website

302. This means that the figures presented here do not necessarily correspond to the ‘raw’ waste treatment data. ‘The conceptual gap between waste statistics and ew-MFA is based on different reporting classifications, and we have allocated waste flows to ew-MFA categories based on the main material components of waste flows. This was only feasible at the level of the main material groups distinguished in ew-MFA, i.e. biomass, fossil energy carriers, industrial minerals, construction minerals, metal ores. Expert informed assumptions were necessary to judge whether waste flows reported in statistics result from energetic or material use. Most waste flows could unambiguously be allocated to wastes from material use. Among the waste flows originating from energetic use were animal and vegetal wastes (W09) and combustion wastes (W124). A few flows recorded in waste statistics (e.g.) were excluded, since they follow a different system boundary and thus are not recorded as extraction in ew-MFA statistics. The quantitatively most important flows that were excluded were soils (W126) and dredging spoils (W127).’ From Supporting Information in Mayer, A., W. Haas, D. Wiedenhofer, F. Krausmann, P. Nuss, and G.A. Blengini. (2018). Measuring progress towards a circular economy: A monitoring framework for economy-wide material loop closing in the EU28. *Journal of Industrial Ecology, 23*(1), 62-76. doi:10.1111/jiec.12809

303. The Danish Environmental Protection Agency (EPA). (2019). *Waste treatment 2019* [dataset]. Internal file.

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APPENDIX A: HOW THE FOUR CIRCULAR STRATEGIES WORK TOGETHER

There are potential overlaps between some of the four circular strategies: narrow, slow, regenerate and cycle. For example, slow and cycle interventions often work together. By harvesting spare parts to use again, we are both cycling—by reusing components—and slowing by extending the lifetime of the product the components are used for. And ultimately, slowing flows can result in a narrowing of flows: by making products last longer, fewer new replacement products will be needed—resulting in decreased material use. There are also potential tradeoffs between the four strategies to be acknowledged. Fewer materials being used for manufacturing—narrow—means less scrap available for cycling. Similarly, if goods like appliances and vehicles are used for longer—slow—their energy efficiency falters compared to newer models, thus preventing narrowing. Using products for a long time—slowing flows—also decreases the volume of materials available for cycling: this can have a significant impact on material-intensive sectors like the built environment, where boosting the availability of secondary materials is particularly important. Some strategies to narrow flows, like material lightweighting, can result in decreased product quality and thus shorten lifetimes—making it more difficult to slow flows.

APPENDIX B: DYNAMICS INFLUENCING THE CIRCULARITY METRIC

Applying our Circularity Gap methodology to countries is complex and has required us to make a number of methodological choices. In a bid to generate actionable insights for national economies and to enable comparison between countries, our *Circularity Gap Reports* take a consumption perspective: we consider only the materials that are consumed domestically and allocate responsibility to consumers by excluding exports. However, the more ‘open’ an economy is, the more difficult calculating the import content of exports becomes within the material flow analysis and input-output analysis frameworks, the latter in particular.

With our assessment approach, most production is ultimately driven by consumer demand for certain products or services. In an increasingly globalised world, the chain that connects production to consumption becomes more entangled across regions. Demand-based indicators—applied in this analysis—allow for a reallocation of environmental stressors from producers to final consumers. This ensures transparency for countries with high import levels and also supports policies aimed at reducing or shifting consumer demand, helping consumers understand the material implications of their choices, or ensuring that costs of, and responsibilities for, resource depletion and material scarcity are allocated to entities and regions based on their roles in driving production processes through consumption.

Considering what residents of Denmark consume to satisfy their needs, we must apply a nuanced lens to the direct imports, meaning we work out the full material footprints of the products. Accounting for the material footprint of raw materials is straightforward, but this is not the case with semi-finished and finished goods. To represent actual material footprints in imports and exports, we apply so-called RME (Raw Material Equivalents) coefficients in this study. As an open, high-income economy with trade equal to 112% of its GDP (2021),[301] doing so in the case of Denmark is more complex than for a smaller, less integrated economy.

Finally, the Circularity Metric represents a country's efforts to use secondary materials; this includes waste collected in another country and later imported for domestic use. The total amount of waste recycled in treatment operations is therefore adjusted by adding waste imports to—and subtracting waste exports and by-products of recovery from—the amount of waste recycled in domestic recovery plants. When we adjust the volumes of recycled waste in treatment operations using imports and exports of secondary materials, 'credit' for saving virgin materials is ascribed to the country that uses that secondary material—recovered from former 'waste'. This perspective is similar to national accounts' logic, in which most re-attributions are directed at final use. Whilst Denmark’s waste management sector has been investing heavily in domestic reuse and recycling infrastructure, the market is not bound by geographical borders. Materials can be transported wherever makes logistical, environmental and economic sense. Difficult-to-recycle materials and those that arise in smaller quantities can often be bulked and then transported for treatment in regional facilities. However, it's also possible to take a more 'production-oriented' approach, in which 'credit' for recycling efforts is given to the country that collects and prepares waste for future cycling. This is, for example, the perspective taken by Eurostat in its calculation of the Circular Material Use Rate. For more information on this, refer to the methodology document.

APPENDIX C: PRACTICAL CHALLENGES IN QUANTIFYING CIRCULARITY

The circular economy is full of intricacies: quantifying it in one number presents several limitations. These are:

- **There is more to circularity than (mass-based) cycling.** A circular economy strives to keep materials in use and retain value at the highest level possible, with the aim of decreasing material consumption. The cycling of materials measured by the Circularity Metric is only one component of circularity: we do not measure value retention, for example. The Metric focuses on the end-of-use and mass-based cycling of materials that re-enter the economy but does not consider in what composition or to what level of quality. As such, any quality loss and degradation in processing goes unconsidered.
- **The Metric focuses on one aspect of sustainability.** Our Circularity Metric focuses only on material use: the share of cycled materials out of the total material input. It does not account for other crucial aspects of sustainability, such as impacts on biodiversity, pollution, toxicity and so on.
- **Relative compared to absolute numbers.** The Circularity Metric considers the relative proportion of cycled materials as a share of the total material consumption: as long as the amount of cycled materials increases relative to the extraction of new materials, we see the statistic improving, despite the fact that more virgin materials are being extracted—which goes against the primary objective of a circular economy.
- **It is not feasible to achieve 100% circularity.** There is a practical limit to the volume of materials we can recirculate—in part due to technical constraints—and therefore also for the degree to which we can substitute virgin materials with secondary ones. Some products, like fossil fuels, are combusted through use and therefore can't be cycled back into the economy, while others are locked into stock, like buildings or machinery and aren't available for cycling for many years. Products that can be cycled, such as metals, plastics and glass, may only be cycled a few times as every cycle results in lower quality and may still require some virgin material inputs. Because of this, reaching 100% circularity isn't feasible: this calls for a more nuanced approach to calculating circularity and setting targets.

APPENDIX D: WASTE MANAGEMENT

Comparing original waste statistics with the modified waste dataset harmonised according to the economy-wide material flow analysis (EW-MFA) system boundary perspective,[302] Denmark shows a cycling rate that is underpinned by a large degree of uncertainty ranging from **75%** (according to EPA methodology for waste statistics,[303] referred to from here onwards as ‘traditional recycling rate’) to **46%** (according to our methodology).

A non-negligible part of what gets recycled in Denmark belongs to waste streams that are excluded from the EW-MFA system boundaries or that do not fall under the socioeconomic cycling; such as: sludges and liquid wastes (accounted for ecological cycling); animal faeces, urine and manure (accounted for in ecological cycling), waste originating from treatment of waste (secondary waste), soils (do not count as domestic extraction) and dredging spoils (do not count as domestic extraction). These waste streams account for **44%** of the total waste treated and while representing **51%** of all the waste volume being recycled and are the main determinants of the difference between traditional recycling and socioeconomic cycling rates.

The Danish Environmental Protection Agency reported 20.3 million tonnes of waste treated in 2019, of which 8.7 million tonnes were soils and dredging spoils that do not fall within the EW-MFA system boundaries.[304] Under the system boundary definition of this analysis, 11.3 million tonnes is considered as reported waste, while another 4.9 million tonnes is unreported. Most unreported waste is constituted by the recalculated amount of manure (4.4 million tonnes), the remaining (0.5 million tonnes) being short-lived material use of crop residues. Of the 16.2 million tonnes of waste that's treated, 46% is technical cycling of materials (7.4 million tonnes, of which 3.5 million tonnes come from construction and demolition waste), while the remainder is lost indefinitely. Of the remaining 54%, 22% ends up incinerated (including energy recovery), 2% is landfilled, and 30% is lost, composed mainly of waste from energetic use in the form of excreta from human food consumption, which is treated in wastewater treatment plants or spread on land, and is not accounted for explicitly in the Circularity Metric. It is rather included as part of the Ecological cycling potential (see pages 28–29 for more information). This difference explains the gap between the rate of domestically cycled materials (46%), which feeds into the Circularity Metric, and the traditional recycling rate obtained from traditional waste statistics (75%). When it comes to trade in waste, Denmark's situation is underpinned by a negative trade balance in secondary materials: the country is exporting more recyclable waste (1.9–2.4 million tonnes) than it is importing (0.6 - 1 million tonnes), generating an import/export ratio as low as 25%. This, in turn, has a considerably negative effect on the Circularity Metric when a consumption-based perspective is taken, as less waste is re-entering the Danish economy as secondary materials.

End-of-life waste is one element of a larger indicator called Domestic Processed Output (DPO), which can originate from both the material use and energetic use of products. DPO is the total mass of materials that have been used in the Danish economy before flowing into the environment—through landfilled waste or as emissions, for example. DPO from energetic use (including food and feed) stands at 60 million tonnes and is composed mainly of emissions to air, as well as manure and combustion waste. These emissions can stem from biogenic sources (35 million tonnes) as well as fossil fuel origins (25 million tonnes). Together with 9 million tonnes of DPO from material use (end-of-life waste excluding recycled materials), this adds up to a total DPO of 69 million tonnes. A small part (6 million tonnes), which originates mostly from energetic use, but partially also from material use, are so-called dissipative uses and losses: materials that are dispersed into the environment as a deliberate or unavoidable consequence of product use. This includes fertilisers and manure spread on fields or salt.

APPENDIX E: NOT THE SAME BUT SIMILAR: DIFFERENT COUNTRIES, COMMON NEEDS

Despite clear divergences between countries, suitable circular economy strategies can be developed based on discernible common needs. Based on the two dimensions of Social Progress—indicated by a Human Development Index (HDI) score, determined through life expectancy, access to education and a decent standard of living—and Ecological Footprint, countries fall into three broad profiles:

Build—A low rate of material consumption per capita means *Build* countries currently transgress few planetary boundaries, if any at all. But they are struggling to meet all basic needs, including HDI indicators such as education and healthcare. Country examples: India, Bangladesh, Ethiopia.

Grow—These countries are manufacturing hubs, hosting an expanding industrial sector and leading the way when it comes to building. This rapid industrialisation, as well as a growing middle class, have occurred concurrently with rising living standards. Country examples: China, Brazil, Mexico, Egypt.

Shift—Home to a minority of the global population, material consumption in *Shift* countries is ten times greater than in *Build*. Their extraction of fossil fuels is relatively high, as is their participation in global trade. So despite high HDI scores, which result in comfortable lifestyles, these countries have a way to go in consuming resources in line with the planet's resources. Country examples: United States of America, EU Member States, Gulf nations.

APPENDIX F: HOW WE CLASSIFY SECTORS

We mapped the sectoral classification from the Input-Output table of Statistics Denmark (SIC code) to the Exiobase industry classification. The Exiobase classification of 163 industries, and the aggregation in sectors, is displayed in Table three. Sectors differ from societal needs, as one sector may contribute to multiple societal needs: construction, for example, contributes not only to housing but also to the need for communication by building infrastructure.

SECTORAL AGGREGATION	EXIOBASE INDUSTRY
Agrifood	Cultivation of paddy rice
	Cultivation of wheat
	Cultivation of cereal grains not elsewhere classified (NEC)
	Cultivation of vegetables, fruit, nuts
	Cultivation of oil seeds
	Cultivation of sugarcane, sugar beet
	Cultivation of plant-based fibres
	Cultivation of crops NEC
	Cattle farming
	Pigs farming
	Poultry farming
	Meat animals NEC
	Animal products NEC
	Raw milk
	Wool, silk-worm cocoons

Table three displays the sectoral aggregation used in this report based on Exiobase industrial classifications.

SECTORAL AGGREGATION	EXIOBASE INDUSTRY
Agrifood	Manure treatment (conventional), storage and land application
	Manure treatment (biogas), storage and land application
	Fishing, operating of fish hatcheries and fish farms; service activities incidental to fishing
	Processing of meat cattle
	Processing of meat pigs
	Processing of meat poultry
	Production of meat products NEC
	Processing vegetable oils and fats
	Processing of dairy products
	Processed rice
	Sugar refining
	Processing of food products NEC
	Manufacture of beverages
	Manufacture of fish products
Construction	Construction
	Re-processing of secondary construction material into aggregates
	Real estate activities

Table three displays the sectoral aggregation used in this report based on Exiobase industrial classifications.

SECTORAL AGGREGATION	EXIOBASE INDUSTRY
Electricity and gas	Production of electricity by coal
	Production of electricity by gas
	Production of electricity by nuclear
	Production of electricity by hydro
	Production of electricity by wind
	Production of electricity by petroleum and other oil derivatives
	Production of electricity by biomass and waste
	Production of electricity by solar photovoltaic
	Production of electricity by solar thermal
	Production of electricity by tide, wave, ocean
	Production of electricity by geothermal
	Production of electricity NEC
	Transmission of electricity
	Distribution and trade of electricity
	Manufacture of gas; distribution of gaseous fuels through mains
Healthcare, education and recreation	Education
	Health and social work
	Activities of membership organisation NEC
	Recreational, cultural and sporting activities

SECTORAL AGGREGATION	EXIOBASE INDUSTRY
Manufacturing	Manufacture of tobacco products
	Manufacture of textiles
	Manufacture of wearing apparel; dressing and dyeing of fur
	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	Re-processing of secondary wood material into new wood material
	Pulp
	Re-processing of secondary paper into new pulp
	Paper
	Publishing, printing and reproduction of recorded media
	Manufacture of coke oven products
	Processing of nuclear fuel
	Plastics, basic
	Re-processing of secondary plastic into new plastic
	N fertiliser
	P and other fertiliser
	Chemicals NEC

Table three displays the sectoral aggregation used in this report based on Exiobase industrial classifications.

SECTORAL AGGREGATION	EXIOBASE INDUSTRY
Manufacturing	Manufacture of rubber and plastic products
	Manufacture of glass and glass products
	Re-processing of secondary glass into new glass
	Manufacture of ceramic goods
	Manufacture of bricks, tiles and construction products, in baked clay
	Manufacture of cement, lime and plaster
	Re-processing of ash into clinker
	Manufacture of other non-metallic mineral products NEC
	Manufacture of basic iron and steel and of ferro-alloys and first products thereof
	Re-processing of secondary steel into new steel
	Precious metals production
	Re-processing of secondary precious metals into new precious metals
	Aluminium production
	Re-processing of secondary aluminium into new aluminium
	Lead, zinc and tin production
	Re-processing of secondary lead into new lead, zinc and tin
	Copper production
	Re-processing of secondary copper into new copper
	Other non-ferrous metal production

SECTORAL AGGREGATION	EXIOBASE INDUSTRY
Manufacturing	Re-processing of secondary other non-ferrous metals into new other non-ferrous metals
	Casting of metals
	Manufacture of fabricated metal products, except machinery and equipment
	Manufacture of machinery and equipment NEC
	Manufacture of office machinery and computers
	Manufacture of electrical machinery and apparatus NEC
	Manufacture of radio, television and communication equipment and apparatus
	Manufacture of medical, precision and optical instruments, watches and clocks
	Manufacture of motor vehicles, trailers and semi-trailers
	Manufacture of other transport equipment
	Manufacture of furniture; manufacturing NEC
	Recycling of waste and scrap
	Recycling of bottles by direct reuse
Mining and extraction	Forestry, logging and related service activities
	Mining of coal and lignite; extraction of peat
	Extraction of crude petroleum and services related to crude oil extraction, excluding surveying
	Extraction of natural gas and services related to natural gas extraction, excluding surveying

Table three displays the sectoral aggregation used in this report based on Exiobase industrial classifications.

SECTORAL AGGREGATION	EXIOBASE INDUSTRY
Mining and extraction	Extraction, liquefaction, and regasification of other petroleum and gaseous materials
	Mining of uranium and thorium ores
	Mining of iron ores
	Mining of copper ores and concentrates
	Mining of nickel ores and concentrates
	Mining of aluminium ores and concentrates
	Mining of precious metal ores and concentrates
	Mining of lead, zinc and tin ores and concentrates
	Mining of other non-ferrous metal ores and concentrates
	Quarrying of stone
	Quarrying of sand and clay
	Mining of chemical and fertiliser minerals, production of salt, other mining and quarrying NEC
Mobility	Transport via railways
	Other land transport
	Transport via pipelines
	Sea and coastal water transport
	Inland water transport
	Air transport
	Supporting and auxiliary transport activities; activities of travel agencies

SECTORAL AGGREGATION	EXIOBASE INDUSTRY
Other services	Hotels and restaurants
	Post and telecommunications
	Financial intermediation, except insurance and pension funding
	Insurance and pension funding, except compulsory social security
	Activities auxiliary to financial intermediation
	Renting of machinery and equipment without operator and of personal and household goods
	Computer and related activities
	Research and development
	Other business activities
	Public administration and defence; compulsory social security
	Other service activities
	Private households with employed persons
	Extraterritorial organisations and bodies
Waste	Incineration of waste: Food
	Incineration of waste: Paper
	Incineration of waste: Plastic
	Incineration of waste: Metals and Inert materials
Waste	Incineration of waste: Textiles
	Incineration of waste: Wood
	Incineration of waste: Oil/Hazardous waste
	Biogasification of food waste, including land application
	Biogasification of paper, including land application
	Biogasification of sewage sludge, including land application
	Composting of food waste, including land application
	Composting of paper and wood, including land application
	Wastewater treatment, food
	Wastewater treatment, other
	Landfill of waste: Food
	Landfill of waste: Paper
	Landfill of waste: Plastic
	Landfill of waste: Inert/metal/hazardous
	Landfill of waste: Textiles
	Landfill of waste: Wood
	Steam and hot water supply
	Collection, purification and distribution of water

Table three displays the sectoral aggregation used in this report based on Exiobase industrial classifications.

SECTORAL AGGREGATION	EXIOBASE INDUSTRY
Wholesale and retail	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motorcycles parts and accessories
	Retail sale of automotive fuel
	Wholesale trade and commission trade, except of motor vehicles and motorcycles
	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods

Table three displays the sectoral aggregation used in this report based on Exiobase industrial classifications.

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