THE CIRCULARITY GAP REPORT

Poland

Closing the Circularity Gap in Poland

innowo

CIRCLE ECONOMY

Natural State

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.

PACE

This report is published as an affiliate project of the Platform for Accelerating the Circular Economy (PACE). PACE is a global community of leaders, across business, government and civil society, working together to develop a collective agenda and drive ambitious action to accelerate the transition to a circular economy. It was initiated at the World Economic Forum and is currently hosted by the World Resources Institute.

BEHIND THE COVER

Tuchola National Park.

Poland

Natural State

Natural State is a strategy agency specialising in placemaking and sustainable economics. It was founded as a new market approach in 2017, accumulating more than 20 years of experience in project development and realisation. The Natural State method is about thoughtfulness and holistic value creation, combining traditional business development with Nordic societal-oriented and Japanese nature-oriented business cultures. It is designed to help you develop and realise ideas for a future-oriented and aware market. Today, Natural State operates as a small group of purpose-driven strategists with expertise ranging from operations and economics to place building and branding. In addition to developing self-initiated projects, we work with both the public and private sectors—locally and globally.

Nordic Circular Hotspot

The Nordic Circular Hotspot is a market transitional partner that works on changing the Nordic market from linear and unsustainable to circular and sustainable by 2030—value chain by value chain, across all the segments and sectors of the Nordic region.

Iceland Liechtenstein Norway grants | Norway grants

This project is made possible by the support from the EEA and Norway Grants. The EEA and Norway Grants are funded by Iceland, Liechtenstein and Norway. The Grants have two goals: to contribute to a more equal Europe, both socially and economically, and to strengthen the relations between Iceland, Liechtenstein and Norway, and the 15 Beneficiary States in Europe.

INNOWO

The Institute of Innovation and Responsible Development Innowo is a non-governmental organisation and think-to-do-tank, established to support the development of innovation and the implementation of systemic changes for the purpose of sustainable socioeconomic progress. Innowo is cooperating with various stakeholder groups such as scientists, government administration, decision-makers, businesses and other NGOs in order to initiate joint actions to improve the environment and society. It combines interdisciplinary knowledge with expertise at the local and international level, which allows it to achieve a broader perspective and conduct effective, coordinated activities.

POLISH CIRCULAR HOTSPOT

To more boldly and widely promote circular concepts, Polish Circular Hotspot combines the potential and resources of various Polish stakeholder groups—state administration, local governments, businesses and science—under one name. Together, it works to support innovative, comprehensive, practical and scalable solutions in all sectors of the economy. It calls for cross-sectoral and supra-regional cooperation, as well as for cooperation in administration and business, thus ensuring greater efficiency of the undertaken activities.

IN SUPPORT *OF THE CIRCULARITY GAP REPORT POLAND*

KLAS CULLBRAND
Innovation Manager and Acting Programme Director at RE:Source

'I am excited to see Poland scoring above the global average—but it is important to understand that the global average is not the goal. We all need to do much better than that. Polish decision makers now have the opportunity to use this report to help prioritise and execute real life actions.'

ELIN BERGMAN
co-founder of the Nordic Circular Hotspot, COO and spokesperson of the Swedish circular economy network Cradlenet

'The current unfortunate global situation regarding rising food-, material- and energy prices are making circular solutions more attractive than ever, and are speeding up the circular transition. This report provides helpful insights about the quantity—and value—of materials that are circulated back into the economy.'

LADEJA GODINA KOŠIR
Founder & Executive Director at Circular Change and Co-Chair at the European Circular Economy Stakeholder Platform Coordination Group

'I am deeply touched by the true collaboration among three outstanding circular economy entities from three countries joining forces: they are walking the talk! Not only to analyse Poland's circularity but much more—to empower stakeholders to explore synergies and move towards circularity faster than they could on their own.'

FREEK VAN EIJK
Managing Director at Holland Circular Hotspot and Co-chair European Circular Economy Stakeholder Platform

'Poland is a powerhouse in Central Europe. I applaud this first *Circularity Gap Report* for measuring circularity—as this is the first step towards managing it. Poland and Central Europe are key to realising the Green Deal objective of transforming Europe into a modern, resource-efficient and competitive economy—and circular economy approaches show how.'

ROBERT CHCIUK
Director at the Waste Management Department, Ministry of Climate and Environment

'Poland has been implementing measures to increase preparation for reuse and recycling, contributing to growth in circularity. As shown in this report, Poland has a good chance to become a circular economy leader—but much work remains to be done. This report should be widely distributed because it shows the challenges for circularity in a very broad spectrum, embracing both the social and economic aspects of circularity.'

MONIKA DMITRZAK
Coordinator at Pomeranian Development Agency

'The *Circularity Gap Report* is an important signpost for the circular economy. It gives us a deeper understanding of our current position—and the potential ahead of us. The shift we are aiming for will require collaboration across industries, and creates new opportunities for small and medium enterprises to innovate, grow and co-create with other companies. This report shows us how we could change our linear approach, and can inspire businesses to take concrete action.'

HANNA GILL-PIĄTEK
Member of Parliament, Chair at Polska 2050 Parliamentary Group, Chair at Urban Intergroup

'As Chair of the Urban Intergroup in the Polish Parliament, I believe Polish cities may take a leading role in the shift towards more circularity in our economy. I am convinced the findings of the *Circularity Gap Report* and the proposed scenarios will be present in the discussion among policy-makers. If we don't bridge the enormous Circularity Gap in sectors like waste management, construction, mobility and food production, we will not be able to secure a good quality life for our citizens.'

SIREN KNUDSEN
Director of Office and Internal Processes at Puro Hotels

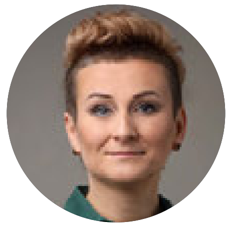
'The launch of the *Circularity Gap Report Poland* is a great initiative that shines a light on the importance of waste management and the acceleration of circular activities. It also improves understanding for all stakeholders, showing how they can contribute to closing economic loops and reducing the carbon footprint. We must work towards a more resilient economy—and this can be achieved if businesses, government, civil society and individuals collaborate for a more sustainable future.'

PROF. MAŁGORZATA KOSZEWSKA
Lodz University of Technology

'The transition to a circular economy is more important in Poland now than ever before. Raw material shortages and disrupted supply chains are just two examples that clearly show the need to leave the linear model behind. The *Circularity Gap Report* shows where we are at the moment, and where we need to go, highlighting barriers and opportunities for Poland's circular transition. The great advantage of this report is that it was prepared and discussed in collaboration with experts from many different fields, helping shape solutions from different angles.'

IN SUPPORT *OF THE CIRCULARITY GAP REPORT POLAND*

ALICJA KUCZERA
Managing Director at the Polish Green Building Council



‘The circular transition requires changes on many levels: from legislation that enables circular activities, through the creation of new business models, to shifts in the daily habits of each resident. These changes will not be possible without specific data showing how a given country or sector is currently performing. The *Circularity Gap Report Poland* perfectly fulfils this task, both highlighting our degree of circularity and identifying key activities necessary for a true circular transformation.'

PROF. JOANNA KULCZYCKA
Mineral and Energy Economy Research Institute—Polish Academy of Sciences

‘Thanks to the *Circularity Gap Report* we can use the Circularity Metric, among other insights, to compare the Polish economy with the global average and other countries that have undergone the analysis. We could also look into the possibilities for gaining a competitive advantage through circular concepts and the implementation of circular business models.'

ANDRZEJ ŁAZĘCKI
Director of the Municipal and Climate Department at Krakow City Office

‘Our planet has limited resources—we can’t continue to develop based on resource extraction and exploitation. We need circular solutions, greater respect for resources, and to use available environmental assets. The City of Krakow implements ambitious climate goals, and the circular economy is an important part of our climate strategy. The *Circularity Gap Report* significantly broadens our knowledge and understanding of both challenges and opportunities.'

PIOTR MIECZKOWSKI
Managing Director at the Digital Poland Foundation

‘There are clear conclusions from many years of representative research: Poles agree that the lack of care for sustainable development, climate change, increasing environmental pollution and increasing problems with waste management are among the leading challenges facing Poland today. This is why I am glad that reports such as the *Circularity Gap Report Poland* are being released—and I believe that it’s urgent to accelerate joint efforts to implement the experts' recommendations.'

PROF. BOLESLAW ROK
Kozminski University, Climate Leadership Programme Co-Funder

‘Going circular is the best way to shape a sustainable world. There is a clear link between closing the loop and climate change mitigation. This report makes us aware that applying circular strategies can cut resource consumption and optimise the structure of material cycles at the micro-, meso- and macro-level. It is widely recognised as a highly effective means for reducing greenhouse gas emissions and environmental pollution—implementing circular strategies is essential for managing climate change issues, the most important challenge of our time.'

PROF. EWELINA SZCZECH-PIETKIEWICZ
Warsaw School of Economics

‘Circularity is not just crucial for sustainability—it is also essential for economic resilience. The *Circularity Gap Report Poland* highlights this alongside its quantitative methodology for calculating circularity and the potential impact of circular scenarios. The report thoroughly analyses changes in Polish material consumption, highlighting opportunities as well as future threats. It places importance on the local conditions and contexts, but also builds upon universal observations of changing business models, showcasing the potential that the circular economy holds.'

PIOTR WOŁEJKO
Socioeconomic Expert at the Federation of Polish Entrepreneurs

‘The circular economy is gaining attention not only due to the increasing awareness of environmental issues, but also as a business mechanism. Currently, in this era of energy crises and turbulence in supply chains and logistics, the potential to recover and reuse materials is also being recognised as a crucial element for achieving economic security and resilience. Entrepreneurs should review their businesses in terms of closing the loop, and the government should support such steps through sound regulation.'

EXECUTIVE SUMMARY

Poland is 10.2% circular—leaving a Circularity Gap of 89.8%. This 'Gap' highlights the extent of Poland's virgin material use: of all the materials flowing through its economy—from metal ores and non-metallic minerals to biomass and fossil fuels—only one-tenth come from secondary sources. The country consumes a total of 613.4 million tonnes of materials per year, with virgin material consumption ringing in at 517.9 million tonnes—or 13.8 tonnes per person, per year. This figure is moderate compared to other European countries: Norwegian residents, for example, consume 44 tonnes per person per year on average.[1] However, Poland's material footprint still tops the global average of 11.9 tonnes per person per year, which is already well-exceeding planetary boundaries. Our current global rate of consumption requires 1.75 Earths to sustain[2]—so even Poland's 'moderate' material footprint leaves much room for improvement. What's more: at 16.7 tonnes per capita per year, the country's domestic extraction rate significantly tops the EU average (10.3 tonnes per capita), owing to its dominant coal industry and production of non-metallic minerals. While these high rates of consumption and extraction are common amongst high-income European nations, it also calls for an approach that goes beyond simply cycling, and provides broader environmental, social and economic benefits. To this end, this report presents means for cutting Poland's excess material use while also boosting its circularity—a means to provide a high-quality lifestyle to all residents without surpassing planetary boundaries.

The material footprint behind Poland's resource use. This report analyses how four resource groups—metal ores, non-metallic minerals, biomass and fossil fuels—are extracted, produced and processed to meet Poland's societal needs such as Housing, Nutrition and Mobility. Its virgin material consumption of 517.9 million tonnes is relatively proportionate to its population: Poland houses 0.49% of the world's people, and represents 0.56% of the global material footprint. This differs notably from other European countries, in which this disparity is far larger. However, consumption and extraction remain relatively high: the country extracts 329.3 million tonnes of non-metallic minerals (representing around 53% of extraction), 142 million tonnes of biomass (23%), 123.3 million tonnes of fossil fuels (20%), and 31.4 million tonnes of metal ores (5%). Fossil fuel extraction is almost entirely dominated by hard coal and lignite—a form of low-grade, brown coal—which is almost all consumed within Poland's borders to generate energy. The country is also heavily dependent on other fossil fuels, such as oil and gas, which have largely been imported from Russia.

A heavy carbon footprint overtakes the moderate material footprint. The high share of fossil fuels in the country's consumption and extraction is cause for concern. Poland lags behind other EU countries in the realm of decarbonisation: it consumes the most hard coal in the EU and comes second only to Germany for the consumption of brown coal,[3] in spite of a sharp decline in coal use across other EU countries over the past decades.[4] EU-wide targets for leaving fossil fuels behind are out of reach for Poland, which will likely require an intermediary shift to oil and gas while scaling up its capacity for renewable energy generation. The country's heavy fossil fuel use contributes to a hefty greenhouse gas emissions profile within territorial borders: Poland's territorial emissions top its consumption-based carbon footprint by 4%. This is a stark contrast to other European nations, whose consumption-based emissions tend to far exceed their territorial ones—by 63% in Sweden, for example. While other European nations are importing vast amounts of carbon embodied in goods produced elsewhere, for Poland, this is far less the case. This will serve the country on its journey to a lower-carbon and resource light economy: Poland has the opportunity to take charge of its own impact, as it's relatively more straightforward to improve the sustainability of domestic activities than controlling the circularity of imports from abroad.

The agrifood and construction sectors are key contributors to Poland's material footprint. Of all biomass extraction, around 82% is represented by crop (food and feed) and livestock production, with forestry playing a smaller role. Agriculture and food processing claim a large portion of the material footprint: 114 million tonnes, or 26%, mostly from the processing of general food products, cattle meat and dairy. Meeting the country's need for nutrition is resource-intensive and represents a substantial share of the carbon footprint (8% of total emissions in 2017), especially due to meat and dairy's prevalence combined with heavy synthetic fertiliser use. Employment in agriculture is high, surpassing other EU countries by far: the sector claims nearly one-tenth of Poland's labour force, comprising plenty of small, fragmented holdings that cover nearly half of its territory. Poland's construction sector presents a similar profile: it consumes vast quantities of materials, energy and water, demanding 228.6 million tonnes of materials yearly within the country (37% of the total material footprint)—and a high prevalence of largely-inefficient older buildings means higher energy consumption, too. This is set to increase: with a relatively high rate of stock additions (35.2%), Poland's construction sector is undergoing steady growth. Going forward, circular strategies will be of particular importance in the agrifood and construction sectors to cut material use, conserve energy, bolster efficiency and improve end-of-life cycling.

Opening up the Circularity Gap. It's easy to put forward a single-figure measurement for circularity tied to a division of good and bad: Poland's material use is 10.2% circular, which is good, while 89.8% is not, which is bad. This isn't the case. Poland's Metric, for example, in part exceeds those of other European countries for which *Circularity Gap Reports* have been conducted due to very high rates of backfilling: a practice that is not fully supported within a circular economy as the value of materials isn't maintained to a high extent. On the other hand, many of the materials not being cycled aren't automatically 'wasted': 35.2%, as noted, are locked into stock in the form of buildings and infrastructure that will serve residents for many decades before being available for cycling. Another 13.8% of Poland's consumption is represented by renewable biomass that has potential for cycling: the country exhibits good ecological cycling potential due to relatively low emissions from Land Use and Land Cover Change. However, inherently non-circular flows—such as fossil fuel combustion—and non-renewable inputs represent 18.7% and 20.7%, respectively, while non-renewable biomass—biomass that is not carbon neutral—represents around 1.4%. These three indicators claim nearly 41%, showing that Poland still has a long way to go to become more circular: reducing this 41% will be just as important as increasing the Metric, as will ensuring that materials locked into stock are designed with circular principles—like longevity, repairability and cyclability—in mind.

A set of circular strategies to narrow the Circularity Gap in Poland. To bridge Poland's Circularity Gap, this report explores six 'what-if' scenarios that apply various strategies to strengthen circularity, slash material use and emissions, and transform the Polish economy. These are 1) Build a circular built environment, 2) Nurture a circular food system, 3) Rethink mobility, 4) Champion circular manufacturing, 5) Keep goods like new for longer and 6) Power Poland with clean energy. Individually, some scenarios were shown to have a greater impact than others, namely those for construction, agrifood and energy. Combined, however, their effect could be revolutionary: they could nearly double the Metric, bringing it up to 19.9%, while cutting the material and carbon footprints by 40.4% and 49.1%, respectively. Other potential co-benefits are numerous: from bolstered supply chain resilience against disruptions and volatility, for example, to less polluted, cleaner cities, to improved health for its residents.

Moving forward, collaboration will be key: Poland can look to learn from its Northern neighbour Norway. Our current linear world is hyper-global—but a circular economy will require narrowing our focus to the local and national level. But no single country can act alone: knowledge transfer and collaboration among nations will be crucial in accelerating the transition. For the first time, this *Circularity Gap Report* explores opportunities for increased circular collaboration between two countries: Poland and Norway. The two countries have very different demographic profiles and consumption patterns: Norway's per capita material consumption sits at 44.3 tonnes, more than triple that of Poland's, for example. Their most material-intensive sectors, however, are broadly aligned—and by building on insights from the analysis of Housing, Mobility, Agrifood, Consumer goods and Energy, we unveil opportunities, challenges and enablers for each. Exploring synergies—or highlighting where one country may come out ahead—reveals the potential for a two-way exchange for trade, human capital, and knowledge and learning: both countries have much to learn from each other.

Poland's economy is full of potential—but there are limitations to how much we can increase its Circularity Metric. Our six scenarios completely reimagine Poland's way of life, overhauling how residents build, eat, make things and move around—so why does the Metric 'only' climb to 19.9%? Firstly: a fully circular economy isn't technically possible—some materials cannot be cycled indefinitely, for example. 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. However, certain factors—such as the country's territorial emissions surpassing its consumption-based emissions, or the fact that almost all the fossil fuels it produces are consumed domestically—mitigates this effect: Poland has sufficient opportunity to control its own circularity, at least in comparison to other European countries. Finally, it's reasonable to assume that materials will always be needed to some degree to fulfil residents' needs: as long as there's a population to house, for example, there will always be a large chunk of materials locked into stock, therefore preventing them from contributing to the Circularity Metric. Nonetheless, in this case, doubling the Metric brings an even more crucial benefit: cutting the material and emissions footprints by nearly half—a huge metamorphosis for Poland's economy.

A circular economy is a means to an end: a safe and just space for people and the planet. By narrowing its Circularity Gap and ultimately slashing consumption, Poland can relieve environmental pressures, reduce resource depletion and support its citizens. Currently, there is room for both environmental and social improvements: for example, the country's older buildings are largely inefficient insulators, sometimes heated with coal, while energy poverty affects nearly one-fifth of the population and has worsened in recent years.[5] Embracing circular strategies that have been designed with a social impact in mind will be crucial, and could serve to enable a more even distribution of resources while fostering greater resilience to shocks. Co-benefits for health and well-being, communities and job creation are also expected: a circular economy can provide Poland with the tools necessary to shape a country that is ecologically safe and socially just.

The time for transformational change is now. Poland lags behind many EU countries in its climate action—and it's starting its journey from a starkly different point. While other nations must transition from oil and gas to renewables, for example, Poland has the relatively more difficult task of phasing out coal. It's expected that a shift to gas will be a necessary intermediary step—rather than a severe climate transgression, as in other European countries. In light of the shocks brought about by a global pandemic and Russia's invasion of Ukraine, Poland's goals are also deeply tied to its preference for energy self-sufficiency: Russia has historically been its biggest gas supplier, while a new pipeline project will shift this responsibility to Norway. However, in spite of slow efforts to decarbonise, Poland boasts a number of promising ambitions for a more sustainable future: plans for offshore wind development, for example, and a recent Circular Economy Roadmap for industrial production, consumption, bioeconomy and new business models. This *Circularity Gap Report* can serve as a guide for efforts to make Poland's economy more circular, providing metrics and measurements to benchmark and kick start the transition. It provides tangible insights as to where the greatest opportunities for circularity lie and highlights cracks in the Polish economy. By focusing on and fixing these cracks, Poland can strengthen its environmental commitments, work towards crucial climate targets, build self-sufficiency and resilience and provide for its people. The circular economy lights the way.

PODSUMOWANIE

Polska jest cyrkularna w 10,2%, oznacza to że „luka" w cyrkularności naszej gospodarki wynosi aż 89,8%. Ta luka jest świadectwem wykorzystania surowców pierwotnych w Polsce. Ze wszystkich materiałów przepływających przez naszą gospodarkę – od rud metali i minerałów niemetalicznych po biomasę i paliwa kopalne – tylko jedna dziesiąta to surowce wtórne. Kraj zużywa łącznie 613,4 mln ton materiałów rocznie, przy czym zużycie surowców pierwotnych wynosi 517,9 mln ton, czyli 13,8 ton na osobę rocznie. Liczba ta jest umiarkowana w porównaniu z innymi krajami europejskimi, na przykład mieszkańcy Szwecji konsumują średnio 25 ton na osobę rocznie. Jednak ślad materiałowy Polski wciąż jest wyższy niż światowa średnia wynoszącą 11,9 ton na osobę rocznie, która i tak znacznie przekracza możliwości regeneracyjne naszej planety. W 2022 roku dzień, w którym wykorzystaliśmy wszystkie zasoby, jakie Ziemia może zregenerować w ciągu roku wypadał 28 lipca. Oznacza to, że nasz obecny globalny wskaźnik konsumpcji wymaga nie jednej a 1 i ¾ Ziemi. Więc nawet „umiarkowany" ślad materiałowy w Polsce pozostawia wiele do życzenia. Co więcej, ze względu na dominujący przemysł węglowy i produkcję kopalin niemetalicznych, przy 16,7 ton na mieszkańca rocznie, krajowe wydobycie surowców znacznie przewyższa średnią unijną (10,3 ton na mieszkańca). Chociaż te wysokie wskaźniki konsumpcji i wydobycia są powszechne wśród krajów europejskich o wysokich dochodach, ich konsekwencje wymagają zastosowania podejścia wykraczającego poza zwykły recycling, zapewniającego szersze korzyści środowiskowe, społeczne i gospodarcze. W tym celu niniejszy raport przedstawia sposoby na ograniczenie nadmiernego zużycia materiałów w Polsce, a także zwiększenie ich cyrkularności – sposób na zapewnienie wysokiej jakości stylu życia wszystkim mieszkańcom, w granicach stawianych przez poziom zasobów dostępnych na naszej planecie.

Ślad materiałowy wykorzystania zasobów przez Polskę jest zdecydowanie niższy niż wydobycie. Niniejszy raport analizuje, w jaki sposób cztery grupy zasobów — rudy metali, minerały niemetaliczne, biomasa i paliwa kopalne — są wydobywane, produkowane i przetwarzane w celu zaspokojenia potrzeb społecznych Polski, takich jak mieszkalnictwo, wyżywienie i mobilność. Zużycie surowców pierwotnych wynoszące 517,9 mln ton jest stosunkowo proporcjonalne w stosunku do liczby ludności: w Polsce mieszka 0,49% ludności świata, zaś kraj odpowiada za 0,57% światowego śladu materiałowego. Pod tym kątem Polska różni się wyraźnie od innych krajów europejskich, w których ta dysproporcja jest znacznie większa. Jednak zużycie i wydobycie pozostają mimo wszystko stosunkowo wysokie. Kraj wydobywa 329,3 mln ton kopalin niemetalicznych (co stanowi około 53% wydobycia), 142 mln ton biomasy (23%), 123,3 mln ton paliw kopalnych (20%), oraz 31,4 mln ton rud metali (5%). W przypadku wydobycia paliw kopalnych niemal w całości odpowiada za nie węgiel kamienny i brunatny, który prawie w całości jest zużywany na terytorium Polski do produkcji energii. Kraj jest również silnie uzależniony od innych paliw kopalnych, takich jak ropa i gaz, które w dużej mierze są importowane z Rosji.

Wysoki ślad węglowy wykracza poziomem poza umiarkowany ślad materiałowy. Ślad materiałowy Polski jest umiarkowany na tle Europy, ale niepokój musi budzić wysoki udział paliw kopalnych w konsumpcji i wydobyciu kraju. Wobec gwałtownego spadku zużycia węgla w Unii Europejskiej w minionych dekadach Polska pozostaje w tyle za innymi krajami UE w dziedzinie dekarbonizacji. Zużywa najwięcej węgla kamiennego w UE i ustępuje tylko Niemcom pod względem zużycia węgla brunatnego. Ogólnounijne cele dotyczące odchodzenia od paliw kopalnych są obecnie poza zasięgiem Polski, zaś transformacja energetyczna kraju wymaga tymczasowego zwiększonego korzystania z ropy i gazu przy jednoczesnym zwiększeniu zdolności do wytwarzania energii ze źródeł odnawialnych. Wysokie zużycie paliw kopalnych przyczynia się do znacznej emisji gazów cieplarnianych na terytorium Polski: emisje terytorialne przewyższają ślad węglowy liczony na podstawie dóbr konsumowanych w kraju o 4%. Stanowi to wyraźny kontrast w porównaniu z innymi państwami Europy, których emisje powiązane z konsumpcją dóbr znacznie przewyższają emisje terytorialne, przykładowo w przypadku Szwecji aż o 63%. Podczas gdy inne narody europejskie są odpowiedzialne za ogromne ilości gazów cieplarnianych powstających podczas produkcji dóbr poza ich granicami, w przypadku Polski ten efekt jest o wiele mniejszy. Jest to sytuacja o wiele korzystniejsza pod kątem możliwości osiągnięcia niskoemisyjnej i niezależnej zasobowo gospodarki. Polska ma możliwość uzyskania pełniejszej kontroli nad negatywnym oddziaływaniem swojej aktywności gospodarczej, ponieważ stosunkowo prościej jest osiągnąć zrównoważoną działalność w ramach gospodarki krajowej niż kontrolować cyrkularność dóbr importowanych z zagranicy.

Sektory rolno-spożywczy i budowlany mają kluczowe znaczenie dla śladu materiałowego Polski. Około 82% łącznej produkcji biomasy oparte jest o produkcję roślinną (żywność i paszę) i hodowlaną, przy czym leśnictwo odgrywa mniejszą rolę. Rolnictwo i przetwórstwo spożywcze odpowiadają za istotną część śladu materiałowego, tj. 114 milionów ton, czyli 26% łącznego śladu. W największym stopniu odpowiedzialne za niego są przetwórstwo ogólnospożywcze, produkcja wołowiny i nabiału. Zatrudnienie w rolnictwie jest na stosunkowo wysokim poziomie, zdecydowanie przewyższając inne kraje UE. Sektor ten zatrudnia prawie jedną dziesiątą polskiej siły roboczej i składa się przede wszystkim z wielu małych, rozdrobnionych gospodarstw, które obejmują prawie połowę terytorium państwa. Zaspokojenie zapotrzebowania kraju na żywność pochłania znaczne ilości zasobów i odpowiada za istotną część śladu węglowego (8% całkowitych emisji w 2017 r.). Wynika to w szczególności z wysokiej konsumpcji mięsa i nabiału w połączeniu z intensywnym stosowaniem nawozów syntetycznych. Podobny profil ma polski sektor budowlany. Zużywa ogromne ilości materiałów, energii i wody, wymagając 228,6 mln ton materiałów rocznie. Dodatkowo w kraju istnieje istotna przewaga, w dużej mierze nieefektywnych, starszych budynków charakteryzujących się wyższym zużyciem energii. Przy stosunkowo wysokim współczynniku przyrostu zasobów wyłączonych z obiegu gospodarczego (35,2%) i kontynuacji trendu wzrostu wielkości polskiego sektora budowlanego, spodziewany jest dalszy wzrost zapotrzebowania sektora na zasoby. Właśnie sektory rolno-spożywcze i budowlane będą kluczowe dla sukcesu strategii cyrkularnych skutkujących ograniczeniem zużycia materiałów, oszczędnościami energii, zwiększeniem wydajności i poprawą zagospodarowania zasobów na końcu życia produktów.

Interpretacja luki cyrkularnej nie jest prosta. Nietrudno jest zaproponować jednowskaźnikowy pomiar cyrkularności powiązany z pozytywnymi i negatywnymi aspektami badanej gospodarki – cyrkularność Polski wynosi 10,2%, co należy ocenić pozytywnie, a 89,8% surowców pochodzi ze źródeł pierwotnych, co zasługuje na krytykę. Taka prosta ocena nie jest jednak prawidłową interpretacją. Na przykład miernik cyrkularności Polski, ze względu na bardzo wysokie wskaźniki wypełniania wyrobisk, przewyższa miernik dla części innych krajów europejskich, dla których sporządzono analizy cyrkularności. Jednak praktyka wypełniania wyrobisk jest dyskusyjna pod kątem zgodności z koncepcjami cyrkularnymi, ponieważ istotna wartość materiałów jest w tym procesie tracona. Z drugiej strony, wiele materiałów, które nie są zawracane do obiegu gospodarczego, nie jest automatycznie „marnowana". 35,2%, jak już wspomniano, tworzy zasoby w postaci budynków i infrastruktury, które będą służyły mieszkańcom przez wiele dziesięcioleci, zanim ponownie zostaną wykorzystane do tworzenia następnych dóbr. Kolejne 13,8% zużycia w Polsce stanowi odnawialna biomasa, której cyrkularność może być stosunkowo prosto osiągnięta. Potencjał ekologiczny zamykania obiegów biomasy w kraju należy ocenić korzystnie, ze względu na relatywnie niskie emisje wynikające z użytkowania gruntów i zmian w sposobie zagospodarowania terenów. Jednak z natury niecyrkularna aktywność – taka jak spalanie paliw kopalnych i stosowanie nieodnawialnych materiałów w gospodarce stanowią odpowiednio 18,7% i 20,7%, podczas gdy nieodnawialna biomasa – biomasa, która nie jest neutralna pod względem emisji dwutlenku węgla – stanowi około 1,4%. Te trzy wskaźniki łącznie stanowią 41%, wskazując, że przed Polską jest jeszcze długa droga do prawdziwie cyrkularnej gospodarki. Zmniejszenie tego wskaźnika z 41% będzie tak samo ważne, jak podniesienie miernika cyrkularności, ponieważ będzie to wymagało aby dobra tworzące zasoby nie będące obecnie w obiegu gospodarczym, były projektowane z uwzględnieniem celu długowieczności, możliwości naprawy i potencjalnego zawracania ich do obiegów gospodarczych.

Opracowano zestaw strategii cyrkularnych mających na celu zmniejszenie luki w zakresie cyrkularności Polski. W celu wypełnienia luki cyrkularnej w Polsce, niniejszy raport analizuje sześć teoretycznych scenariuszy, które sugerują różnego rodzaju strategie aby osiągnąć pełniejsze wdrożenie koncepcji obiegu zamkniętego, ograniczyć zużycie materiałów i emisje oraz przekształcić polską gospodarkę. Są to: 1) Zamykaj obiegi w budownictwie, 2) Zadbaj o cyrkularne systemy żywności, 3) Przejdź na zrównoważony transport, 4) Postaw na cyrkularną produkcję, 5) Dłużej utrzymuj towary jak nowe i 6) Zasil Polskę czystą energią. Pojedynczo scenariusze mają niewielki wpływ na gospodarkę, ale ich łączny efekt może być rewolucyjny: skutkują podwojeniem wskaźnika cyrkularności, podnosząc go do 19,9%, przy jednoczesnym zmniejszeniu śladu materiałowego i węglowego odpowiednio o 40,4% i 49,1%. Potencjalne dodatkowe korzyści to m.in. zwiększona odporność łańcucha dostaw na zakłócenia (np. spowodowane wojnami), mniej zanieczyszczone miasta, czy lepsze zdrowie mieszkańców.

Kluczowa dla transformacji cyrkularnej będzie współpraca; Polska może uczyć się od swojego północnego sąsiada - Norwegii. Nasz obecna linearna gospodarka jest w dużym stopniu zglobalizowana, ale przejście na model cyrkularny będzie wymagał skupienia aktywności gospodarczej na poziomie lokalnym i krajowym. Jednak żaden kraj nie może działać w pojedynkę: transfer wiedzy i współpraca między narodami będą miały kluczowe znaczenie dla przyspieszenia transformacji cyrkularnej. W związku z tym po raz pierwszy raport na temat luki cyrkularnej bada możliwości zwiększonej współpracy w zakresie zamykania obiegów gospodarczych między dwoma państwami: Polską i Norwegią. Oba kraje mają zdumiewająco różne profile demograficzne i bardzo różne wzorce konsumpcji. Przykładowo konsumpcja materiałów w Norwegii wynosi 44,3 tony na mieszkańca, ponad trzykrotnie więcej niż w przypadku Polski. Jednak sektory o największym śladzie materiałowym są w dużym stopniu zbieżne dla obydwu krajów. Opierając się na spostrzeżeniach z analizy mieszkalnictwa, transportu, artykułów rolno-spożywczych, towarów konsumpcyjnych i energii, odkrywamy potencjał cyrkularny, bariery i czynniki wsparcia dla każdego z tych obszarów. Badanie synergii czy też identyfikacja sektorów o największym potencjale zamykania obiegów gospodarczych, ujawnia ogromne korzyści płynące z dwustronnej wymiany w zakresie handlu, kapitału ludzkiego i wiedzy. Obydwa kraje z pewnością mogą się od siebie wiele nauczyć w zakresie cyrkularności.

Potencjał gospodarki Polski jest wysoki, ale istnieją pewne ograniczenia co do możliwości wzrostu jej wskaźnika cyrkularności. Sugerowane sześć scenariuszy całkowicie zmienia sposób życia w Polsce, rewolucjonizując podejście mieszkańców do budowania, odżywiania się, wytwarzania dóbr i poruszania się. Dlaczego więc wskaźnik wzrasta „tylko" do 19,9%? Po pierwsze, gospodarka w pełni cyrkularna nie jest technicznie możliwa. Przykładowo niektóre materiały nie mogą być przetwarzane w nieskończoność. Po drugie, struktura działalności gospodarczej w naszej wysoce złożonej i zglobalizowanej gospodarce światowej również utrudnia kontrolowanie zamykania obiegów w ramach jednego kraju. W przypadku Polski pewne czynniki, takie jak wyższe emisje mające miejsce na terytorium kraju w porównaniu do emisje implikowanych poziomem konsumpcji lub fakt, że prawie wszystkie produkowane przez nią paliwa kopalne są zużywane w kraju, łagodzą ten efekt. Polska ma stosunkowo wysokie możliwości kontrolowania cyrkularności swojej gospodarki, przynajmniej w porównanie z innymi krajami europejskimi. Wreszcie, rozsądne jest założenie, że surowce wtórne nigdy nie zaspokoją wszystkich potrzeb mieszkańców. Na przykład zawsze część materiałów wykorzystywana w mieszkalnictwie i szerzej w działalności budowlanej będzie wyłączona z obiegu gospodarczego, co uniemożliwi im przyczynianie się do wzrostu wskaźnika cyrkularności. Mimo wszystko w przypadku Polski podwojenie wskaźnika, nie jest celem samym w sobie, lecz przynosi jeszcze ważniejsze korzyści: zmniejszenie śladu materiałowego i węglowego o prawie połowę. Urzeczywistnienie tych celów będzie świadczyło o prawdziwej metamorfozie polskiej gospodarki.

Gospodarka o obiegu zamkniętym to środek do celu jakim jest zapewnienie odpowiednich warunków dla rozwoju ludności, nie naruszając przy tym ograniczeń zasobowych naszej planety. Zmniejszając lukę cyrkularną, a więc również obniżając konsumpcję, Polska zrealizuje chlubne dążenie do łagodzenia presji na środowisko, ograniczania wyczerpywania się zasobów i polepszania stanu tkanki społecznej. Obecnie istnieje znaczące pole do poprawy zarówno w obszarze środowiska naturalnego, jak i obszarze społecznym. Na przykład istotna część starszych budynków w kraju jest w dużej mierze nieefektywnie izolowana, czasami ogrzewana węglem, podczas gdy ubóstwo energetyczne dotyka prawie jednej piątej populacji i uległo pogorszeniu w ostatnich latach. Przyjęcie strategii cyrkularnych, które zostały zaprojektowane z myślą o korzyściach społecznych, będzie kluczowe dla osiągnięcia bardziej równomiernej dystrybucji zasobów przy jednoczesnym uzyskaniu większej odporności na szoki gospodarcze, polityczne i społeczne. Równocześnie spodziewane są korzyści w zakresie zdrowia, dobrobytu, lokalnych społeczności i tworzenia miejsc pracy. Gospodarka obiegu zamkniętego może zapewnić Polsce narzędzia niezbędne do kształtowania sprawiedliwego społecznie kraju niezagrażającemu bezpieczeństwu środowiska naturalnego.

Czas na transformację gospodarczą już nadszedł. Polska pozostaje w tyle za wieloma krajami UE w działaniach na rzecz klimatu. Oprócz tego rozpoczyna swoją podróż z zupełnie innego punktu. Podczas gdy inne narody muszą na przykład zastąpić ropę i gaz odnawialnymi źródłami energii, Polska ma stosunkowo trudniejsze zadanie stopniowego wycofywania węgla. Oznacza to, że zwiększenie znaczenia gazu w polskiej energetyce będzie prawdopodobnie niezbędnym krokiem pośrednim, w obliczu alternatywy jaką jest kontynuowanie aktywności skutkującej ogromnymi szkodami dla klimatu. W świetle szoków wywołanych globalną pandemią i rosyjską inwazją na Ukrainę, cele Polski są również głęboko powiązane z dążeniem do samowystarczalności energetycznej. Rosja była największym dostawcą gazu do kraju, zaś nowe projekty, przykładowo nowy gazociąg na dnie Bałtyku, przesunie ten ciężar na inne kraje, w tym Norwegię. Jednak pomimo opóźnionych wysiłków na rzecz dekarbonizacji Polska może pochwalić się ambitnym podejściem do osiągnięcia celu bardziej zrównoważonej przyszłości. Przykładami takich działań są odważne plany rozwoju morskiej energetyki wiatrowej oraz niedawna Mapa Drogowa Transformacji w Kierunku Gospodarki o Obiegu Zamkniętym mająca znaczenie dla produkcji przemysłowej, konsumpcji, biogospodarki i wdrażania nowych modeli biznesowych. Niniejszy raport na temat luki cyrkularnej może służyć jako przewodnik dla wysiłków na rzecz zamykania obiegów gospodarczych w Polsce, dostarczając wskaźników i analiz, które mogą stanowić punkt odniesienia i zapoczątkować transformację cyrkularną kraju. Raport identyfikuje największe szanse na poprawę cyrkularności kraju i wskazuje na kluczowe mankamenty polskiej gospodarki w tym zakresie. Koncentrując się na słabych stronach i poprawiając je, Polska może łatwiej sprostać rosnącym zobowiązaniom środowiskowym, pracować na rzecz kluczowych celów klimatycznych, budować samowystarczalność i odporność na szoki oraz zapewnić dobrobyt swoim mieszkańcom. Gospodarka o obiegu zamkniętym stanowi narzędzie konieczne do osiągnięcia tych celów.

CONTENTS

GLOSSARY

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 Northern Ireland's 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), similar (recycling) or lower (downcycling) embodied value and/or complexity than it originally was.

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) are 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). [Source]

Greenhouse gases (GHG) refers to a group of gases contributing to global warming and climate breakdown. The term covers seven greenhouse gases divided into two categories. Converting them to **carbon dioxide 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), is the attribution of global material extraction to the domestic final demand of a country. In this sense, the material footprint represents the total volume of materials (in Raw Material Equivalents) embodied within the whole supply chain to meet final demand. The total 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. [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.

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]

Raw Material Consumption (RMC) represents the final domestic use of products in terms of RME. RMC, referred to in this report as the 'material footprint', captures the total amount of raw materials required to produce the goods used by the economy. In other words, the material extraction necessary to enable the final use of products. [Source]

Resources include, for example, land, water, air 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]

Secondary materials are materials that have already been used and recycled. 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. These relate closely to the European sector classification framework NACE Rev. 2.

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. [Source]

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). [Source]

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

1. INTRODUCTION

Our current era has been defined by our globe's dominant linear economy: a system where resources are extracted from the Earth and made into products that largely become waste at the end of their life cycles. This take-make-waste paradigm has caused increasing devastation to the natural world: spiralling emissions and mountains of waste. According to our global *Circularity Gap Report 2020*,[6] the global economy is only 8.6% circular—meaning that more than 90% of the resources we consume come from virgin sources. Meanwhile, our latest Report found that on the road from COP25 in Paris to COP26 in Glasgow, the global economy consumed more than half a trillion tonnes of materials—equaling more than 100 billion tonnes per year, which is almost double that of consumption in 2000.[7] In many parts of the world (and particularly in high-income nations), a culture of consumerism is now the norm, putting intense pressure on ecosystems and climate. Our *Circularity Gap Report* analysis finds that Poland's Circularity Metric is 10.2%—sitting just above the global average. While the nation has made some strides towards a more sustainable future—aiming to add more renewables to its energy mix and increasing recycling efforts, for example—it has a way to go in achieving a truly circular economy. Poland's material footprint measures up at 13.8 tonnes per person per year: a moderately high figure slightly above the global average of 11.9 tonnes. However, the global average still sits far above what's estimated to be a sustainable level of consumption:8 tonnes[8,9] per person per year. In other words: we're demanding far more resources than the world can provide. With a booming construction industry and fruitful agricultural sector, Poland's consumption isn't set to decrease unless it incorporates circular economy strategies. Doing so will be crucial, allowing residents to maintain their standard of living, and delivering social benefits within the boundaries of our planet.

From climate change and biodiversity collapse to resource depletion and rising sea levels, the Earth's natural capacity is being pushed to its limits. Nature is essential for human existence and good quality of life. The high quality of life enjoyed in industrialised, high-income nations such as Poland depends entirely on natural resources,[10] from arable land and fish stocks to biodiversity and freshwater reserves. But natural resources are limited and vulnerable. Resource use conveys environmental (and social) consequences: the extraction, transport, processing, use and disposal of materials to satisfy societal needs and wants often leads to permanent environmental damage.[11][12][13] Material use is thus a good proxy for measuring environmental degradation. For example, the extraction and processing of materials, fuels and food contribute half of total global greenhouse gas emissions and over 90% of biodiversity loss and water stress.[14] Within this context, it is crucial to reduce material use to sustainable and fair levels by optimising its transformation into social benefits, especially by high-income nations which are responsible for the bulk of excess material use worldwide.[15]

POLAND'S ECONOMY AND THE RISKS OF LINEARITY

Poland's economy relies heavily on virgin resource extraction and accumulates vast amounts of waste. Like much of the globe, Poland's economy is linear: it is characterised by 'take-make-waste' processes powered by fossil fuels. Although Poland's per capita material footprint is lower than many of its European neighbours, it still exceeds the already high global average. Its dominant extractive industry also counteracts progress made in other areas—and while the EU seeks to ditch coal, a highly carbon-intensive and polluting fossil fuel,[16] Poland is still extracting it at the highest rate in Europe. In satisfying the needs of its population—and the world's through its exports—Poland extracts 16.7 tonnes of resources per capita per year within its borders, rising above the EU and global average of 10.3 and 12.3 tonnes per capita per year, respectively. It also extracts more copper concentrates, silver and helium than any other European country—unsurprising, as the mining and quarrying industry is a significant employer in the Polish economy, giving work to nearly 145,000 people, representing almost 1% of the total workforce in the same year.[17][18] Imports of other fossil fuels are also high: while Poland doesn't produce much oil and gas, it imports it, primarily from Russia. Due to the recent invasion of Ukraine, the EU has recognised a need to shift from Russian gas, and aims to coordinate measures to secure alternative energy supplies.[19][20] To this end, the new Baltic Pipe Project—a pipeline running between Norway, Denmark and Poland—is expected to be fully operational by late 2022: in other words, the import of oil and gas into Poland isn't expected to slow any time soon.

If Poland wants to thoughtfully pursue a circular economy, it must adapt core parts of its economy. All elements of the circular economy must be leveraged to preserve material value at the highest extent possible, eliminate waste and pollution, keep materials in use and regenerate natural systems—shifting towards cleaner energy sources.[21] Poland should consider its economy as one interconnected system to cut resource extraction and optimise consumption.

THE ROAD TO CIRCULARITY

Poland is 10.2% circular: of the 613.4 million tonnes of materials the country consumes, 89.8% are not cycled back into the economy. 328.8 million tonnes are added to long-term stock—like buildings and infrastructure—while a massive 343.8 million tonnes are dissipated into the environment or wasted (see pages 40–41 for more information). But the Circularity Metric only reveals one part of a large and complex picture—circularity isn't limited to secondary material use, and many other critical factors are at play. Poland can be characterised as a country with lower levels of material consumption compared to its European neighbours—at 13.8 tonnes per capita per year, it sits comfortably below the EU average of 17.8 tonnes per capita per year. However, in the global context, where the average material consumption is 11.9 tonnes per capita per year, Poland is exceeding what is already classified as an 'excessive' level of material consumption: our current level of consumption technically requires 1.75 Earths to sustain.[22]

Despite improvements in resource productivity over recent decades, material consumption still continues to rise, counteracting these gains.[23] This may be explained by Poland's strong economic growth that doubled between 2000 and 2020.[24] Material- and emissions-intensive sectors like construction, agriculture and mining account for the majority of the country's material use and waste generation. Current trends—such as a steadily growing rate of consumption and significant infrastructure developments—only indicate that material use, emissions and waste are set to increase, in spite of decreasing population growth. What's more: while the country's cycling rate appears to be relatively high compared to other European countries—such as Sweden, at 3.4%—this is partly due to far-higher-than-average rates of backfilling. The process of refilling excavated holes caused by mining or construction operations (often using waste materials that have been produced through excavation), backfilling plays a debatable role in the circular economy. This high backfilling rate, however, contributes to around one-fifth of the Circularity Metric. This implies significant material value loss—and we should remember that keeping materials in use at the highest value possible is a key component of circularity.

A SOCIAL AND ECONOMIC CROSSROADS

The circular economy is a means to an end for Poland: the end goal being a country where social needs are met, for current and future generations, within the ecological limits of the planet. Social considerations—such as decent employment opportunities and leveraging the skills of the existing workforce—should be front and centre as Poland pursues this aim. With a historically large workforce in the coal mining sector, Poland must carefully consider the effect this has on the workforce as the sector diminishes, ensuring alternative activities and jobs can be made attractive and accessible to both workers and employers. Like many countries, Poland experiences conflicting interests across sectors alongside a deeply entrenched focus on GDP-based economic growth, meaning that strong commitments and a holistic, integrative approach backed by strong collaboration will be needed to steer action. A deeper understanding that current lifestyles, typically marked by high consumption, are unsustainable is also needed—necessitating a mindset shift away from the idea that ownership is better than sharing. Notions of progress must be broadened beyond GDP growth—incorporating social and environmental indicators in the country's definition of prosperity, progress and well-being. While the absolute decoupling of resource use and economic growth is theoretically ideal—it is also unattainable for any country. And although Poland has achieved relative decoupling[25]—its GDP has grown at a higher rate than its material use—efficiency gains won't be enough if they're met by ever-rising extraction and consumption both domestically and abroad. It must, therefore, be recognised that relieving environmental pressures will require that resources are transformed into products that benefit society. Achieving a circular economy will require Poland to reimagine and redesign the way it meets its residents' needs and wants, ensuring the ecologically safe and socially just space it strives for.

AN ECONOMY FULL OF POTENTIAL

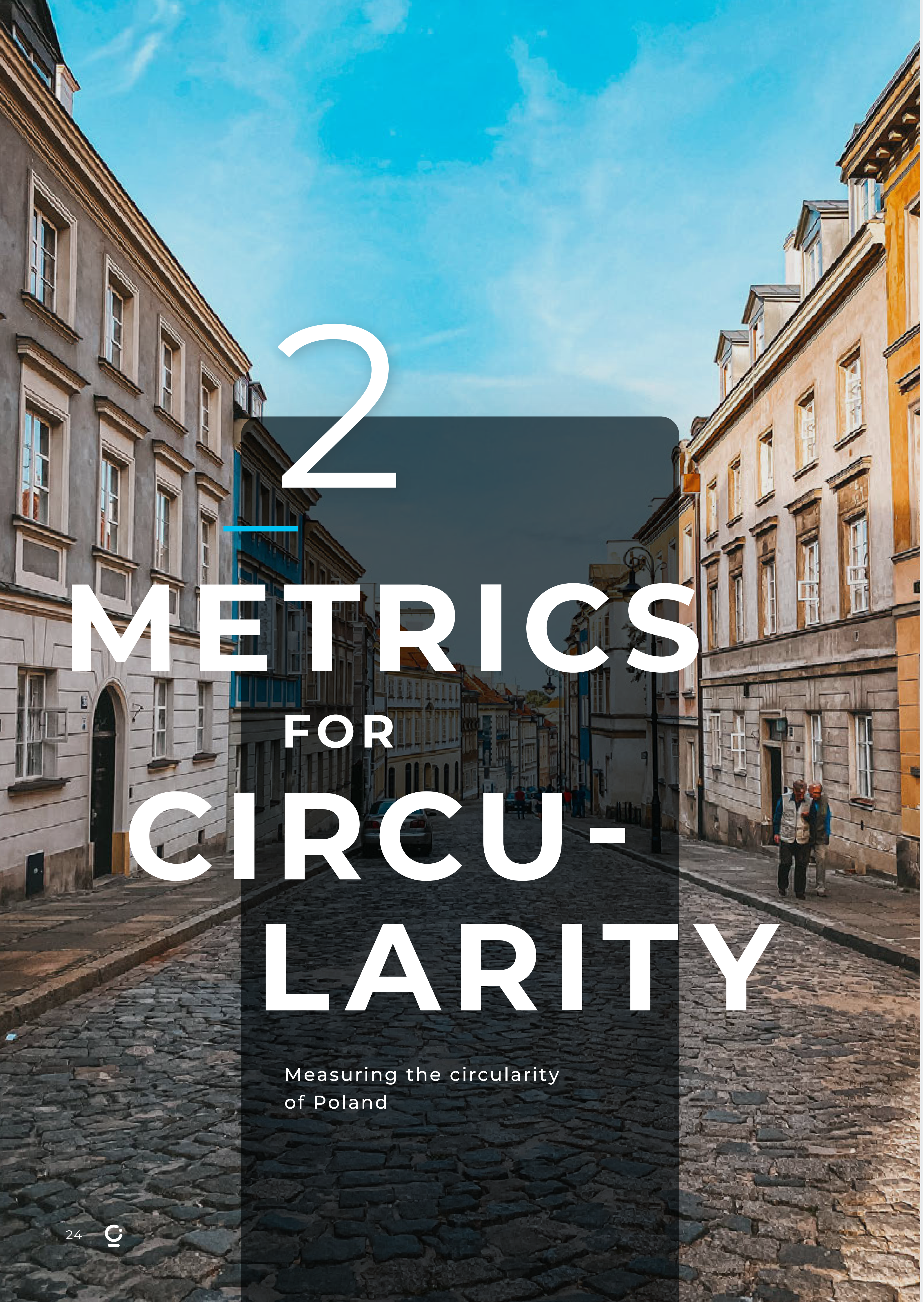
The circular economy is instrumental in achieving global climate goals: the *Circularity Gap Report 2021*[26] reported that 70% of emissions stem from material use and handling—and therefore decreasing consumption and boosting Poland's Circularity Metric through circular strategies will play a part in emissions reduction. Our analysis finds several avenues for boosting Poland's Metric, from nurturing a more circular food system and rethinking the way housing is built and powering the economy with renewable energy. Combined, these strategies hold the power to cut material consumption by 40.4%, bringing it down to 308.7 million tonnes, and slash the carbon footprint (excluding direct emissions) by 49.1%, bringing it down to 174.8 million tonnes. While boosting the Metric from 10.2% to 19.9%.

Poland ranks as the top extracter in the EU for many minerals, fossil fuels and ores[27] and over one-quarter of all waste generated is currently landfilled.[28] The economy is also characterised by its high levels of emissions, owing to its heavy coal use. The country's carbon footprint—a consumption-based measure—sits under its territorial emissions by 4%, showcasing that Poland is less reliant than its neighbours on consuming materials and generating emissions abroad. This provides the country with more control, but also responsibility, to transition away from an extraction-based economy with high domestic emissions. Poland is already taking some steps towards decarbonising its electricity mix, with its solar photovoltaic installations increasing fivefold in just two years, and ambitious plans to build the biggest offshore wind market of countries bordering the Baltic Sea.[29] However, this action isn't sufficiently bold; and a focus on climate change—just one of nine planetary boundaries—isn't enough. Poland's priority should also centre on integrating circularity into its climate strategy to cut its material consumption alongside its carbon footprint, supporting aims beyond emissions reductions, such as more prosperous ecosystems, cleaner air and water, and flourishing biodiversity. Poland's Circular Economy Roadmap provides high-level direction, with specific focus on sustainable industrial production, sustainable consumption, bioeconomy, new business models and the implementation, monitoring and financing of circular initiatives. However, it lacks binding targets with concrete plans moving forward.

The circular economy may provide a means to take control of its excessive waste generation and fossil-fuel based economy—and must become a core building block of Poland's future environmental strategy. Coherent policy, strategic innovation and investment that tackles these issues will be key in realising a country that operates more within planetary boundaries. This report presents six scenarios that can help Poland cut its material footprint by 40.4%, substantially increase its cycling power and bring the country from theory to action: the kind of systemic shift needed to realise a circular economy.

Aims of the *Circularity Gap Report Poland*

1. Provide a snapshot of how circular Poland 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 Poland'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 opportunities for Poland and Norway to collaborate on reducing their material footprints while boosting circularity.
6. Communicate a call to action based on the above analysis, to inform future goal setting and agendas.



2 METRICS FOR CIRCULARITY

Measuring the circularity of Poland

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 to measuring a systemic transition. In the first edition of the global *Circularity Gap Report*, in 2018, Circle Economy launched the Circularity Metric for the global economy. This analysis adapts the Metric to suit a national profile. This section explains how we assessed Poland's circularity and introduces supporting metrics that help us understand the significant material flows that contribute to the country's 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.

MEASURING CIRCULARITY: A MEANS TO AN END

The circular economy is a big picture and holistic idea. Ultimately, it is a means to an end—the end being a socially just and ecologically safe space, where our environment can flourish and people can thrive. Exactly how the circular transition can deliver more beneficial social and environmental outcomes is not a question with just one right answer, however. There is no simple straight-line solution and the feedback loops in the system run in all directions.[30] In particular, three connected spheres need to be taken into account: 1) how resources 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[31] and social systems, which include government institutions, businesses, communities and markets.[32] 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 social outcomes, but at very different levels of material use. This is how the circular economy can transform societies, allowing us to thrive with minimal environmental impact.

In this analysis, we take the socioeconomic metabolism of a country—how resources flow through the economy and are kept in long-term use—as the starting point for measuring and capturing its level of circularity. We also consider the importance of reducing consumption. This is because impact prevention through reduced demand is an important first step to take before exploring other mitigation options—a tenet reflected by a number of environmental management hierarchies wherein reductions of production and consumption, narrowing flows, is always the preferred and most effective strategy.

To ensure our data is in line with the reality of Poland, we worked with the Institute of Innovation and Responsible Development (Innowo), primarily using data from Statistics Poland and Eurostat.

MATERIAL FLOWS AND FOOTPRINTS

Societies consume materials and energy to maintain themselves. Figure one provides a schematic depiction of the socioeconomic metabolism of Poland. It depicts the amounts of materials (clustered into four key resource groups) embodied in the inputs and outputs of highly aggregated industry groups. Due to the level of detail and intricacy of how materials flow through an economy, we are not able to visualise all flows and all sectors. 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 as a result of direct domestic extraction. These are minerals (limestone, copper and lithium, for example), metal ores (iron, cobalt and titanium dioxide, for example), fossil fuels (petroleum, for example) and biomass (food crops and forestry products, for example).

We also see on the left 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. 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 the 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, such as metals from ores, which are manufactured into products in the produce stage. The finished products provide satisfaction to 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.

The end-of-use resources of these products 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.

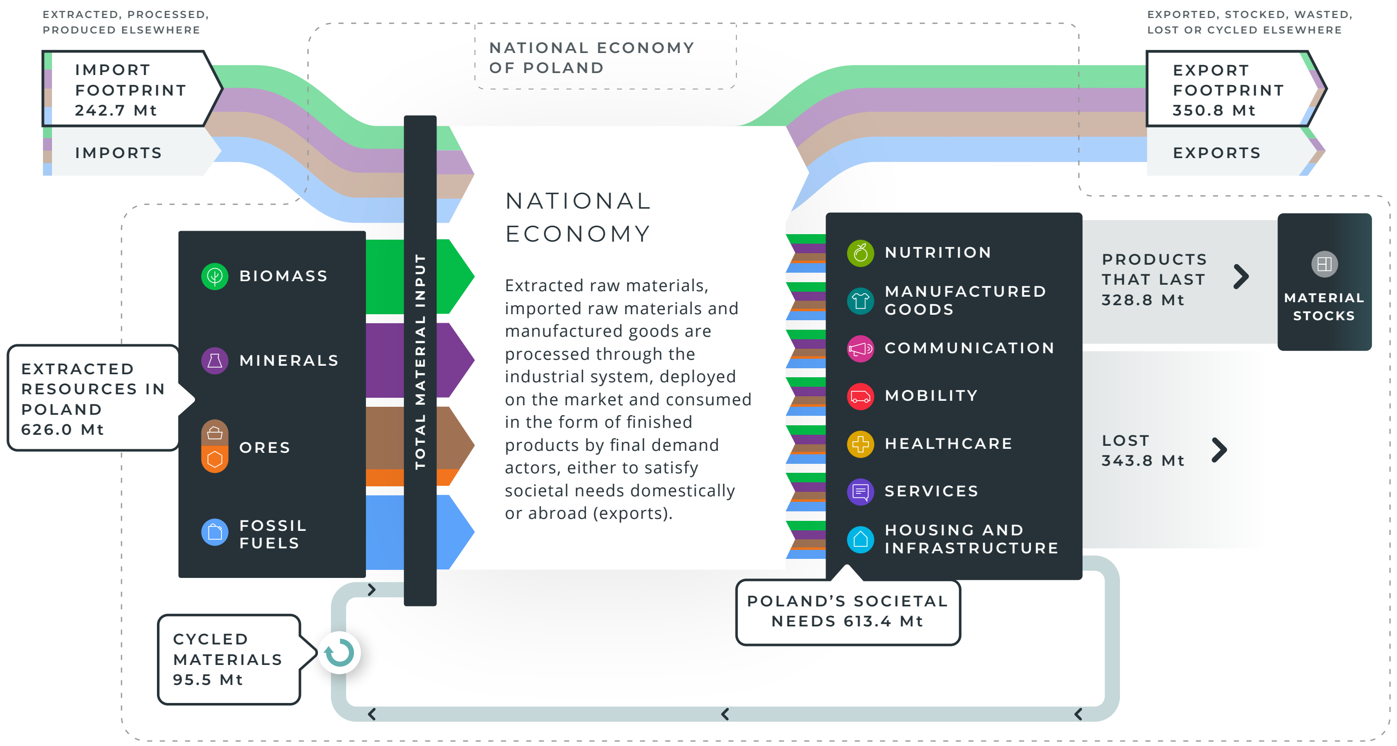


Figure one shows a schematic overview of the material footprint and metabolism of Poland. Note: material stock and cycled material flows are not scaled to proportion.

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—how materials flow through the economy and are used over the long-term—as the starting point. This approach builds on and is inspired by the work of Haas et al.[33] (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).[34]

The core objectives are:

- **Objective one:** Resource extraction from the Earth's crust is minimised and biomass production and extraction are 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 is prevented; and biomass is optimally cascaded.

The four strategies we can use to achieve these objectives 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 through circular design 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, repair, remanufacturing, refurbishing, renovation and remodelling over building new structures.
- **Regenerate flows—make clean:** Fossil fuels, pollutants and toxic materials are replaced with regenerative sources, 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 or 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, recycling.

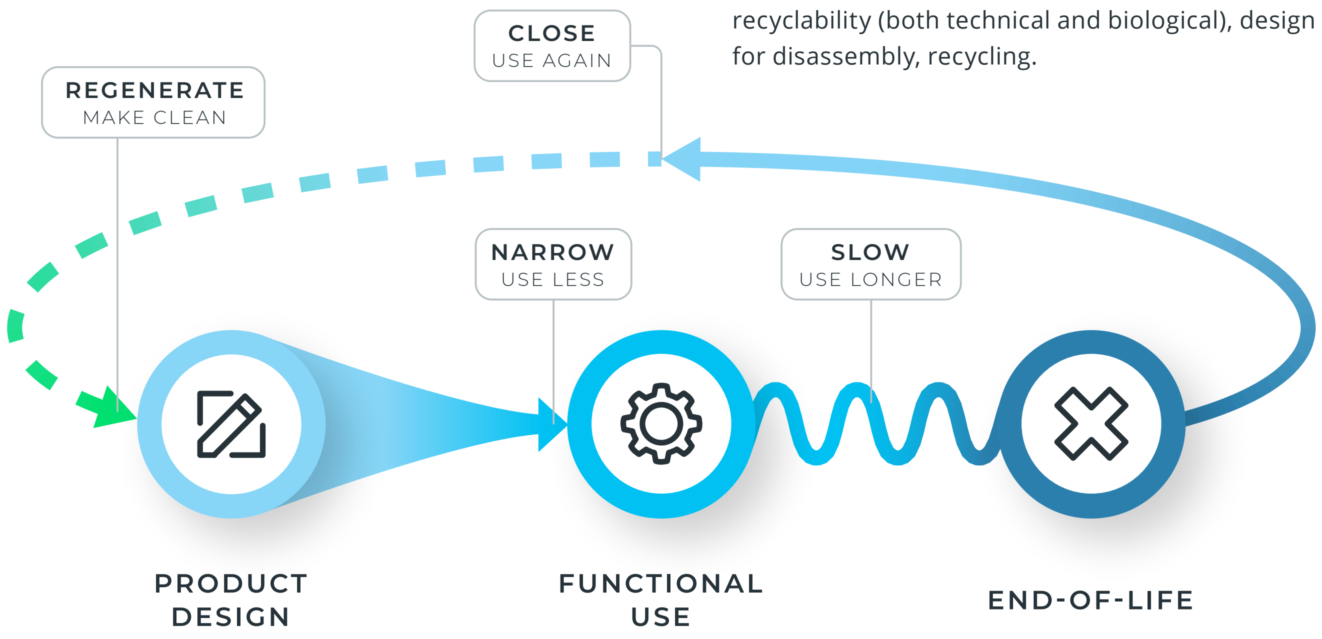


Figure two depicts the four flows to achieve circular objectives: narrow, slow, regenerate and cycle (here labelled 'close').

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, preventing narrowing. Using products for a long time—**slowing** flows—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 shorter lifetimes—making it more difficult to slow flows.

If we effectively deploy strategies focused on **narrowing, slowing, cycling and regenerating** the flow of materials, we may, ultimately, require a lesser amount and variety of materials to provide for similar needs. Because of this, fewer materials will be used by the economy, they will have a longer lifespan, and they can be reused more effectively and with less harm caused to the environment. For our Circularity Metric to capture this crucial process, we measure the share of cycled materials as part of the total material consumption of an economy. As such, it illustrates the current progress towards achieving the circular economy's ultimate goal of designing out waste through the four listed strategies. We capture circularity in one number: the Circularity Metric. It is an 'input-focused' metric. Communicated as a percentage, it 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. It can provide direction as to how Poland 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.

INSIDE THE CIRCULARITY GAP

To accelerate the transition toward a circular economy, we need to use data and data-driven insights in the best way to support top-level decision making. At the same time, given the breadth and scope of a systems change towards a more circular economy, local and bottom-up grassroots initiatives are equally crucial to drive changes forward at the community level. To address the complexities and intricacies of a nation's economy, we aim to provide as much information and context on how individual nations can better manage materials to close their 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 Poland extracting domestically, and is it sustainable? How dependent is Poland on imports to satisfy the basic societal needs of the population? How much material is being added to Poland's stock like buildings and roads every year? These categories are based on the work of Haas et al. (2020).[35]

Socioeconomic cycling rate (10.2%)

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, including recycled materials from both the technical (such as recycled cement and metals) and biological cycles (such as paper and wood). In Poland, this number is above but close to the global average of 8.6%, totalling 10.2% of total material input—although for Poland, around one-fifth of this is due to backfilling, a process with a debatable role in the circular economy.

Ecological cycling potential (13.8%)

Ecological cycling concerns biomass, such as wood, manure, food crops or agricultural products that are lost as waste or emissions. 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. Because detailed data on the sustainability of primary biomass is not available, the estimation of the ecological cycling potential needs to rely on a broader approach: if the amount of elemental carbon from Land Use and Land Cover Change (LULCC)[36] emissions is at least the same as the carbon content of primary biomass in the total consumption of an economy, then all the consumed biomass can be considered carbon neutral. Poland exhibits a good ecological cycling potential due to the relatively low LULCC emissions.

Non-renewable biomass inputs (1.4% in Poland)

This metric indicates a biomass input rate that is not carbon neutral. As long as LULCC emissions are positive, there is going to be a share of biomass that is not carbon neutral: this indicates that the CO2 emissions from biomass use and waste are larger than the CO2 embedded in the biomass products consumed (CO2 embedded in biomass in Domestic Material Consumption). For Poland, this figure represents 1.4% of the total material footprint.

Non-circular flows (18.7% in Poland)

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 18.7%, Poland's rate of non-circular inputs is high, suggesting a fossil-fuel dependent character of the Polish economy, especially sectors such as transport, electricity and heating.

Non-renewable inputs (20.7% in Poland)

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. Poland's non-renewable input rate stands at a relatively high 20.7%, suggesting that there is ample room for the

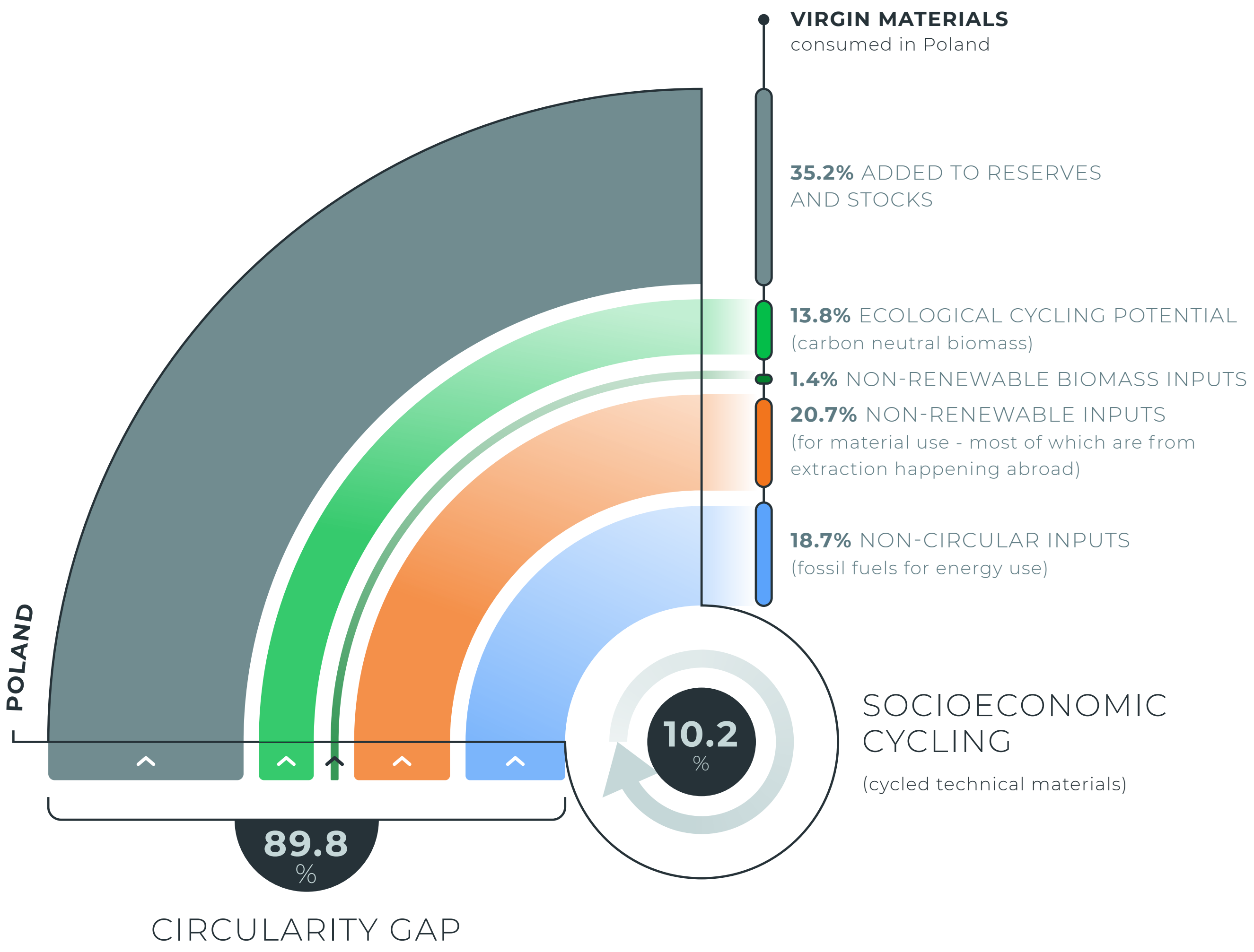


Figure three shows the full picture of circular and non-circular materials that make up Poland's Circularity Gap.

improved cycling of non-renewable materials such as metals, glass, plastics and packaging, textiles, and electronics.

Net additions to stock (35.2% in Poland)

The vast majority of materials that are 'added' to the reserves of an economy are 'net additions to stock'. Countries are continually investing in new buildings and infrastructure, such as to provide Housing, as well as for renewable energy, such as building wind turbines. 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 over 35%, Net additions to stock in Poland are relatively high, suggesting high growth of the building stock (residential, commercial and infrastructure). This can be explained by a decrease in average household size in recent years (number of people per dwelling), and the need to upgrade infrastructure.

IF CONTINUED STOCK BUILD UP IS INEVITABLE—SHOULD IT BE CONSIDERED PART OF THE 'GAP'?

Stock build-up will continue to be necessary as Poland's population demographics change— more and more residents are looking to rent or own bigger homes, for example— and as the need for infrastructure is increasing. However, the rate of stock build-up is also relatively large due to a range of interlinked social, cultural and demographic factors. Yet,the country's high stocking rate may not be inherently problematic, especially if circularity is afforded attention in the design, use and end-of-life phases. For this reason, it may be argued that Net additions to stocks should not be considered part of the Circularity Gap. If all the materials locked into stock were not considered as part of the full indicator set, the Circularity Metric would increase substantially. So why don't we do this?

The Circularity Metric is ultimately a measure of what is cycled—not just what is circular—and materials added to stock can't be cycled for many years, potentially decades, if not more. What's more, the circularity of materials added to stock cannot be ensured: it is not always clear which portion of these materials are designed and used with cycling in mind or to what extent they are regenerative and non-toxic, for example. The bottom line is that: the built environment consumes a huge volume of resources: its impact on Poland's overall consumption should not be ignored, especially given crucial resource depletion concerns. The role of circular strategies in decreasing material consumption—and Net additions to stock on the whole—is critical.

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

While carbon neutrality is a necessary condition for biomass to be considered sustainable—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. To this end, in line with past *Circularity Gap Reports*, we have excluded ecological cycling in our calculation of Poland's Circularity Metric, even though this could potentially boost the country's circularity rate to 24%. For all nations, we take a precautionary stance with its exclusion, with the knowledge that its impact on the Metric may not be accurate. For example, we cannot track biomass extracted in Poland to its final end-of-life stage, so it isn't easy to ensure that the nutrient cycle has closed. If this were the case, however— and sustainable biomass management becomes the norm—circularity could significantly increase.

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 our metric, resulting in certain methodological choices.[37]

In a bid to generate actionable insights for the economy and consumption on the ground, and to enable comparison between countries, our *Circularity Gap Reports* take a consumption perspective: we consider only the materials that are consumed domestically. However, there are some limitations to our approach: the more 'open' an economy is the more susceptible to the limitations of both the material flow analysis and input-output analysis, the latter in particular. Some of these limitations include difficulties in calculating the import content of exports.

Secondly, most production is ultimately driven by the demand of consumers for a certain product or service. 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 re-allocation 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, at helping consumers understand the material implications of their choices, or at 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.

So, why is it imperative to reduce consumption? Global resource extraction has exploded during the past fifty years, more than tripling from 27 billion tonnes in 1970 to 92 billion tonnes in 2017.[38] The use of biomass, fossil fuels, metal ores and non-metallic minerals doubled between 2005 and 2015, increasing from 26.3 billion tonnes to 46.4 billion tonnes.[39] While increased resource use has fuelled economic development, this has come at a tremendous environmental cost, pushing the Earth system beyond a safe operating space, ultimately threatening human wellbeing.[40] Bringing socioeconomic systems within planetary boundaries requires a deliberate downscale of global resource throughput (i.e. material and energy use), especially by high-income nations.[41] Keeping (global) resource use within sustainable levels requires cutting excess consumption and focusing on delivering human needs that contribute to improving well being within a safe and just operating space for humanity, from an efficiency and equity perspective. Impact prevention through reduction in demand is an important first step before exploring other mitigation options. This is reflected also by environmental management hierarchies (for example, the waste hierarchy established in the EU Waste Framework Directive[42]), wherein reduction of production and consumption is always the preferred and most effective strategy.

Thirdly, when considering what Polish residents 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. To account for the material footprint of raw materials is straightforward, but this is not the case with semi-finished and finished goods. 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. To represent actual material footprints in imports and exports, we apply so-called RME coefficients in this study. As an open, high-income economy with trade equal to 118% of its GDP (2021),[43] doing so in the case of Poland 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. 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.

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. Some detail needs to be shed for the benefit of having an updated and relevant figure of circularity to guide future legislative action.

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, striving to decrease material consumption. The cycling of materials measured in 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.

Lack of consistency in data quality. 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.

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.

For a more exhaustive look into the methodology behind the Circularity Gap, you can visit our website:

circularity-gap.world/methodology

3

SIZING POLAND'S CIRCULARITY GAP

Ressource use and meeting societal needs

Poland is 10.2% circular: the vast majority of materials flowing through its economy are 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. Our analysis reveals Poland's material footprint is similar to other Central European countries, at 517.9 million tonnes. On a per capita basis, this is 13.8 million tonnes—almost 16% more than the global average of 11.9 million tonnes. To put this into perspective: our globe's average material consumption already far surpasses what can be considered a safe ecological limit. In depicting Poland's resource use, key themes have emerged: the country is marked by considerable levels of per capita extraction and prosperous trade, with material- and emissions-intensive activities in the mining and quarrying, agrifood, manufacturing and construction sectors. These observations provide a clear starting point, so we can better understand where sectors and supply chains should focus their strategies as they move toward a circular economy.

GLOBAL CIRCULARITY: FROM BAD TO WORSE

Circle Economy's 2020 edition of the global *Circularity Gap Report* identified that, for the first time in history, more than 100 billion tonnes of materials are entering the global economy every year. But as global resource use has reached new heights, the Circularity Metric has wilted from its 2018 rate of 9.1% to 8.6% in 2020. The reasons for this on the global stage are threefold. Namely, high rates of virgin material extraction; ongoing stock build-up to feed a ballooning population and low levels of end-of-use processing and cycling. The most recent *Circularity Gap Report* illustrates the extent of our resource use: in the five years between landmark climate conferences in Paris and Glasgow, we consumed close to half a trillion tonnes of materials, causing emissions to spiral upwards.

The consumption of resources varies across continents and geographies, however. In light of the analysis in the 2020 Report, we see that Poland fits into the *Shift* country profile—alongside most other high-income countries in the global North (see text box). This means that it scores very highly on the United Nations' Human Development Index (HDI), between 0.8 and 1 (Poland is 0.88), but its Ecological Footprint—which accounts for human demand for biological sources—reflects its high level of consumption. If everyone on earth were to live like the average Polish resident, we would require the resources of almost three Earths.[44]

In this way, the classic profile of a *Shift* country is one of high impact: these countries produce 66% of gross domestic product (GDP), while housing only 20% of the global population. They also consume the largest share of the more than 100 billion tonnes of materials used globally and are major world traders. The pressure is on them to shift away from over-consumption of resources in servicing their relatively affluent and comfortable lifestyles. Their role in terms of global circularity is also prominent—the true impact of *Shift* countries extends far beyond their national borders, with many environmental and social costs incurred elsewhere. Poland is a *Shift* country: a high-income economy which consumes more materials and energy per capita than most of the world's countries in fulfilling its residents' needs and wants. However, Poland was not characterised as a *Shift* country until 2002, long after some of its European counterparts. Its starting place still remains somewhat different on its road to circularity, which can be seen in policy considerations, such as the EU Effort Sharing legislation, in which Poland is given much more leniency to reduce emissions in the coming decades compared to richer countries.[45]

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, and 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, Middle Eastern nations.

SEVEN SOCIETAL NEEDS AND WANTS

Here 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 Poland's total material consumption of 613.4 million tonnes. Since various products can be allocated differently, here we make our choices explicit. For example, 'radio, television and communication equipment' can be classified either as part of Communication, or as 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 not accurate.

SEVEN SOCIETAL NEEDS & WANTS

HOUSING AND INFRASTRUCTURE

The biggest category in terms of resource use is Housing. The construction and maintenance of the built environment accounts for 228.6 million tonnes (37%) of the total material consumption.

NUTRITION

Agricultural products such as crops and livestock require 161 million tonnes (26%) per year. Food and beverage products tend to have short life cycles in our economy, being consumed quickly after production.

MOBILITY

A considerable share of total material consumption is taken up by the need for mobility: 57 million tonnes (9.3%). In particular, two resource types are used: the materials used to build transport technologies and vehicles like cars, trains and airplanes; plus, predominantly, the fossil fuels used to power them.

MANUFACTURED GOODS

Consumables are a diverse and complex group of products—such as refrigerators, clothing, cleaning agents, personal-care products and paints—that generally have short to medium lifetimes in society. Textiles including clothing also consume many different kinds of resources such as cotton, synthetic materials like polyester, dye pigments, and chemicals. They account for 65.8 million tonnes (10.7%) worth of resources.

SERVICES

The delivery of services to society ranges from education and public services, to commercial services like banking and insurance. The related share of total material consumption is 61.9 million tonnes (10%) in total, and typically involves the use of commercial buildings, professional equipment, office furniture, computers and other infrastructure.

HEALTHCARE

With an expanding, ageing and, on average, more prosperous population, healthcare services are increasing globally. Buildings aside, typical products used include capital equipment such as X-ray machines, pharmaceuticals, hospital outfittings (beds), disposables and homecare equipment. This accounts for 29.4 million tonnes (4.8%).

COMMUNICATION

Communication is becoming an evermore important aspect of today's society, provided by a mix of equipment and technology ranging from personal mobile devices 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. Total material consumption in this group is less intense, standing at 9.6 million tonnes (1.6%).

THE MATERIAL FOOTPRINT SATISFYING SOCIETAL NEEDS IN POLAND

Domestic extraction

Figure four on pages 40–41 builds on the schematic material footprint diagram in Figure one on page 26. It dives into the socioeconomic metabolism of Poland; linking how four resource groups (minerals, metal ores, fossil fuels and biomass) satisfy the seven key societal needs and wants shown on page 37. From left to right, the figure shows the domestic extraction of resources (Take) which amounts to **626 million tonnes**, mainly through the production of agricultural crops (23% of total extraction), the mining of non-metallic minerals (53% of total extraction) and through the extraction of fossil fuels (20% of total extraction). These extraction processes result in raw materials like food, stone or coal. However, in a national context, domestic extraction represents only one of the inputs to the economy, which also includes directly imported products, weighing up at **157.7 million tonnes**. Re-exports—products that are imported and without any processing are exported again—likely do not make up a significant part of Polish imports and therefore are not explicitly quantified in this study.

Material footprint

Considering not just the direct imports, but also the Raw Material Equivalents (RMEs), as previously introduced on page 25, we see that Poland imports an additional 85 million tonnes of RMEs for a total import footprint of **242.7 million tonnes**. This means that Poland's import footprint is, in reality, around 50% larger than the physical weight of its finished imports. The virgin materials typically undergo processing (Process), for example in the production of metals from ores, cement from limestone, or refined sugar from beets. Subsequently, these refined materials can be used for the manufacturing (Produce) and assembly of products like automobiles from metals, plastics and glass, or the construction of roads and houses. These finished products can, in turn, be distributed and delivered to provide services (Provide) and access to products that can satisfy societal needs and wants locally or be exported. In 2019, Poland exported some **110.7 million tonnes** of final products with an associated RME of **240.1 million tonnes**, resulting in an absolute export footprint of **350.8 million tonnes**. This shows over a three-fold difference between the final product and the virgin material consumption, which stems from the substantial amount of waste that is produced domestically in the production processes of export products.

Essential to identifying and addressing opportunities for a more circular economy is what happens to products and materials after their functional use in our economy (End-of-use). This is mostly related to the **517.9 million tonnes** of material consumption: Poland's material footprint. Factoring in the **95.5 million tonnes** of secondary material use, Poland exhibits a total material consumption of **613.4 million tonnes.** The lion's share of the total material consumption can be attributed to two societal needs: Housing—with **228.6 million tonnes** (37.3% of the total material footprint)—and Nutrition—with **161 million tonnes** (26.2%). The rest of material consumption serves manufacturing and services, contributing 10.7% and 10.1%, respectively, whilst Mobility, Healthcare and Communication contribute 9.3%, 4.8% and 1.6% respectively.

Waste management

A considerable amount of the waste generated and treated belongs to waste streams that are not included in the systems boundaries of this analysis—and therefore should not be considered in estimating an economy-wide material cycling indicator[46] like our Circularity Metric. Under the new system boundary definition, 142.8 million tonnes of waste are classified as reported waste while another 54.1 would be classified as unreported. Almost all unreported waste is made up of extractive waste (30.6 million tonnes),[47] with the remaining 13.5 million tonnes consisting of manure and fractions of crop residues. Of the 196.9 million tonnes of end-of-life waste that's treated (both reported and unreported), 48.5% is 'technically' recycled (95.5 million tonnes), while the remainder is lost indefinitely. Of the latter, 3% ends up incinerated (including energy recovery) while another 21.2% is landfilled. The remaining 27.5% is composed of mainly 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;31 for more information). About 15% of the waste that is recycled in Poland belongs to waste streams that either don't fall within the system boundaries of our analysis (such as sludges and liquid wastes from waste treatment, soils and dredging spoils) or do not fall under the definition of socioeconomic cycling (such as animal faeces, urine and manure). These differences in system boundaries and in the nature of the indicators explain the gap between the rate of domestically cycled materials (48.5%), which feeds into the Circularity Metric,[48] and the traditional recycling rate obtained from traditional waste statistics (67%).[49] When it comes to trade in waste, Poland's situation is underpinned by a slightly negative trade balance in secondary materials: based on Eurostat data, the country is exporting 0.2 million tonnes more recyclable waste than it is importing, generating an almost balanced import/export ratio of 97%. This shows that Poland imports a similar amount of secondary materials than it exports. This, in turn, has a somewhat negative effect on the Circularity Metric when a consumption-based perspective is taken, as less waste is re-entering the Polish 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 from energetic use (including food and feed) stands at 252.3 million tonnes, and is composed mainly of emissions to air, as well as manure and combustion waste. These emissions can stem from biogenic sources—i.e., they're produced by living organisms (100.8 million tonnes)—as well as fossil fuel origins (151.2 million tonnes). Together with 91.5 million tonnes of DPO from material use (end-of-life waste excluding recycled materials), this adds up to a total DPO of 343.7 million tonnes. A small part (21.7 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.

Of the waste streams that *do* contribute to the Circularity Metric, and compared to other Northern European countries, Poland has high rates for the recycling of chemical and medical waste (80.4%), very high rates for traditional recyclables (93.1%), low rates for mixed ordinary waste (37.1%), excellent rates for animal and vegetal waste (96.2%) and moderate rates for mineral waste (71.7%). Mineral waste is the most prevalent, claiming more than 55% of the total, followed by mixed ordinary waste which claims 15% of the total. Boosting the cycling rates of these streams would therefore be a key avenue for Poland to boost its Metric.

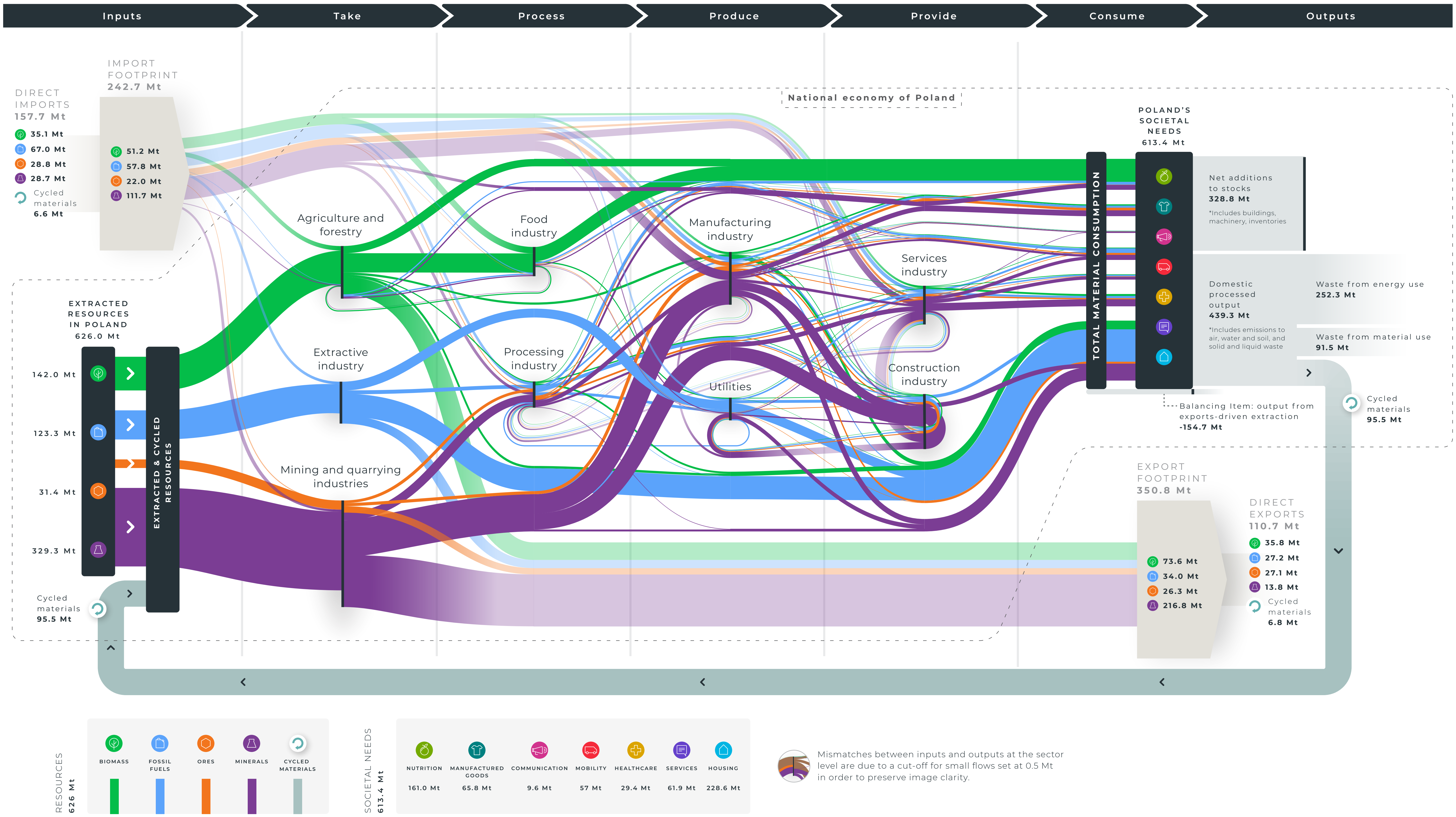
HIGH DEGREE OF UNCERTAINTY FOR WASTE FIGURES

Estimating Poland's waste flows with complete certainty may be difficult. When all waste flows are taken into account from an EW-MFA system boundary perspective,[50] its recycling rate can range from as high as 66% to as low as 26%.This is because of the amount of potential unreported waste that our analysis suggests may exist. This degree of uncertainty has a big impact on waste figures and is particularly problematic: there may be big differences in the figures due to recalculating waste flows according to other system boundaries. Unfortunately this means that there is no room for making 'educated guesses'.

What is known are the factors that play a role in this uncertainty range. One of the main factors regards construction and demolition waste (C&DW). Although construction waste of municipal origin has high reported recycling rates, construction and demolition waste of industrial origin (typically much larger constructions) is not accounted for as municipal waste, despite being situated within a municipality. This occurs because municipal waste is handled by a different type of local government (gmina) compared to industrial waste (voivodeship). Overall, industrial C&DW exists in much larger quantities than municipal C&DW and thus has a significant effect on the reported waste figures. In addition to this, it is widely recognised that illegal disposal of waste is rife in Poland, namely stemming from neighbouring Germany. It is often cheaper for neighbouring countries to export their waste to Poland, and this sometimes happens illegally, resulting in the dumping and subsequent burning of waste.[51] Due to the widespread presence of harmful substances and chemicals in this waste, it is detrimental to the local environment.[52]

X-RAY OF POLAND'S ECONOMY

Figure four displays an X-Ray of Poland'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.

KEY THEMES OF THE POLISH ECONOMY

Poland's economy is highly dependent on virgin resources-dependent and presents a relatively material-intensive and highly carbon-intensive profile. This can largely be attributed to: 1) a high extraction rate and dominant quarrying and mining industry and 2) heavy coal use impacting emissions. On a sectoral level, the agrifood and construction sectors concentrate the largest shares of the country's material flows.

POLAND'S DOMINANT QUARRYING AND MINING INDUSTRY DRIVES A HIGH EXTRACTION RATE

Rich in natural resources, Poland stands out from many of its European neighbours owing to its high levels of material extraction. On a per capita basis, domestic extraction equals 16.7 tonnes per person per year—well above the EU average of 10.3 tonnes and world average of 12.3 tonnes. Poland extracts more hard coal, coke, copper concentrates, silver and helium than any other EU country and is a top extractor of many other metal ores and non-metallic minerals.[53] On an annual basis, **626 million tonnes** of materials are extracted within the country's borders: this is largely attributable to **329.3 million tonnes** of non-metallic minerals (primarily sand and gravel)—representing around 53% of extraction—followed by **142 million tonnes** of biomass (consisting equally of crops and crop residues), or around 23% of extraction, **123.3 million tonnes** of fossil fuels (almost entirely hard coal and low-grade, brown coal), representing approximately 20% of extraction, and a relatively low **31.4 million tonnes** of metal ores, claiming just 5% of extraction. Despite the relatively low ore extraction rate compared to the other resources, they still represent very high levels compared to other European countries. For fossil fuels—largely coal—the vast majority is used domestically, as compared to the other extracted natural resources for which a large share is exported.

These figures, however, are set to decline: Poland intends to phase out coal production by 2049[54]—just before the EU's net-zero target—and has already closed around two-thirds of its coal mines over the last three decades. The domestic production of hard coal has seen a steep decline, dropping 2 million tonnes between 2018 and 2019 alone[55]—although much of this has been matched by increased imports from Russia. While the country's invasion of Ukraine has spurred a ban on coal imports, leading Poland to seek out new partners for trade,[56] the general trend for both production and consumption is decreasing. Similarly, jobs solely in the coal mining sector have dropped from 300,000 to 80,000[57]—spurring the creation of a social agreement between the government and miners' union, which will allow operations in individual mines to continue for the coming decades. The Polish government has announced plans to invest in 'clean coal' technologies, to ensure demand for at least 10 million tonnes per year over the next decade.[58] Clean coal technologies may help reduce sulphur dioxide, NOx and dust emissions,[59] but will likely not impact the vast quantities of CO2 that will continue to be emitted for decades to come. Poland must invest in more sustainable technologies and renewables that cause less environmental damage. In doing so it must pay attention to the transferability of skills for workers in this area. On average, ex-miners generally have low levels of formal education and may find it difficult to find alternative jobs in the same region, or with a similar salary and employee benefits. However, many ex-miners do find employment in the manufacturing and construction sector due to the lower formal education gap. This process should be actively facilitated and reskilling should be offered to workers who want to move towards other sectors with a higher formal education gap.[60]

Beyond coal, extraction in Poland remains steady. The number of raw material extraction sites—such as quarries, mines and sand pits—has grown to 4,914, an 81% increase between 2000 and 2020. However, since 2012 this number has somewhat plateaued. This figure largely consists of sand and gravel sites, which generally extract significantly smaller quantities of materials compared to sites dedicated to coal mining[61]—although overall extraction tops coal by more than ten times. Mineral extraction activities in Poland generated the highest value added to the EU by country in 2019:[62] in 2020, these activities had an annual turnover of €11 billion[63], around 2% of the country's GDP.[64] The total Polish mining and quarrying sector directly employs 144,900 people, making it the largest employer in the sector in the EU and representing over one-third of the EU total.[65]

In addition to domestic extraction, Poland is also responsible for significant raw material extraction outside of its borders, with just under half (46.3%) of its raw materials imported from abroad. The import of raw materials is worth US$24 billion (zł92.2 billion), representing almost 10% of all imported goods.[66] More than one-third of Poland's consumption-based material footprint can be attributed to a handful of countries, dominated by China (providing mainly non-metallic minerals), Russia (providing mainly fossil fuels) and other Asian and Eastern-European countries (providing mainly biomass and non-metallic minerals). Metal ores play a relatively small role in the economy, both in terms of domestic and foreign extraction. Globally, iron ore is by far the most produced metal ore, primarily for producing steel.[67] Poland has a modest-sized steelmaking industry and thus its demand for iron is not significant.[68] Extraction outside of Poland represents an absolute import footprint of **242.7 million** tonnes, composed primarily of non-metallic minerals (111.7 million tonnes), and followed by fossil fuels (57.8 million tonnes), biomass (51.2 million tonnes), and metal ores (22.0 million tonnes)—similar to its domestic extraction profile. With an overall raw material net trade balance of -108.1 million tonnes, Poland imports less raw materials than it exports. When accounting for both extracted and cycled materials, we find that Poland is self-sufficient in terms of just over half (53.7%) of its resources. In essence, this means that the ecological footprint of Poland's exports—accounting for waste generated during mineral extraction, for example—is much higher than their physical weight. Of the total extraction in Poland, just under half (44%) is used to satisfy its own final demand while the rest is exported. In total, Poland exports 110.7 million tonnes of materials, resulting in an absolute export footprint of 350.8 million tonnes. The difference between these figures is telling: Poland's exports have a much larger material footprint than their 'final' physical weight might suggest, meaning that the country is, in essence, exporting environmental impacts. Non-metallic minerals (at 216.8 million tonnes) and biomass (at 73.6 million tonnes) are responsible for the vast majority of this. From these figures, we can discern that Poland has an impact on other countries' consumption-based footprints—and is itself suffering environmental damage for their benefit.

A HEAVY CARBON FOOTPRINT OUTWEIGHS A MODERATE MATERIAL FOOTPRINTRK

As noted, while Poland's material consumption is moderate, its economy is largely dependent on fossil fuels, namely coal. Some plans to decarbonise its economy have rolled out: ambitions to create the biggest offshore wind energy industry of all Baltic sea countries by 2050, for example.[69] However, Poland is still heavily dependent on fossil fuels to heat homes, power industry and fuel transport—and while goals for offshore wind plants are laudable, plans to swap coal for gas are most prevalent. While the country's high dependence on coal means they've got far further to go than their neighbours and that current EU targets may be out of reach, Poland must try to bridge this gap by taking a more radical approach of systemically changing their consumption footprint.

The consumption of fossil fuels is also inherently linked to material consumption, which also stems from the use of other natural resources such as minerals, metal ores and biomass. Construction and real estate claims the largest portion of the material footprint, representing 20.5% of the total, followed by agrifood, which is responsible for 8.8% of the total. However, a large share—nearly one-fifth—of the material footprint is represented by fossil-driven activities, such as coal and lignite mining (11.3%), the production of electricity through coal (4.1%) and petroleum refinery (2.3%). Poland consumes a total of **517.9 million tonnes** of virgin materials on a yearly basis: an average of 13.8 tonnes for each resident. Consumption, however, is relatively proportional to the country's size: Poland houses 0.49% of the world's population and represents 0.56% of the global material footprint. For many other wealthy European nations, this disparity is far larger: Sweden, for example, hosts just 0.13% of the world's population, yet claims a substantial 0.3% of the global material footprint,[70] while Norway is home to 0.07% of the population and represents 0.23% of the global material footprint.[71]

The link between material use and emissions is clear when examining Poland's material footprint, which translates to a relatively heavy carbon footprint: Polish residents account for 10.5 tonnes of greenhouse gas emissions each year. While this rests slightly below the EU average of 11 tonnes, it's nearly double the global average of 6.3 tonnes. Poland accounts for 0.78% of the global anthropogenic carbon footprint; far exceeding its share of the population (0.49%). While the country's total carbon footprint reaches 398.9 million tonnes, it's important to recognise that residents are only directly 'responsible' for 55.7 million tonnes of this—by heating their homes or commuting to work, for example. The remaining 342.2 million tonnes arise through non-residential activities, such as industrial processes and trade activities, both of which may take place abroad: from this figure, 72% (or 246.7 million tonnes) originate within Poland while 28% are embodied emissions in imports from the rest of the world. Of the total consumption-based carbon footprint—including both direct and indirect emissions—62% relate to emissions from within the country's borders. This is significant: in Sweden, for example, only one-third of the consumption-based carbon footprint comes from within the country; for Poland, the opposite is true. This will serve the country on its journey to a lower carbon, more resource light economy: while most Shift countries are heavy importers of materials, therefore generating substantial environmental impacts elsewhere in the world, Poland has the opportunity to take charge of its own impact. This is because it's easier to control the sustainability of domestic production than the sustainability of products imported from abroad.

The bulk of the consumption-based carbon footprint can be attributed to three industries: steam and hot water supply (28.1% of the total), construction and real estate (11.1% of the total) and processing of food products (3.6%). The presence of both construction and agrifood as large contributors to both the material and carbon footprints—albeit in different proportions—exemplifies the tight link between material use and emissions. By advancing circularity and slashing its material footprint Poland cut crucially pare down its carbon footprint.

Poland’s consumption-based carbon footprint is 4% lower than its territorial carbon footprint **(416 million tonnes)**—the emissions produced within its borders. The country is essentially exporting carbon embodied in the goods it produces domestically. This tells a different story from many other European nations, whose consumption-based emissions tend to far exceed their territorial ones. The footprint of Swedish consumption, for example, is 63% larger than its territorial emissions, meaning that the country imports carbon embodied in goods produced around the world. However, this is fairly intuitive given Poland's significant mineral exports to Germany, Slovakia and Czechia[72]—and it indirectly benefits the Circularity Metric: the country's export footprint tops its import footprint by 50%, resulting in a lower material footprint than if these were flipped. This, in turn, acts as a determinant for a higher Metric. Nonetheless, these practices generate substantial waste within Polish borders, such as from mining and quarrying activities. This waste is usually landfilled or recycled for lower value purposes and the main barrier identified to reuse such waste for higher value purposes is the lack of incentive to invest in new practices. This will need to be overcome to relish the long-term environmental and social benefits that can come with closing the loop on mining waste.[73]

AGRICULTURE AND FOOD COME OUT AS A DOMINANT SECTOR OF THE ECONOMY

In Poland, biomass extraction runs strong at 142 million tonnes: this is split between crops, at 59 million tonnes, and crop residues, fodder crops and grazed biomass at 57 million tonnes—as well as wood at 25 million tonnes. For this resource group, exports top imports: with an export footprint of nearly 73.6 million tonnes and an import footprint of 51.2 million tonnes. Most of the biomass Poland consumes has been extracted within its own borders: the nation is largely self-sufficient in terms of the agrifood products it consumes.[74]

It's unsurprising, then, that the agrifood industry stands out as a key contributor to Poland's economy, with a longstanding tradition that has stood strong in the modern age. While the portion of the workforce employed in agriculture has declined substantially over the past three decades, it rests today at 10%—a figure far surpassing neighbouring countries such as Germany (1%) and Czechia (3%).[75] This decline is likely owed to the increasing size of farm holdings with less labour intensive practices, in conjunction with increased opportunities in the service sector. Poland's agricultural land use ranks among the highest in the EU, with only France, Spain and Germany surpassing it:[76] farms occupy more than 47% of the country's land.[77] Holdings tend to be small and fragmented, especially when compared to the European average: in 2016, more than half of farms covered less than five hectares—a portion of small holdings distinctly higher than Germany (9%) and Czechia (19%).[78] Agriculture is closely linked to the food processing industry which has been experiencing strong growth in recent years driven by both domestic and foreign demand. Poland now houses the largest food processing industry in Central and Eastern Europe, and the 6th largest in the EU.[79]

Agriculture and food processing claim a large portion of the material footprint: 114 million tonnes, or 26%. This is divided between a wide range of relatively small activities, with the largest being the processing of food products (5%), processing of cattle meat (2%), and processing of dairy products (2%). Of the biomass extracted in Poland, 41% are crops for human consumption, 40% is used for livestock production and animal feed and 18% corresponds to wood from the forestry sector. Economically, cereals dominate, claiming €4.1 billion (zł17.6 billion)[80] or 16.7% of agricultural economic output, followed by industrial crops, from oil seeds and sugar beets to protein crops, representing €1.8 billion (zł7.74 billion) or 7.3% of agricultural economic output. Livestock is split between animals, namely pigs, poultry and cattle (€7.5 billion (zł32.3 billion) or 30.4% of agricultural economic output) and animal products, such as milk and eggs (€5 billion (zł21.5 billion) or 20.2% of agricultural economic output). Food processing also plays an important role in the Polish economy as one of its fastest growing sectors: the country is a net-exporter of processed agrifood products, garnering most of its profits from meat, bread and chocolate.[81]

The societal need for Nutrition accounts for nearly 26.3% of Poland's total material consumption, largely due to the agrifood industry. Given the tight link between material use and emissions—and especially due to meat and dairy products' emissions-intensive nature—agriculture accounts for a large share of Poland's carbon footprint: 8% of total GHG emissions in 2017. Although GHG emissions have decreased by 34% between 1988 and 2017,[82] this does not implicitly mean that such improvements have been intentional or due to concerted action against climate breakdown. The sharpest drop in emissions—achieved in the early 1990s—followed a decrease in cattle stock and fertiliser production and use as the Polish economy shifted from a socialist to capitalist market economy.[83] Moving forward, there is ample room to drive progress in the industry through intentional efforts along the same trajectory: this is discussed in more detail in Chapter four.

GROWING BUILDING STOCK AND INFRASTRUCTURE TO HOUSE AND TRANSPORT POLISH RESIDENTS

The construction sector is highly resource-intensive, as it uses vast quantities of materials, energy and water in Poland. Satisfying the demand for buildings and infrastructure requires 228.6 million tonnes of materials (representing 37% of total material consumption), and consumes around 79.6 of the total 329.3 million tonnes of non-metallic minerals extracted domestically (such as basalt, limestone, sand and gravel). In addition, 28.7 million tonnes of non-metallic minerals are imported from abroad, with an associated RME of 111.7 million tonnes: almost 80% of the non-metallic minerals embodied in the final goods imported are extracted abroad: meaning that even though imported non-metallic mineral products have a relatively low weight (28.7 million tonnes), their RME is much higher (111.7 million tonnes), meaning that Poland is externalising the environmental costs of these imported products.

Poland's building stock and infrastructure is growing—and material use is therefore set to continue: over the course of 2021, the number of finished residential buildings swelled by 10%, while the infrastructure sector, civil engineering in particular, is booming due to ongoing road and railway construction projects.[84] The Polish government announced in 2022 that it will double its planned railway investments to €2.36 billion euros (zł11 billion) to construct and reconstruct a total of 1,203 km railway lines (representing around 6% of the total railway lines already operating in the country).[85][86] While the onslaught of the covid-19 pandemic has caused slight declines, the construction sector is expected to continue on an upward trajectory—and is the sixth largest within Europe.[87]

In Poland, more than half (61%) of the consumption-based material footprint of Poland is accumulated in the country: 328.8 net million tonnes added to stocks, a relatively high figure that hints at the steady growth within Poland's construction sector. Most of this growth comes from the residential sector, with 21.8 million square metres of new space constructed in 2021, alongside 14.1 million square metre in the non-residential building sector.[88] Prices for residential properties are soaring, resulting in nearly half of Poles between 25 and 34 living with their parents.[89] Current estimates suggest a shortage of 2.2 million residential dwellings,[90] which is likely to be further exacerbated by an influx of refugees from neighbouring Ukraine.[91] The sector is particularly vulnerable to shocks and has indeed felt the effects of the pandemic and war: supply chain disruptions have resulted in material shortages and price spikes, especially owing to the energy-intensiveness of producing key building materials like cement, brick and concrete.[92] Shifting to more regenerative, circular building materials—such as wood—and production processes that favour clean energy over coal will be a key avenue for Poland's transition to a circular economy. As long as new buildings and infrastructure are necessary to house and transport the population, circular strategies will be crucial in ensuring that secondary, more efficient and less emissions-intensive materials are prioritised, along with design strategies and revitalisation practices such as renovation and retrofitting. This is discussed in further detail in Chapter four.

4 BRIDGING POLAND'S CIRCULARITY GAP

Exploration of ‘what if’ scenarios for key sectors

Now that we have presented how Poland’s Circularity Metric and Indicator Set are derived, deep dived into the country's material footprint and investigated the messages it portrays, it’s time to suggest a remedy. For the chosen sectors, 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 Poland. They serve as an exploration of a potential path forward but also sketch which type of sectors and interventions could be most impactful in terms of steering the Circularity Metric and material and carbon footprints.

BRIDGING THE CIRCULARITY GAP: 'WHAT IF' SCENARIOS

In our *Circularity Gap Reports*, our scenarios have been largely free from the constraints of law or political realities: deliberately non time-specific and exploratory, their real-life materialisation did not inform our analysis. Through this approach, we are able to freely imagine what our society could look like with truly transformational change: a close to fully circular economy. Below, we present an action plan that allows us to 'dream big' and sketch which type of interventions and levers are most impactful in terms of cutting the material and carbon footprints, while driving up the Circularity Metric.

We have funnelled our focus for the ‘what-if’ scenarios into six key areas and industries that represent key leverage points for Poland’s economy, using 2019 as the baseline year for our analysis. These scenarios are 1) Build a circular built environment, 2) Nurture a circular food system, 3) Rethink mobility, 4) Scale resource-efficient manufacturing and zero waste, 5) Keep goods like new for longer, and 6) Power Poland with clean energy. 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 Poland’s economy, we can only measure the changes to the material footprint and the Circularity Metric, taking a mass perspective. We also measure changes to the carbon footprint; however, due to data limitations, we can only measure changes in indirect emissions (and not direct emissions). Although indirect emissions (343.1 million tonnes of CO_2e) represent roughly 86% of Poland’s total carbon footprint (398.8 million tonnes of CO_2e), the fact that direct emissions (55.7 million tonnes of CO_2e) are excluded from our calculation for the footprint reduction means that some interventions' full potential is not captured. This is especially true for interventions targeting households. Additionally, under each scenario, we also 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.

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

Our scenarios are informed and developed by the ultimate aims of slowing, narrowing, cycling and regenerating resource flows, as described on page 27.

1. BUILD A CIRCULAR BUILT ENVIRONMENT

Worldwide, our societal need for housing and buildings has a massive impact: it consumes 38.8 billion tonnes of materials and represents one-third of the global material footprint.[93] Combined, building, construction and operation activities account for more than one-third of the global carbon footprint.[94] Our current way of building is largely linear. We prioritise emissions-intensive materials like cement and allow for flawed design that hinders cycling at end-of-life, for example, while wasteful operation practices that consume energy in buildings' use phase are common: heating rooms that are not in use, for example. Circular strategies provide an opportunity to cut the industry's material use, through better design, material use, operation and end-of-life management. Buildings are essentially banks of often-reusable materials—and making the most of this is key to shaping a more circular, resource-light and low-carbon economy.

In Poland, the need for Housing consumes 228.6 million tonnes of materials (virgin and secondary)—representing 20% of virgin material use. If the entire life cycle of buildings are considered, the industry represents 41% of primary energy demand and releases around 38% of the country's CO2 emissions.[95] It also has a key role to play in the Polish economy, yielding a total turnover of €144.4 billion (zł679.7 billion)[96] and representing 6.7% of GVA.[97] It provides work to 1.7 million people[98]—10% of the total workforce,[99] which has increased by nearly 21% since 2010. The industry's growth won't slow any time soon: demand for new housing is on the rise, with the total supply of new homes increasing by 235,000 in 2021—more than 6% growth compared to 2020.[100] The country's contemporary housing market is characterised by a severe shortage, with the worst housing to resident ratio and among the highest overcrowding rate in the EU, and high housing deprivation rates—with 7.9% of households considered to have poor amenities.[101] [102] On the other hand, salary growth is substantially outpacing housing prices: average monthly salaries nearly doubled between 2007 and 2020, while housing prices grew only 12% in the same period. In other words: as housing has become more affordable, demand has risen concurrently.[103] If stock build-up is set to continue, it must be done in as circular a manner as possible. Poland's *National Housing Programme*[104] is a step in the right direction, focusing on both the social and environmental problems facing its housing sector. The programme includes a Thermomodernisation and Renovation Fund aimed at improving the energy efficiency of the country's (largely inefficient) building stock, and a package of instruments (*Mieszkanie+*) that aim to enhance access to housing for persons vulnerable to social exclusion with moderate or low incomes by constructing affordable flats. The government has identified 29 national job shortages, nine of which relate to the built environment—such as carpenters, joiners and building finishers. In addition, workers previously involved in construction activities represent one of the largest share of unemployed workers (9.7% in 2019).[105] It is critical that shortages and unemployment are addressed in order to ensure that activities related to circular construction can be fulfilled.

In this what-if scenario for the built environment,[106] we explore opportunities for Poland to optimise its building stock expansion, prioritise deep energy retrofitting and create a more resource-efficient building stock—allowing the country to boost its circularity while slashing its material footprint.

1.1 OPTIMISE BUILDING STOCK EXPANSION

Our first intervention aims to lower the Polish construction sector's material footprint through strategies that **cycle** and **narrow** flows. Construction and demolition waste can be used as resources for residential construction and maintenance, for example, while idle and unused commercial buildings can be better utilised to cut demand for new floor space. A cap is placed on new constructions for residential, commercial and public buildings, based on construction and demolition waste availability.

Poland's housing stock is increasing: in a time when we need to use substantially fewer materials, the built environment is demanding more for more—and larger—homes. Inhabited and uninhabited dwellings topped 15 million in 2022—an increase of more than 12% over the last decade, in spite of substantially lower population growth (0.66%) over the same time period.[107] This can partially be attributed to the country's ageing population: the elderly are more likely to live alone, and in smaller houses,[108] while high occupancy rates have begun to drop: from 2.8 people per household in 2012 to 2.5 people per household in 2021.[109] As of 2020, the number of rooms per person remained among the lowest in the EU, however, at 1.2. The country was found to lack more than 2 million homes,[110] and pressure on the market is set to increase further as refugees fleeing war in Ukraine seek housing in Polish cities.[111] Nonetheless, floor space is already increasing: the average Polish property is now around 74.5 square metres, around double that of housing built in Warsaw in the 1960s and 1970s.[112] [113] As building stock continues to increase, a focus on circular strategies will be crucial to ensure this is done in an optimal—and less materially-intensive—manner. Secondary materials should be prioritised over virgin ones for new builds: here, construction and demolition waste can serve as a resource and help scale secondary material use. Currently, Poland boasts high levels of construction and demolition waste recovery: 91%, which far exceeds the EU requirement of 70%. However, the largest portion of construction and demolition waste in Poland is represented by concrete and brick, which is largely downcycled into aggregate for the construction of roads, embankments, railway embankments, the production of concrete mixes, or used for land hardening.[114] There's a substantial opportunity to maintain this waste's value through direct reuse for new construction projects. Expanding the industry for deconstruction and recovering building and construction waste can simultaneously help to boost local jobs. Poland can also optimise the space it already has: in early 2022, 1.73 million square metres of commercial space stood vacant, representing 13.8% of the country's nine largest business centres.[115] This is expected to increase: supply for commercial buildings is outpacing demand.

In this intervention, we modelled a cap on the physical volume of available virgin materials and investments for the construction of new residential, commercial and public buildings by reintegrating construction and demolition waste into the loop. At the same time, in this intervention a maximum collection rate for recycling of construction and demolition wastes is assumed, while 50% of it is suitable for reuse. By optimising its stock expansion, Poland could cut its material footprint by a massive 19.6%, bringing it from 517.9 million tonnes to 416.3 million tonnes, and slash its carbon footprint by an even larger 21.8%, lowering it from 343.1 million tonnes to 268.4 million tonnes (excluding changes in household emissions). The Circularity Metric could increase by a substantial 2.2 percentage points, bringing it up to 12.4%.

1.2 PRIORITISE DEEP RETROFITTING

In line with this scenario's first intervention, new builds should be optimised: this may mean improving older buildings rather than immediately opting for demolition followed by new projects. To this end, our second intervention centres on the deep retrofitting of buildings: this will **narrow** flows, by reducing the energy required to heat homes through significant improvements in building insulation. This activity should prioritise secondary and non-toxic, regenerative materials to the greatest extent possible to further **cycle** and **regenerate** material flows. Material choice remains important for retrofitting: it's important to consider how carbon embodied in certain materials—such as concrete—may generate other consequences, counteracting efficiency gains.

European building stock is old on average: in most EU countries, around half of residential buildings were built prior to 1971, when the first regulations regarding energy efficiency emerged in Europe.[116] The same is true for Poland—and by 2012, only half of these pre-1971 buildings had been renovated to improve their efficiency. Today, a large proportion still fail to meet current requirements. Nearly one-fifth of total residential buildings require energy-related retrofitting—exceeding the EU average of 12.3%.[117] Nonetheless, energy efficiency has seen marked improvements in Poland over the past century: today, buildings consume 83% less than their counterparts built before 1918, and 50% less than those built between 2003 and 2007.[118] This is set to improve further: in 2018, the Polish government announced plans to allocate more than €22.7 billion (zł103 billion) to finance the thermo-modernisation of the building stock by replacing emissions-intensive heat sources and boosting energy efficiency in single-family residential buildings,[119] while the Stop Smog programme will work to realise similar aims with a focus on upgrading energy-poor residential buildings.[120] Nonetheless, current funding for retrofitting the Polish building stock is deeply insufficient: around €3.9 billion (zł16.8 billion) from the country's *Recovery and Resilience Plan 2021–2026* has been allocated to retrofit-related projects,[121] representing around 11% of the total—yet the National Energy and Climate Plan estimates that €195 billion will be needed annually to scale deep retrofitting and improve buildings' energy efficiency.[122] Action in this arena is largely driven by policy at the EU and national level: Poland has adopted an EU directive—the Energy Performance of Buildings Directive—requiring improved insulation alongside a transition to lower-carbon heating sources.[123] In 2021, Poland's *Long-Term Renovation Strategy* was formulated as part of this directive's implementation, with the aim of supporting the decarbonisation of the building stock by 2050, and centring on two key actions: large-scale heat source replacement and a gradual increase in the scale of deep renovation and retrofitting activities. The former will target phasing out coal use in cities while scaling shallow thermal modernisation by 2030, with rural areas lagging behind, aiming to phase out coal use by 2040. The latter will aim to bring two-thirds of buildings to passive-house standards, and a further 21% to energy efficient standards—assuming the remaining 13% won't be possible to modernise for either technical or economic reasons. While ambitious, the *Long-Term Renovation Strategy* fails to address the issue of embodied carbon in building materials. The circular economy approach requires attention be paid to the materials used to retrofit buildings for increased energy efficiency: prioritising secondary, bio-based and non-toxic materials. In addition, behavioural changes must be monitored to avoid potential rebound effects, such as consuming more heating fuel despite having a more energy efficient building. Considering all aspects of the circular economy will become increasingly important as buildings' energy efficiency increases in the years to come. This should become a key point of focus in the strategy's next iteration, scheduled for 2023.

To model this intervention's impact, we assume that all retrofits carried out are 'deep' retrofits that achieve energy savings of 60%: the rate of deep retrofitting is raised from the current 0% to the needed 17%. Based on this, we assume an average cut of 50% in energy needs. By scaling its deep retrofitting practices, Poland could reduce its material footprint by 2.7%, bringing it from 517.9 million tonnes down to 504.1 million tonnes, and its carbon footprint by a substantial 5.2%, bringing it from 343.1 million tonnes down to 325.2 million tonnes. The Metric could increase by a moderate 0.2 percentage points, to 10.4%.

1.3 CREATE A RESOURCE-EFFICIENT BUILDING STOCK

Our final intervention for the built environment comprises a range of strategies to make the stock of residential, commercial and public buildings more efficient. We consider the impact of choosing lightweight materials, such as timber—**narrowing** flows—while also increasing the lifetime of bearing elements, **slowing** flows. Through improved construction processes, such as modularisation and off-site construction, fewer material losses can be achieved—and efforts to keep the supply chain as local as possible—we seek to **narrow** flows. At home, Polish residents can make certain behavioural changes to **narrow** flows and ensure resource-efficiency, as well: thinking twice before blasting the heat, making use of smart metres, and using energy-efficient appliances, for example.

Poland has already shown some promising action in this direction: the number of wooden buildings has more than doubled across the country over the last five years, for example. However, there is significant potential yet to be reached: market estimates place the potential for wooden buildings at up to 15,000 per year,[124] and currently, the share of wood construction in the total building market rests at only around 1%.[125] Fulfilling this potential will have a crucial role to play in cutting the building sector's impact: international studies show that the life cycle emissions embodied in timber structures are up to 42% lower than their concrete counterparts,[126] while substituting concrete with cross-laminated timber can bring reductions of up to 60% at the individual building level.[127] One of the most consumed building materials, steel, relies heavily on imports—with 13.7 million tonnes of steel being imported to Poland in 2021, compared to 8.5 produced domestically—making Poland the fourth largest net importer of steel globally.[128] Prioritising local supply chains for building materials could deliver substantial benefits. External factors—from the covid-19 pandemic to the Russian invasion of Ukraine—have caused severe shortages and price hikes, with a record portion (17%) of Polish contractors indicating that their projects were damaged by lacking building materials or delayed deliveries. Producing common building materials such as cement, brick and concrete is also becoming more and more expensive owing to supply chain disruptions, including Russia's decision to eliminate gas deliveries to Poland. To make up the difference, contractors are raising their prices at record rates: nearly half of Polish building firms plan to increase prices, the highest percentage over the last decade.[129]

Shifting to more local and sustainable building materials could present a way to alleviate expenses and build resilience locally, cutting susceptibility to shocks from abroad—while also delivering material savings and slashing emissions. On the demand side, some action is already underway to scale the use of smart metres: the country aims to roll-out smart metres to 80% of consumers by 2028, for example. As of 2018, however, this figure hovered around 8%, lagging far behind the goal—and energy consumption per household has grown substantially since the turn of the century for electrical appliances and lighting, cooking, and water heating: there's still significant room to adopt circular strategies in this arena whilst paying close attention to potential rebound effects.

In modelling the impact of this intervention, we make a number of assumptions. For material use in construction, steel, aluminium and cement use is reduced—by 50%, 33%, and 20%, respectively—while the use of regenerative materials like wood shoots up by 200% to offset the decrease in concrete; on site material losses decrease by up to one-fifth while local supply chains are prioritised for material sourcing, reducing the overall transportation required. In households, we assume room temperatures drop by an average of 2-degrees, while smart metering decreases energy consumption by up to 4%. We also assume an uptick in the use of energy-efficient washing machines, tumble dryers and irons, with fewer wash cycles taking place at lower temperatures in an effort to save energy. These strategies could cut the material footprint by a substantial 6.2%, bringing it down to 485.7 million tonnes, while the carbon footprint could decrease by a massive 15.2%, down to 291.1 million tonnes (excluding changes in direct household emissions). The Metric could grow by 0.6 percentage points, to 10.8%.

Impact on Poland circularity:

Combined, our three interventions for housing could cut Poland's material footprint by a massive 26.4%, bringing it down from 517.9 million tonnes to 381.2 million tonnes. The carbon footprint would see an even greater reduction of 36%—from 343.1 million tonnes down to 219.6 million tonnes (excluding changes in direct household emissions). Finally, the Metric could grow by 3.1 percentage points, to a total of 13.3%. This scenario would also usher in a range of co-benefits for Poland: increased resilience to global commodity price fluctuations through more local material sourcing, as well as reduced energy costs for households through lower energy consumption— in turn also helping to alleviate energy poverty. Smart metres can also provide the additional benefit of greater consumer awareness, as they encourage users to think more critically about their energy consumption. Measures to reduce overall energy consumption will reduce fossil fuel use, thereby improving air quality and local health. Creating a local market for secondary materials, coupled with the labour intensity of renovation and retrofitting activities, could bring new business and employment opportunities to the local economy.

2. NURTURE A CIRCULAR FOOD SYSTEM

The current global food system is one of the single largest driver of environmental damage,[130] from climate change to biodiversity loss: it contributes one-third of total GHG emissions[131] and eats up nearly 40% of total landmass to grow crops, graze livestock and produce animal feed.[132] In Poland, this figure is even larger: agricultural practices consume nearly 47% of the country's land, amounting to 14.4 million hectares. Of this, only 0.5 million hectares are used for organic farming—and ever-prevalent intensive land use is a prime driver of biodiversity loss.[133] Poland's agricultural land use is among the highest in the EU—yet neighbouring countries' boast higher agricultural output: this can be attributed to a high prevalence of small, fragmented holdings, with the majority of farms covering less than five hectares—well below the EU average of 16.6 hectares.[134] Only 8.6% of neighbouring Germany's land, for example, can be attributed to farms—most of them large and with heavily industrialised output, often due to intense use of synthetic fertilisers. Poland represents more than one-tenth of the EU's farms, yet yields a substantially lower proportion of the total economic output: most of the country's small farms consume more than half of what they produce, contrary to their larger, more industrial counterparts.[135] Such industrialisation practices may bring great economic benefits in the short-term, but they also often come with negative environmental impacts, such as soil depletion and local water contamination. Instead of boosting the Polish agriculture economy in this way, the country can seek benefits through ecological intensification practices, which can provide high outputs and have a positive impact on the soil and local environment.[136]

The climate and soil in the country favour a mixed farming approach, where both crops and livestock play an important role—only 13% of farms are dedicated solely to raising livestock.[137] This serves as a good foundation for regeneration practices that integrate both crops and livestock to mutually benefit from each other. Poland's food system, however, is not without impact: agriculture is responsible for the largest portion of ammonia emissions by far (94%) in the country, putting Poland at the top of EU rankings for agriculture-related ammonia emissions. Meat consumption is heavy—around double the global average[138]—and indeed, more than three-quarters of ammonia emissions stem from livestock manure. Ammonia pollution leads to a host of negative consequences, from biodiversity loss to harm to human health—and thus the country is obliged to cut emissions by 1% annually compared to 2005 figures, until 2029, and 17% annually after that.[139] In spite of these challenges, Poland is well-poised to adapt its agricultural systems. For example, the recently proposed post-covid socioeconomic programme, Polish Deal, will aim to support smaller farms through measures such as tax reforms, the digitalisation of farming services and developing a digital food passport to increase their competitiveness in the supply chain.[140] A circular food system will require optimal agricultural production with minimal waste generation, with a focus on cutting pollution and nurturing soil health; it will also go hand in hand with the availability of and access to healthy diets that nourish people and the planet.

To this end, this scenario comprises three interventions to cut food's impact: through adopting more sustainable food production, endorsing more sustainable diets and reducing household food waste, Poland can both boost its circularity and substantially reduce its material footprint.

2.1 SHIFT TO MINERAL-FREE FERTILISER AND CHAMPION SEASONAL, LOCAL PRODUCE

Nutrition's final intervention focuses on the production side: we explore a range of strategies promoting farming methods less dependent on mineral fertilisers—such as regenerative or organic farming—to regenerate flows. Shifting to more seasonal and local food production will also serve to narrow flow by lessening dependence on greenhouse-grown foods and lowering travel distances, thus cutting fuel consumption for heating and transport.

As discussed in this Scenario's introduction, Poland is characterised by its high proportion of land dedicated to agricultural purposes: farms cover much of the country, and smallholdings dominate, despite a trend towards larger, and often more industrialised farms. Farmers have a crucial role to play in the circular transition by adopting more regenerative practices guided by circular principles. Current practices have led to excessive emissions of ammonia—a harmful pollutant damaging to human health—from the sector: 94% of the country's ammonia emissions can be attributed to agriculture—among the highest rates in the EU. While most of these can be attributed to livestock manure, a large portion (22%) stems from nitrogen fertiliser use: Poland has among the highest levels of mineral fertiliser consumption in the EU,[141] and places within the world's top 20 for fertiliser imports and exports.[142] Unfortunately, a shift towards more organic farming methods is not imminent: between 2012 and 2020, the share of organic agricultural land has decreased by nearly one-quarter—in stark contrast to other EU countries, all of which have significantly increased their shares of organic farmland. Why? Subsidies granted to organic farms were subject to strict and complicated restrictions following significant fraudulent action—and this change in the rules caused a decline in the number of organic farms, implying that a number of farms didn't intend to truly operate following organic standards.[143]

Despite the falling uptake of organic farming subsidies in recent years, the latest reform of the EU *Common Agricultural Policy* (CAP) has hopes to spur sustainable agriculture in Poland. The Polish CAP national strategy plan aims to provide direct payments to incentivise sustainable agricultural practices such as maintaining agro-forestry services, mixing manure on arable land, and implementing diversified cropping patterns. The plan also intends to provide financial support for start-ups and young farmers.[144] Given the extent of the workforce involved in agricultural activities, it will be critical to financially support more sustainable practices, and provide training and other practical support to the local farmers. While fertiliser use saw a sharp decrease in the late 1980s, it has steadily increased back to 1970s levels: 177.6 kilograms per hectare of arable land as of 2018.[145] Poland's agricultural sector is characterised by mixed land use for both crops and livestock. This can be leveraged to truly embrace regenerative farming in which crops and livestock benefit each other and the land. By embracing regenerative agricultural principles, from inorganic fertiliser-free farming to more local production, Poland could shape an agrifood system that benefits the environment, minimises resource use and protects biodiversity.

In modelling this intervention, we assume a 50% cut in mineral fertiliser use, and boost the proportion of local and seasonal food on the market to 50% and 30%, respectively. By doing so, Poland could cut its material footprint by 1.4%, bringing it down from 517.9 million tonnes to 510.7 million tonnes, and its carbon footprint by 1%, from 343.1 million tonnes to 339.8 million tonnes. The Metric could increase by 0.1 percentage points, to 10.3%.

2.2 ADOPT SUSTAINABLE FOOD PRODUCTION

This scenario's second intervention centres on food consumption: we examine the impact of shifting to more planet-friendly, healthy diets that favour plant-based foods over animal products. As plant-based foods require fewer inputs and are inherently more efficient to produce, this would serve to **narrow** resource flows.

Dietary choices have a substantial impact on both our health[146] and the environment:[147] research shows that the healthiest diet for people is also best for the planet, and is very low in meat and high in plant-based protein and unprocessed foods like vegetables and whole grains.[148] Polish residents' dietary choices tend not to align with this ideal: excessive meat consumption, well-known to have adverse environmental and health impacts, has almost doubled per capita across the country since 1961. As of 2017, it topped 88 kilograms per person per year[149]—substantially above the EU average of 67 kilograms that same year[150] and double the global average.[151] High cholesterol—primarily caused by excessive consumption of saturated fats present in animal products, salted snacks and sweets—is common among Poles, affecting nearly two-thirds of residents.[152] Overweight and obesity rates have been on the rise over the past two decades and top the EU average, with the latter affecting nearly one-fifth of Polish adults—and policy on healthy food has been criticised for being far too lax. Few—if any—restrictions exist regarding advertisement of unhealthy foods to children, while private companies lack support and training for their employees.[153] Actions prioritised for the future centre on improved labelling systems—calling attention to salt, sugar and trans fats—as well as training for those responsible for feeding children,[154] with little focus on environmentally-friendly and health focused diets. However, food's affordability in the country may provide a solid lever of adopting more planet-friendly diets: food prices in Poland are among the lowest in the EU[155] and healthy options are widely available. One study indicated that three-quarters of Poles are interested in buying more sustainable agricultural products, with most indicating that they'd be willing to pay a premium of 20% for these goods.[156] And what's more: meat-free diets are on the rise, with more than one-third of the population making attempts to limit their consumption of animal products.[157]

In modelling this intervention, we assume three different dietary strategies throughout the population—all of which focus on shifting to a more plant-based caloric intake. The modelling parameters of each strategy have considerable overlap with each other and thus should not be seen as individual aggregated strategies. The first demand-side strategy, assumes Polish residents transition to a vegetarian diet: This strategy would have a large impact on both the material and carbon footprints, reducing them by 3.6% and 2.1%, respectively. The Metric could swell by 0.7 percentage points, to 10.9%. If each Polish resident were to embrace a vegan diet—with otherwise similar assumptions to the previous strategy—the material and carbon footprints would decrease by 6.8% and 8.3%, respectively; with the Metric growing 1 percentage point. Embracing a Mediterranean diet would bring lower (but still substantial benefits): the material footprint would drop by 1.9%, and the carbon footprint by 0.8%. The Metric would still benefit substantially, growing by 0.5 percentage points, to 10.7%.

2.3 REDUCE FOOD WASTE

This intervention revolves around cutting household-level organic waste: preventable food waste—that which is tossed in the bin post-expiry-date, 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**.

Poland's total food waste is estimated to be 4.8 million tonnes per year – equating to 127 kilograms per capita—slightly less than neighbouring Germany (146 kilograms per capita)[158] but significantly more than what was reported in Czechia (80 kilograms per capita).[159] However, households have a bigger role to play in the food waste issue than in other EU countries: in Europe, 42% of food waste stems from households. People tend to buy too much, store their food improperly, discard edible components (think bread crusts or apple peels), toss leftovers or prepare portions too large to finish.[160] In Poland, this portion is far above the average: households are responsible for 60% of food waste—representing around 2.9 million tonnes—with the manufacturing, service and retail sectors only claiming 30%.[161] Causes are fairly standard, but 'best before' dates (or *daty minimalnej trwałości*) are poorly understood in particular: 24% of Polish residents grasp the term's true meaning, compared to the European average of 47%. On the other hand, 'use by' dates (*przydatności do spożycia*) are better understood by Poles than the European average: 57% compared to 40%. The difference in these figures may indicate that Polish shoppers interpret all dates printed on food as indicative of final consumption. Nationally there is a lack of coherent and unification in organic waste collection and management, meaning that some cities are lagging far behind in recovering such waste for recycling and a national strategy is more difficult to coordinate.[162] One strategy being pursued to recycle food waste is through anaerobic digestion to produce biogas for energy. However, thus far Poland has one of the lowest installed capacities of anaerobic digesters in the EU with approaximartely 5% of the installed capacity of front-runner Germany.[163]

EU-wide action has been rolled out to tackle food waste as an economic and ethical issue, with awareness-raising campaigns and educational initiatives aimed at consumers particularly prevalent.[164] In response to EU objectives to cut organic waste generation, Poland has launched a number of regulations targeting manufacturers, entrepreneurs and other food chain stakeholders: The Act on Counteracting Food Waste, for example, prevents retailers from tossing unsold food still suitable for consumption, while shops that earn half their sales from food items are obliged to donate leftover items to charities, with fines dolled out for food that's deliberately thrown out.[165] In 2019, the Roadmap towards the transition to a circular economy included more consumer-focused measures on food waste reduction, including educational campaigns centring on proper planning, preparation, storage and sharing. Local NGO-run initiatives are also tackling the issue at a smaller scale, promoting campaigns and events from zero waste fairs that demonstrate methods to cut waste while cooking to campaigns for food sharing and donation.[166]

In modelling this intervention's impact, we assume a flat reduction of 75% in the amount of organic waste produced by households. By doing so, Poland could cut its material footprint by 1.5%—bringing it down to 510.1 million tonnes, and its carbon footprint by 1.2%, from 343.1 million tonnes to 339.2 million tonnes. The Metric could increase by 0.5 percentage points, to 10.%.

Impact on Poland's circularity:

All together, this scenario could bring substantial benefits: Poland's material footprint could drop by a substantial 7.9%, bringing it from 517.9 million tonnes to 477 million tonnes, while the carbon footprint could drop by 9.1%, lowering it from 343.1 million tonnes to 311.8 million tonnes. The Metric could grow 1.1 percentage points, to 11.3%. Embracing a circular food system could also bring a range of co-benefits to Poland, from the improved health of its residents' to lower air pollution to healthier soil and flourishing biodiversity. Cutting back on food waste could economically benefit consumers through buying less food overall, while sustainably producing food locally could help ensure greater resilience, protecting against future shocks such as pandemics or wars. 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.

3. RETHINK MOBILITY

Transporting people and products from A to B consumes vast quantities of materials and spews emissions—and yet we're dependent on transport for every-day commuting, travel and freight shipping. It's not surprising that transport claims the second-largest portion of Poland's territorial emissions, representing nearly one-fifth of the total.[167] Poland's *Sustainable Transport Development Strategy Until 2030*[168] aims to tackle this by supporting the integration of different forms of mobility; maximising the share of no- and low-emission transport modes; modernising and expanding transport infrastructure; modernising vehicle stock where appropriate; and better managing freight transport to improve shared services. Achieving these aims will require heavy investment in infrastructure—mobility hubs and electric vehicle charging stations, for example—to quickly implement technological advancements, as well as measure and instigate a society-wide modal shift towards more sustainable forms of transport. So far, the electrification of public transport is already making good progress, but this progress is hindered by an electricity system still heavily reliant on fossil fuels. Progress to decarbonise other road transports as well as for air, train and sea travel will require further innovation backed by heavy investment. This is of particular concern for the country: air pollution—for which transport is a key driver—poses a significant threat to health in Poland and is among the worst in Europe.[169] Some action is taking place to combat this: the government now permits all municipalities to set up zero-emission zones, the purchase of electric vehicles are subsidised, and support is given for the implementation of electric vehicle charging facilities at multi-family buildings.[170] Where electrification isn't possible, alternative technologies—such as hydrogen and alternative fuels—should be considered for example in shipping and for long-haul road transport. The *Law on Electromobility and Alternative Fuels*, introduced in 2018, supports the development of markets and infrastructure for both electrification and alternative fuels such as biofuels.[171] However, it must be emphasised that technical solutions alone won't be enough for Poland to reach its net-zero goals; a shift in modes of transport and mobility patterns will be crucial. Future policy and action must reflect this, enabling behavioural change through infrastructure and urban planning that supports residents in embracing a car-free lifestyle.

This 'what if' scenario reimagines Polish mobility, modelling four interventions to cut the material footprint and boost circularity. The scenario includes strategies that reduce private mobility demand through embracing a car-free lifestyle, encouraging a modal shift and supporting flex work as well as decarbonising the vehicle fleet through prioritising electric vehicles. In general, the prioritisation of circular mobility strategies should take the approach of: reducing mobility demand, lightweighting vehicles and infrastructure and finally, powering with clean energy. 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. It's also worth noting that this scenario only measures the impact of changes to private mobility—passenger vehicles in particular. Ensuring the optimisation and decarbonisation of all transport across Poland—from buses and trains to ferries—will require broader and more systemic change.

3.1 ADOPT A CAR FREE LIFESTYLE

This scenario's first intervention imagines a modal shift among Polish residents, illustrating potential benefits from 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 Poland, more and more residents are aiming for car ownership: few opt for options such as car sharing, carpooling or even active transport modes like cycling—and the number of cars on the road has more than doubled over the past two decades. Poland boasts 642 cars per 1,000 inhabitants, the third highest rate in the EU as of 2020, and has now surpassed other vehicle-heavy nations such as France, Sweden and the United Kingdom.[172] Many of these 'new' vehicles are actually second-hand cars imported from other EU Member States: and while shopping second-hand is often considered a core circular strategy for consumers looking to lessen their impact, these older cars tend to be highly polluting, both damaging human health and slowing the battle against climate change.[173] In spite of these imports slowing over recent years, their presence on Polish roads were at an all-time high in 2020.[174] However, alternatives to passenger cars are gaining popularity: the total length of bicycle paths have increased by 139% between 2011 and 2018, while bicycle sharing options represent the biggest portion of shared mobility.[175] Car sharing options are on the rise in major cities—such as Warsaw, Wroclaw, Poznan, Krakow and Tricity[176]—with an explosion in the market over recent years: in 2017, eight companies offered approximately 900 vehicles, a figure that more than quadrupled to 4,482 in 2019.[177] This growth can be attributed to rising demand: 630,000 Polish residents expressed a need for car sharing services in 2019, with this figure forecast to triple by 2025.[178] This intervention represents a huge opportunity for the country: replacing car use with more active modes of transport—such as walking and cycling—or leveraging public transport could bring benefits beyond the environmental. Its larger cities, such as Lodz, Krakow, Wroclaw and Warsaw, all rank within the world's top 30 for traffic congestion[179]—and many of its cities are characterised by some of the EU's worst air pollution, exposing residents to harmful particulate matter.[180]

In modelling this intervention, we assume that all of the urban population and half of the rural population embrace a car-free lifestyle. This means that one-quarter of mobility by car is eliminated and reallocated to bicycle use (15%) and walking (10%). 30% of total mobility is reallocated to car sharing and car pooling, while the remaining 45% is unchanged. In all, this intervention could decrease Poland's material footprint by as much as 0.8% (primarily due to reduced fossil fuel demand), bringing it down to 513.8 million tonnes, while the carbon footprint would shrink by 1.5%, down to 338.1 million tonnes. The Metric could grow by 0.7 percentage points, to 10.3%. Embracing more circular modes of transport—circumventing pollution from second-hand car use and congestion—and shifting to active transport would benefit health among Polish residents.

3.2 STICK TO FLEX WORK

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

Traditionally, the Polish workforce has been office-based, with only 4.6% of workers based at home in 2019—a trend flipped by the pandemic's onset. This figure almost doubles to 8.9% in 2020.[181] This is slightly below the EU average of 12.3%, with neighbouring Germany boasting a substantially higher proportion of work-from-home workers—14.8% in 2020.[182] As this relatively new facet of work culture develops, the Polish government has sought to create regulations for remote working—a step up from telework's current level of recognition. This also implies greater changes to come: employer duties that are currently advised, such as providing workers with the equipment necessary to perform their duties, may become mandatory in the future as regulations develop.[183]

To model this intervention, we assume a 15% boost in work-from-home matched an equal reduction across transport modes for commuting: a 20% reduction for car, bus and train. We also estimate lessened demand for commercial real estate, as required office capacity will decrease as more workers stay at home. By embracing this intervention, Poland could usher in a 0.5% reduction in the material footprint, bringing it down to 515.6 million tonnes, and decrease the carbon footprint by 0.3%, bringing it down to to 342 million tonnes. The Metric would increase by 0.3 percentage points, to 10.24%.

3.3 EMBRACE 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. Polish residents 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.

As noted previously, car use in Poland is high, although relatively on-par with the EU average (around 80% versus 82%)—and it's grown exponentially over recent years, with the number of passenger kilometres travelled increasing by 120% between 1995 and 2019. This far surpasses the EU average, where passenger kilometres have increased by just 30% over the same time period. And what's more: while passengers across the EU have been taking the train more and more, with kilometres travelled increasing by nearly 44%, train travel in Poland has veered in the opposite direction—seeing a decrease of 17% over the past few decades. A similar trend has emerged for tram and metro use in the country.[184] Studies show that instigating a modal shift in Poland may be difficult: economic factors, such as decreasing public transport fares, weren't found to be very effective in persuading travellers to lower their car use. Increasing the modal share of public transport will likely require interventions that make car use more burdensome in tandem with improving the quality of public transport services and infrastructure.[185] Currently, investment in rail and bus infrastructure is approximately equal to that of passenger car infrastructure. This ratio will have to shift more towards developing public transport infrastructure to realise this scenario.[186] It will be most efficient to make these changes in urban areas, which house 60% of the population and are far more dense, meaning that public transport networks would be utilised at a far greater rate.[187]

In modelling this intervention, we assume that 35% of passenger kilometres currently travelled by car are redistributed to journeys by bus (74%) and urban rail (26%). By doing so, Poland could cut its material footprint by 0.3%, down to 516.3 million tonnes, and its carbon footprint by 0.6%, down to 341 million tonnes. The Metric would grow by 0.3 percentage points, to 10.24%.

3.4 ELECTRIFY THE VEHICLE FLEET

While reducing mobility—especially by car—should be Poland's priority, cleaner mobility should follow. This scenario's final intervention comprises a number of strategies that tackle vehicles use phase by electrifying Poland's vehicle fleet. This will **narrow** resource flows (by cutting fuel use) while also **regenerating** flows, through powering all additional electricity demand with renewable energy. Here, it's worth noting potential trade-offs and knock-on effects: electric vehicles typically consume more materials than their fossil-fuelled counterparts, and also contain critical materials, particularly in their batteries. The development of electrification infrastructure is also highly materially-intensive. This intervention should crucially be understood in the context of the previous ones as well as considering the energy system in Scenario six. To be effective, electrification must be developed in tandem with a substantial fleet reduction and modal shift, to prevent a spike in the material footprint or other potential consequences, as well as sourcing energy from a low-carbon energy system. While Poland is making progress in shifting to electric vehicles, it lags behind the rest of the EU for all vehicle types: in 2020, electric vehicles represented just 2% of new registrations, ranking Poland the third lowest in the EU.[188] This figure sharply contrasts with other European nations—such as Norway—where electric vehicles make up as much as 75% of new registrations. Of all vehicles in use in Poland, only 0.1% are electric. However, sharper progress has been made in terms of electric buses: before 2015, no systems were in place, and by 2020, 33 systems were rolled out throughout the country[189]—and the country has become the EU's largest exporter, shipping electric buses primarily to Germany and Italy. While a stronger shift to an electrified fleet may be necessary, it's not imminent: Poland currently lacks the infrastructure needed to meet EU regulations that will ban the sale of combustion engines in 2035, and processes to build up charging points remain slow, between one and three years—substantially lagging behind other EU countries. Insufficient infrastructure means that adoption among Polish residents has been slow—and may also imply fiscal penalties down the road if EU objectives aren't met.[190] Nonetheless, the general outlook is positive: the Polish Alternative Fuels Association expects charging points to increase tenfold in the next three years, while the government has launched a number of strategic frameworks and regulations to drive electric vehicle use forward. The *Electromobility Development Plan* and the *Law on Electromobility and Alternative Fuels*, for example, promote the development of electric fuel vehicles, while the *My Electric Vehicle (Mój Elektryk)* subsidises the purchase of electric vehicles by individuals and companies. In busier cities such as Warsaw, Lodz and Krakow, where parking spaces are few and far between—and expensive—perks like free parking have also encouraged some drivers to go electric, with others swayed by tax breaks.[191] While Poland has a way to go, the overall transport policy environment within the country represents a move in the right direction but should work closely in tandem with decarbonising the electrification system (Scenario six) to harvest all of the benefits of electrification.

To model this intervention's impact, we assume that all of the bus fleet and half of the car fleet goes electric—with the additional demand for electricity fully satisfied by renewable sources. The demand for transport—usually expressed in terms of passenger kilometres for both modes—is kept constant. By electrifying its fleet to this extent, Poland could see a 1.4% reduction in its material footprint and 2.3% reduction in its carbon footprint, lowering them to 510.4 million tonnes and 335 million tonnes, respectively. The Metric would rise by 0.13 percentage points, to 10.3%.[192]

Impact on Poland’s circularity:

By combining four mobility-related interventions, Poland has the power to substantially cut its material footprint, bringing it down to 510.4 million tonnes—and 1.4% reduction. It could also lower its carbon footprint by 2.3%—down to 335.4 million tonnes—while bumping up its Metric by 0.1 percentage point, to 10.3%. Poland would also likely enjoy a range of other environmental, social and economic co-benefits from implementing these strategies: less harmful air pollution, as noted, as well as lighter congestion in busy cities, less noise, and increased room for green spaces, for example.

4. CHAMPION CIRCULAR MANUFACTURING

Our current linear system excels at generating vast quantities of waste. This can top 25 billion tonnes worldwide in a single year,[193] driving climate change and polluting air, land and water, with dire impacts on many ecosystems and species.[194] Currently, the approach to waste management largely centres on end-of-the-pipe solutions such as incineration and landfilling as opposed to strategies that design out waste to begin with or use it as a resource. A circular approach revolves around eliminating 'waste' as we know it, improving manufacturing processes, for example, to cut material losses, or championing industrial symbiosis in which the waste or byproducts of one industry become raw materials for another. Manufacturing waste contributes to a greater share of total waste generation in Poland compared to the EU average: 17% compared to 10.6%. This shows the importance of tackling the country's manufacturing waste relative to other sectors, in which only mining and quarrying generates more (36.7%).[195] In absolute terms, almost 30 million tonnes of manufacturing waste were generated in 2018, however, this is more than half of that generated in 2006.[196] Building on the progress made already in terms of waste reduction, Poland has launched a National Waste Prevention Programme.[197] The programme includes strategies to reduce waste in the industrial sector, such as improving cooperation between industrial facilities to boost industrial symbiosis through the exchange of raw materials, infrastructure and services. However, this programme also aims to stimulate economic growth, which intrinsically implies more resource use and thus more waste. Therefore, it also must go further to minimise environmental impact by cutting total waste generation through further investments in infrastructure, new technologies and research and development programmes, as well as improved education and awareness programmes.

4.1 IMPLEMENT RESOURCE EFFICIENT MANUFACTURING

This scenario's only intervention combines three strategies to improve resource efficiency in manufacturing. Gains in material efficiency should be integrated in early stages: cutting yield losses involves making the most of technological advances to get more from less. Further along the value chain, where the metals will be used to make a vehicle or machinery, 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.

The impact in Poland could be substantial as it is a significant manufacturing hub, with manufacturing contributing to 17% of the country's GDP, making it the eighth-largest in terms of contribution to GDP within the EU.[198] Leading manufacturing sectors include automotive; metal products; and miscellaneous machinery and equipment.[199] Metals are the top exports (by value) for Poland with vehicle parts (many of which are metals) accounting for US$12.4 billion (zł45.1 billion)[200 201] and entire vehicles, the fourth largest export product, accounting for US$5.42 billion (zł20.6 billion). Therefore, efficiency improvements in the metal sector not only provide huge opportunities to reduce waste but also opportunities for companies to cut production costs.

According to the Bloomberg Innovation Index in 2021, Poland currently ranks as a 'moderately innovative' as determined by R&D spending, manufacturing capability and the presence of high-tech companies. Investment in innovation is increasing and now totals US$9 billion (zł34.2 billion) with more than 300 research and development centres having been established as a result of this.[202] Low labour costs and high productivity also contribute to the country's leading position: labour productivity in the manufacture of basic metals has jumped by 13% between 2011 and 2022, for example. To boost Polish industry, the Government launched its Industry 4.0 Platform in 2019, aiming to act as an integrator between all stakeholders seeking to pursue Industry 4.0 and accelerate the transition to digital technologies. The platform hopes to achieve this through increasing innovation, encouraging knowledge sharing on 4.0 processes and developing competencies in robotics and automation, for example. The platform will be accompanied by a 25-year period of funding as part of the Responsible Development Plan (Morawiecki Plan).[203] The Government also incentives advanced manufacturing through tax breaks and grants for further R&D. While Poland is actively pursuing more innovation in its advanced manufacturing sector, it still has technological and regulatory barriers holding it back. There is a shortage of experts in the sector, loose technological standards and often resistance to embracing new innovation.[204]

In modelling this intervention, we consider a mix of strategies. We assume that metal inputs of aluminium and steel for specific products are reduced by 28% due to process improvements. We also model the impact of reducing yield losses and diverting scrap (both for metals) from the manufacturing industry to other sectors, thereby reducing their virgin material use.

Impact on Poland's circularity:

By boosting resource efficiency in manufacturing, Poland could cut its material footprint by 2%, lowering it from 517.9 million tonnes to 507.7 million tonnes. The carbon footprint could be reduced by 1.2%, from 343.1 million tonnes to 339.1 million tonnes, while the Metric could grow by a slight 0.2 percentage points, up to 10.4%. The country could also 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.

5. KEEP GOODS LIKE NEW FOR LONGER

With the industrialisation of production and an economic model focused on profit that encourages businesses to sell more and more goods, replacing items when they don't work perfectly, are costly to repair or simply unwanted due to a desire to 'keep up with the trends' has become the norm. However, such consumer choices are often driven by industry-led initiatives such as planned obsolescence which necessitates that businesses and consumers must buy more products while the manufacturers cash in on producing new machinery, equipment and consumer goods. Therefore, it is the duty of both manufacturers and consumers to make the shift away from quantity and towards quality through embracing activities that can extend the life of both industrial and consumer goods.

Industrial manufacturers can deploy a range of activities to extend the life of machinery and equipment. Industrial manufactures can complement their offerings beyond sales, and offer services such as refurbishment and regular repair and maintenance of large equipment—providing additional revenue streams, increasing the trust and loyalty of customers and displaying an accolade of conducting more sustainable practices.

Polish consumers are in fact already showing an appetite for more circular goods: two-thirds of respondents in an Innowo survey would like to repair their goods more often and 98% of respondents regularly choose products based on durability and quality. In terms of fashion and clothing, the same survey found that the vast majority (74% of respondents) usually wear clothes until they wear out, and 67% try to buy clothes made of high-quality materials so that they serve them for as long as possible. As it stands, there is only so much that Polish consumers can do themselves to spur a circular economy for goods: repair can be expensive and it also requires a set of skills that are generally lacking and should be reintroduced to the community, and many products aren't designed to be easily repaired in the first place. Fortunately, the country can hugely benefit from the EU Sustainable Product Initiative[205] that aims for products to be more durable, reusable, repairable, recyclable, and energy-efficient, and will therefore help Polish consumers, and importantly businesses, bring some of these demands into reality. The country should also invest in reintroducing crucial skill sets into the workforce through training that can facilitate and promote circular practices such as repair and remanufacturing.

This 'what-if' scenario reimagines how Polish machinery, equipment and consumer goods are designed, used and treated at end-of-life. It shows that, ultimately, it's possible to have assets that function 'as good as new' for longer. The scenario boosts repair, remanufacturing activities and longer-lifetimes for products—on both the industry and consumer side.

5.1 ADOPT R-STRATEGIES FOR MACHINERY AND EQUIPMENT

This scenario's first intervention employs various R-strategies (see text box on page 64) for manufacturing machinery and equipment.[206] Strategies such as remanufacturing, refurbishment and repair can be leveraged to stretch product lifetimes, **slowing** flows, subsequently lowering the need for new products, resulting in an overall **narrowing** of flows.

While remanufacturing goods is not a large and standalone market in Poland, it holds huge potential. Currently, remanufacturing activities happen on a small-scale, and in practice it's often difficult to distinguish these activities from reconditioning and repair. Across Central Europe, remanufactured equipment is typically purchased to replace an old product—rather than as a new product—indicating that consumers may perceive remanufactured goods as lower quality.[207]

The automotive industry reportedly has the highest remanufacturing potential in Europe—a fact that is likely to expand Poland's strong automotive manufacturing industry.[208] This potential partly lies in the rise in EV (Electric Vehicle) purchases. And partly due to EV parts, such as electric driving motors and lithium batteries, being potentially easier to remanufacture than traditional ICE (Internal Combustion Engine) car parts, due to the lower number of parts and reduced mechanical complexity.[209] Manufacturers would be smart to pursue remanufacturing strategies, especially as the supply of end-of-life EV parts is expected to soon rise: the EV remanufacturing market will see between 2 and 5% growth a year between 2020 and 2025.[210] Manufacturers who can rapidly increase penetration of circular models, such as remanufacture, stand to gain financially and unlock a differentiated advantage compared to their competitors. But they will likely need to seek out third-party partners and remanufacturing sub-contractors to carry out these new operations. Remanufacturing would also be an asset to other industries such as industrial capital equipment (such as wind, gas and steam turbines, pumps, and more). In the case of wind turbines, remanufacturing and repurposing products entails increasing the recovery and recycling of materials from decommissioned turbines and replaced blades from repowering.[211] With the ambitious offshore wind plans in Poland, the remanufacturing of such equipment in the future could substantially boost the circularity of the energy sector. And in general, Poland has a strong capital equipment manufacturing sector and so many opportunities will arise as interest in remanufacturing and refurbishment increases. This opportunity may be greater in Poland than in other neighbouring countries, such as Germany, due to cheaper labour costs.

To model this intervention, we make a number of assumptions related to remanufacturing, refurbishment, repair and maintenance, and reuse. For remanufacturing and refurbishment, we assume that the overall volume of sales would stay the same due to the redistribution and resale of the remanufactured/refurbished products, thereby creating a new life cycle. The displacement of new sales is, therefore, modelled as a net-reduction in the inputs needed to produce the same volume of product output. For repair, maintenance, upgrading, and reuse, we assume a reduction in sales due to the life cycle extension of products already in the loop. We apply strategies at the same level across product categories, with the following split: 50% remanufacturing and refurbishment, 25% reuse, and 12.5% each for both repair and maintenance and upgrading.

Impact on Poland's circularity:

By making the most of R-strategies for machinery and equipment, Poland could achieve a 2% reduction in its material footprint, bringing it down to 507.7 million tonnes, while cutting its carbon footprint by 1.5%, bringing it down to 338.1 million tonnes (excluding changes in direct household emissions). The Metric could be boosted by a slight 0.2 percentage points, bringing it up to 10.4%.

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 entire 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.

5.2. PROMOTE A MATERIAL SUFFICIENCY LIFESTYLE

This intervention explores a range of strategies to help Polish residents adopt a lower-impact lifestyle, that values minimalism and conscious living over excess and waste. Minimising the consumption of everyday goods—from electronics and appliances to furniture and textiles—will **narrow** flows, while encouraging product repairs will stretch their lifetimes, thereby **slowing** flows. This intervention encourages a lifestyle of material sufficiency: having and consuming enough, but not too much.

Electronics and appliances are integral parts of modern society, allowing people to communicate with friends and family, conduct many types of work and wash clothes more conveniently than ever. However, coupled with the linear economy, and the planned obsolescence of many products, they produce vast amounts of waste. The current lifetime of personal electronics, for example, is two years less than their designed lifetimes—showing the potential extending products' usable life and encouraging repair, remanufacture and recycling.[212] The excessive consumption of electronics is reflected in the amount of waste electrical and electronic equipment (WEEE) collected every year in Poland. In 2019 this amounted to 11.8 kilograms per capita, above the EU average of 10 kilograms per capita and almost double that of 2018.[213] The increasing trend of buying more electronics and appliances has significant effects on the extraction of virgin materials, including rare earth elements, as well as environmental concerns over their management, with many products contaminating soil, water and air pollution at their end-of-life.

Furniture follows a similar trend to that of electronics and appliances, with Poland throwing away almost 500,000 tonnes of furniture per year—one of the highest levels of any EU country.[214] In order to help combat this, the country hosts a range of circular trials:[215] the 'Might be Useful' and 'Good Wardrobe' projects encourage customers to bring back unused products instead of throwing them out—the 'Good Wardrobe' project enabled the collection of 8 tonnes of clothes which were given to people in need. Meanwhile, the first potential furniture subscription offers are being prepared as part of a Furniture-as-a-Service project and a collection service for old IKEA furniture was launched in Warsaw, encouraging consumers who buy new furniture to return their old purchases which are then passed on to Habitat for Humanity, Poland. As in the rest of Europe, hyper-consumerism is rife when it comes to clothing—accelerated by the emergence of local and international fast fashion players in the country.[216] Research notes that not all clothing sector entrepreneurs are ready to talk about the environmental challenges related to their business[217] and the concept of sustainable fashion has yet to be popularised.[218] Nonetheless, the companies aware of the environmental challenges of fashion are growing: every year, new organisations show others how supply chains can be organised to both meet quality criteria and the principles of sustainable development.[219] Consumer demand for sustainable fashion is also on the rise, signalling that if the offering is there, consumers will make the most of it.

In order to reduce the environmental impact of consumer goods, consumption must radically decrease. This can be achieved by using goods for longer through actively repairing and refurbishing products as much as possible, as well as adopting the view of being satisfied with less things, without seeing this as a compromise on quality of life or wellbeing.

In modelling this intervention, we assume Polish residents adopt a minimalist lifestyle: they buy local products, and prioritise furniture offerings where replacement parts are provided when components become worn or broken. Spending on appliances and electronics such as radios, televisions and computers is cut by 50%, while textile use is cut in half. In doing so, Poland could cut its material footprint by 2.9%—bringing it down to 502.8 million tonnes. The carbon footprint embodied in these products, however, would not change. The Metric could increase by a slight 0.3 percentage points, bringing it up to 10.5%.

Impact on Poland's circularity:

By extending the life of goods, Poland could cut its material footprint by 4.8%, lowering it from 517.9 million tonnes to 507.7 million tonnes. The carbon footprint could be reduced by 1.3%, from 343.1 million tonnes to 339.1 million tonnes, while the Metric could rise by 0.4 percentage points, up to 10.6%. This scenario could also bring a range of co-benefits: support local businesses with a specialisation in restoring goods, reducing waste and tackling the rising cost of living crisis, by reduced consumption of goods which aren't enhancing the quality of life or wellbeing of residents and thus saving money.

6. POWER POLAND WITH CLEAN ENERGY

The world has been powered by fossil fuels for centuries: coal use can be traced back to the 1300s, and ancient civilisations used petroleum in its various forms well before technology for drilling or refining was developed. Now, it's time to embrace a new source of energy, harnessing the power of clean, renewable sources: from wind or hydro to solar. As part of the *European Green Deal*, the 2030 *Climate Target Plan* sets out to cut GHG emissions by at least 55% by 2030.[220] In a bid to achieve this goal, the *REPowerEU* plan aims to increase the share of renewable energy sources in the energy mix to 45% in the same period.[221] Ultimately, the *European Green Deal* aims to reach net zero emissions by 2050—a mammoth task, but desperately needed. However, Poland has developed a specific national derogation due to its difficult starting point: heavily dependent on coal, Poland has a far larger transition ahead than many other European countries. While the *Energy Policy of Poland Until 2040* sets a solid framework for the transition to a low-emissions energy system—and substantial progress has been made in cutting the energy sector's impact over the past years—fossil-fuel-dependence remains among the highest in Europe: a just transition that considers Poland's starting point and associated social context and economic burden will be crucial.[222] The process will be expensive, likely requiring an investment as high as €372.1 billion (zł1,600 billion) over the next two decades to shift energy and electricity production to renewable and nuclear power. It's crucial that attention is afforded to maintaining energy prices throughout the transition, preventing increases in energy poverty,[223] which already affects nearly one-fifth of Polish residents and has worsened over recent years.[224] Various national and EU-level funds will be allocated to the energy transition over the next decade, totalling €60.5 billion (zł260 billion), from the *Cohesion Policy* and *Recovery and Resilience Facility* to the *Just Transition Fund*, *React-EU* and other priority programmes. Plans for Poland's first nuclear power plant have rolled out, with the aim to launch in one decade—and further targets to build six units by 2043, providing a reliable source of power generation with low emissions. However, it's worth noting that nuclear plants are more expensive and time-consuming to construct than other renewable infrastructure: Poland may consider diversifying its energy mix to circumvent nuclear's significant downsides, such as managing radioactive waste, and reducing dependence on foreign input for nuclear fuel, building expertise and maintenance.

While Poland's transition to a greener energy system will be complex, it's of critical importance—and is inevitable. To this end, this scenario models the impact of broad changes in the energy mix, examining the impact of a shift away from coal to various other energy sources.

6.1 PHASE OUT COAL USE

This scenario presents a single intervention that examines the impact of shifting away from coal through a range of strategies, involving substitution with cleaner energy sources, such as renewable energy and natural gas, to generate electricity and heat. All strategies (gas excluded) serve to **narrow** and **regenerate** flows by reducing coal consumption and embracing cleaner energy sources—however, it's worth noting that the energy construction will be highly material-intensive where the build up of new infrastructure is concerned.

Poland can be characterised by its tight relationship with and reliance on coal, which provides more than two-thirds of the country's electricity—a figure it aims to pare down to 37.5% by 2030. Although production isn't planned to halt until 2049, its use will be phased out of cities over the next decade, with rural areas lagging behind. Gas, which currently only represents 17% of the total energy supply, will have an important role to play in the short-to-medium future: although still a fossil fuel, it represents a cleaner alternative—and will be crucial in reducing greenhouse gas emissions in the short-term. The Baltic Pipe—connecting Norway, Denmark and Poland—will help diversify the country's supply and provide a steady inflow for the coming years. A shift to biomass-based energy will also play an important role in the energy transition. Biomass already contributes 11.5% of total energy consumption, and claims more than two-thirds of total renewable energy consumption: this can be further strengthened through domestic resources, such as waste from the forestry industry. This strategy is particularly relevant to Poland, as coal plants can be gradually converted to biomass plants—operating by burning both in the meantime, and therefore allowing a quicker transition than renewables, which require all-new infrastructure. If managed well and with the intention to safeguard domestic employment, alternative employment opportunities for those currently employed in the coal industry could be identified, including through initiatives to match to and re-skill these workers for working with technologies and processes in biomass plants. In the longer term, Poland aims to embrace more renewable energy sources, although targets are more modest than for other EU countries: 32% of electricity to be renewable by 2030, as opposed to energy. As noted previously, offshore wind and solar are both expected to increase—although these have the problem of providing an intermittent energy supply as opposed to nuclear energy which can provide a base supply.

In modelling this scenario, we assume that half of households' electricity consumption currently stemming from coal will be replaced by gas (25%) and a mix of solar and wind power (12.5% each). The same parameters will be applied to industrial electricity consumption. For heating, we assume that all coal is replaced by oil and gas products as well as wood fuel.

Impact on Poland's circularity:

By shifting away from its dependence on coal, Poland could cut its material footprint by a substantial 12.8%, bringing it from 517.9 million tonnes down to 451.6 million tonnes.[225] The Metric could increase by 1.2 percentage points, up to 11.4%. This scenario could also bring a range of co-benefits: cleaner air, for example, and the creation of numerous jobs in cleaner energy sectors. The conversion of coal power plants to biomass can maintain jobs by reskilling and training workers in new technologies.

COMBINED INTERVENTIONS

Individual interventions along a range of platforms have a limited impact on the Circularity Metric and the material footprint, but when we combine the interventions we see a substantial impact.

In our broad 'what-if' image for the economy, if we harness the cross-intervention synergies, Poland reaches a Circularity Metric of 19.9% and the material footprint of consumption is lowered by a remarkable 40.4%, from 517.9 million tonnes to merely 308.7 million tonnes.

When combining the interventions, it is crucial to be aware of potential overlaps across the different interventions. In particular, the scenarios on repair, recycling, as well as fossil resource consumption, are applied across sectors, thereby also influencing the industry specific interventions on construction and agriculture. 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.

SCENARIOS, INTERVENTIONS & STRATEGIES

	INTERVENTIONS	STRATEGIES	IMPACT AND MATERIAL FOOTPRINT
1. BUILD A CIRCULAR BUILT ENVIRONMENT	**1.1 Optimise building stock expansion**	• Limit housing stock expansion • Use secondary materials for new construction	Reduction of material footprint by **26.4%**, decrease from 517.9 to **381.2 million tonnes**. Reduction of carbon footprint by **36%**, decrease from 343.1 to **219.6 million tonnes** of C02e. Circularity rises from 10.2% to **13.3%**. Co-benefits: Reduction in energy consumption and waste, new businesses and job opportunities, reduced fuel poverty and increased wellbeing at home.
	1.2 Prioritise deep energy retrofitting	• Ensure deep energy retrofitting of housing stock	
	1.3 Create a resource-efficient building stock	• Use lightweight and durable bearing elements • Reduce losses during construction process • Prioritise local construction materials and supply chains	
2. NURTURE A CIRCULAR FOOD SYSTEM	**2.1 Shift to mineral-free fertiliser and champion seasonal, local produce**	• Reduce fertiliser use, use of heating fuels and transportation services • Shift towards organic, seasonal and local food production	Reduction of material footprint by **7.9%**, decrease from 517.9 to **477 million tonnes**. Reduction of carbon footprint by **9.11%**, decrease from 343.1 to **311.8 million tonnes** of CO2e. Circularity rises from 10.2% to **11.3%.** Co-benefits: Health benefits, increase in biodiversity and soil health, reduced household expenditure on food, new business opportunities, increased cooperation between industry, local government and farmers.
	2.2 Endorse a balanced diet	• Shift diets towards more plant-based protein	
	2.3 Reduce food waste	• Cut waste generation and maximise food recycling	

	INTERVENTIONS	STRATEGIES	IMPACT AND MATERIAL FOOTPRINT
3. RETHINK MOBILITY	**3.1 Adopt a car free lifestyle**	• Encourage car-sharing and -pooling to reduce car use • Increase journeys by bicycle and walking	Reduction of material footprint by **2.9%**, decrease from 517.9 to **502.9 million tonnes.** Reduction of carbon footprint by **4.2%**, decrease from 343.1 to **328.5 million tonnes** of CO2e. Circularity rises from 10.2% to **10.5%.w** Co-benefits: Improved air quality, less vehicle congestion, greater access to mobility through improved sharing and public transport systems, increased space for other purposes, such as green spaces.
	3.2 Stick to flex work	• Support flexible, hybrid mix working-from-home	
	3.3 Embrace a modal shift for transport	• Increase public transport occupancy	
	3.4 Electrify the vehicle fleet	• Electrify private cars, buses and freight transport	
4. CHAMPION CIRCULAR MANUFACTURING	**4.1 Scale industrial resource efficiency**	• Improve industrial processes to reduce virgin inputs for key manufacturing industries • Reduce yield losses • Divert scraps	Reduction of material footprint by **2%**, decrease from 517.9 to **507.7 million tonnes.** Reduction of carbon footprint by **1.2%**, decrease from 343.1 to **339.1 million tonnes** of CO2e. Circularity rises from 10.2% to **10.4%** Co-benefits: increased resilience to price volatility, reduced energy consumption and waste, reduced costs for waste disposal.

	INTERVENTIONS	STRATEGIES	IMPACT AND MATERIAL FOOTPRINT
5. KEEP GOODS LIKE NEW FOR LONGER	**5.1 Adopt R-strategies for machinery and equipment**	• Increase the lifetime of machinery, equipment and vehicles • Increase in remanufacturing, refurbishment, repair and maintenance, upgrade, and reuse services	Reduction of material footprint by 4.8%, decrease from 517.9 to **507.7 million tonnves**. Reduction of carbon footprint by **1.3%**, decrease from 343.1 to **339.1 million tonnes** of CO2e. Circularity rises from 10.2% to **10.6%**. Co-benefits: support local businesses, reduce waste and household expenditure.
	5.2 Promote a material sufficiency lifestyle	• Use circular textiles (through reusing, repairing, DIY, donating, recycling) • Adopt a minimalist lifestyle for furniture and home appliances, increase reparation • Adopt a minimalist media lifestyle with less focus on electronics	
6. POWER POLAND WITH CLEAN ENERGY	**6.1 Phase out coal use**	• Substite coal with renewables, gas and other lower emission fuels for electricity and heating in households and industries	Reduction of material footprint by **12.8%**, decrease from 517.9 to **451.6 million tonnes.** Circularity rises from 10.2% to **11.4%.** Co-benefits: cleaner air, creation of jobs in new sectors and maintaining jobs in existing sectors through reskilling.
COMBINED SCENARIOS	**The power of combined interventions**	**This row** presents the baseline result for enacting all scenarios in combination with each other.[226]	Reduction of material footprint by **40.4%,** decrease from 517.9 to **308.7 million tonnes.** Reduction of carbon footprint by **49.1%,** decrease from 343.1 to **174.8 million tonnes** of CO2e. Circularity rises from 10.2% to **19.9%.**

5

COLLABORATION FOR A CIRCULAR POLAND

Our current linear world is hyper-global—but for a successful circular economy, we need to scale down our focus to the local and national level by restructuring and reinventing value chains. While virgin materials may still be sourced globally, reusing materials on a local or national scale is often more economical, energy efficient and increases resilience against global supply chain disruptions. Shifting back to more localised economies will require new innovation in business and knowledge—components at the core of the circular economy. To this end, this chapter highlights the potential for circular collaboration between two countries: Poland, this report's focus, and Norway, a strong trading partner. Norway has a lot to learn from Poland's resilient, self-sufficient economy that uses a higher share of secondary materials. On the other hand, Poland can also learn from Norway, which boasts an abundance of circular initiatives across a range of sectors.

The *Circularity Gap Report Poland* is the result of regional cooperation between nations, merging circular competences in Poland, Norway and the Netherlands. The report is financed by European Economic Area (EEA) Norway Grants. The Grants have two goals: contributing to a more equal Europe—both socially and economically—and strengthening relations between Iceland, Liechtenstein and Norway, and the 15 Beneficiary States in Europe. The EEA grants are jointly funded by all three donor countries, Iceland, Liechtenstein and Norway, based on their size and GDP. Over the 2014–2021 funding period, the EEA grants totalled €1.5 billion, of which Poland received the largest portion: €398 million. This report builds on Circle Economy's experience of applying the Circularity Gap methodology to six countries and regions, and was jointly initiated by Natural State, a Norwegian strategy and project company promoting sustainability and circularity, and the Polish institute Innowo, a think-to-do tank established to spur innovation and drive systemic change towards sustainable socioeconomic progress. It provided the local network and knowledge of the Polish economy. This chapter is a first attempt to explore how two countries, Poland and Norway, could collaborate—through trade, knowledge exchange and human capital—to support each other's circular growth.

This chapter intends to build upon the industries identified in Norway and Poland that contribute most to each country's material footprint. Given the commonalities of these industries between both countries, it was deemed appropriate to focus on the industries selected in Chapter four to maintain consistency. The only omission is industrial resource efficiency, due to the local character of many of the possible circular strategies: this means there is less room for collaboration between countries. For each selected industry, a deep dive highlights opportunities for mutual benefits, in terms of circularity, based on the trade profile and specialisation of both economies, as well as the associated challenges and enabling factors. The intention is to provide a basis to realise the opportunities through joint pilot projects, knowledge exchange platforms and strengthened political ties. Although this chapter primarily focuses on bilateral opportunities between Poland and Norway, it also aims to shed light on the many regional circular opportunities for Poland in the EU and Central Europe.

DIFFERENT BACKGROUNDS, BUT A SHARED PATH FORWARD FOR POLAND AND NORWAY

Poland and Norway exhibit very different demographic profiles. Poland has a population seven times larger than Norway—with a population density more than eight times higher. Movement across borders differs greatly, with Poland being a net emigration country and Norway being a net immigrtion country. In recent decades, Poles have been relocating to other countries, typically those with higher levels of income. The opposite is seen in Norway, with more people being received into the country. This is reflected in the difference in GDP per capita between both countries, with Norway having a figure five times larger than Poland. At a high level, the economies are characterised by a similar breakdown by contribution to GDP across agriculture, industry and services sectors. The main discrepancies are a larger agriculture sector in Poland and a larger industry sector in Norway. Unemployment is relatively low in both countries, with 2.6% of the labour force in Poland being unemployed and 2.9% in Norway—both below the world average of 6.2%.

Poland has a material footprint of 13.8 tonnes per capita—a footprint that surpasses the global average of 11.9 tonnes per capita. However, this is well-exceeded by Norway's footprint, which comes in at a huge 44.3 tonnes per capita, a level far beyond our planetary boundary limits.[227] In terms of the circularity, Poland is around four times more circular than Norway (10.2% compared to 2.4%). This is because Poland's economy uses more cycled materials than Norway's, compared to their material consumption. However, it's worth noting that the Circularity Metric cannot be directly compared between countries: the methodology used for Poland's

	POLAND	NORWAY
Population (million persons)[228] *2021*	37.8	5.4
Population density (persons per square kilometres of land area)[229] *2021*	123	15
Net migration (persons)[230 231232] *2017*	-146,976	140,000
GDP per capita (€)[233 234] *2021*	15,165	75,823
GDP distribution (% of GDP)[235 236 237 238] *2021*	Agriculture = 2.4 Industry = 29.3 Services = 55.6	Agriculture = 1.6 Industry = 35.6 Services = 52.5
Unemployment (% of total labour force)[239] *July 2022*	2.6	2.9
Material footprint (tonnes per capita per year)	13.8	44.3
Domestic extraction (tonnes per capita per year)	16.7	63[240]

analysis is a newer, more sophisticated version than that used for the *Circularity Gap Report Norway*. It's not known to which extent applying the new methodology to Norway's economy would change its Metric—but we would expect a significant impact. Construction, agriculture and extractive industries contribute most to the material footprint in both Poland and Norway, with the impact of extractive industries being seen by domestic extraction levels far exceeding the global average of 12.3 tonnes per capita per year in both cases. However, potential for reducing impact is also present in other sectors, such as the mobility and energy sectors.

Poland and Norway are strong trading partners due to their proximity to the Baltic Sea, common membership of the European Economic Area (EEA), and demand for each other's unique goods and services. Although exports from Poland to Norway only represent 1.1% of all Polish exports,[241] the trade flow is important for several particular products. Exports amount to US$2.81 billion (zł10.7 billion) and are dominated by vehicles[242] (22.7% of all exports); followed by iron and steel articles (10.3%), mechanical and electricity machinery and their associated parts (13.4%)[243] and furniture (8.1%).[244] Similarly, exports from Norway to Poland represent a small portion of total Norwegian exports (2.7%), but provide a significant share of several distinct products to Poland. With an export value of US$2.36 billion (zł9 billion), trade is dominated by: fish and fish products (53.5%),[245] raw aluminium (11.5%) and crude petroleum (5.5%).[246]

As noted, this chapter builds upon the industries identified in Chapter four, which have a substantial impact on both countries' material footprints. Both countries have the potential to benefit and progress in their circular journeys: these opportunities—as well as their potential challenges and enabling factors—are presented in the coming sections.

1. HOUSING

- In Poland, 99% of buildings are made with energy- and emissions-intensive concrete and steel—or a combination of both.[247]
- Buildings consume 80–94% of their energy in the use phase (for example, lighting, heating, and cooking systems) and the remainder comes from embodied carbon in building materials. Hence, it's important to reduce energy consumption as much as possible while also transitioning to renewable energy.
- Construction and demolition waste in Poland is largely recovered (90%), however most of this is downcycled into aggregate.[248] Constructing with materials and techniques that allow for reuse and recycling without losing material value are therefore a priority.

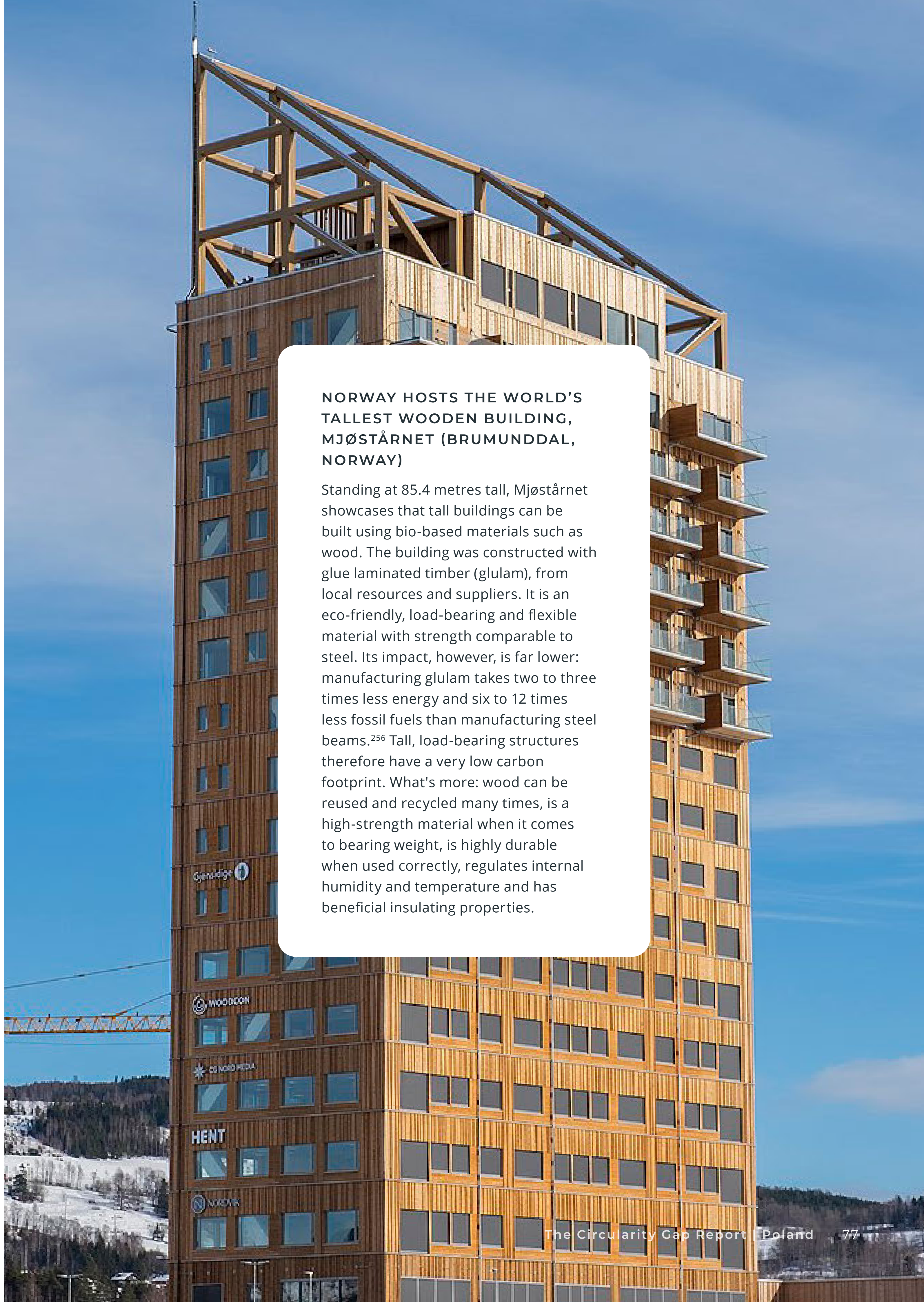
OPPORTUNITY: INTRODUCE AND SCALE UP ZERO-EMISSION BUILDINGS, WOODEN CONSTRUCTIONS AND THE USE OF SECONDARY MATERIALS

A zero-emission building is one defined by significantly high levels of energy efficiency. This eliminates the need for a conventional heating system, such as a gas boiler: these buildings can be heated and cooled more easily via renewable energy sources, such as heat pumps. Zero-emission buildings are also designed to harness nature's power to the greatest extent possible, by making efficient use of the sun during colder months and passive cooling techniques, such as strategic shading, in the warmer months. Because operational energy use drops to nearly zero, the share of embodied energy in the life cycle of a zero-emission building is higher than that of a conventional building: it tops 74%, while for a conventional building, it rests between 6 and 20%.[249] To further reduce zero-emission buildings' impact, using secondary and bio-based materials—like wood—should be a top consideration. Currently, these materials play a minor role in the Polish housing stock.

Norway is a leader in the field of sustainable buildings. The Norwegian energy system is primarily based on renewable sources, yet overall energy consumption remains high, largely due to the country's cold winters. Buildings consume a great deal of energy, and represent a large portion of total energy consumption—and this is expected to increase further. This is still the case in spite of Norway's high building standard code—one of the most impressive globally—for energy consumption that requires passive house-level energy efficiency in all new builds and renovations. In the future, these standards are set to become almost energy neutral. However, when the entire building life cycle is considered, Norway has a long way to go: only 3% of all the materials it uses are cycled back into the economy.[250] There is some criticism that policies do not go far enough to address the full life cycle of buildings and local actors are increasingly taking matters into their own hands with impressive circular practices arising across the sector.[251]

Poland has potential but is lagging. Poland does not share the same levels of renewable energy as Norway, making zero-emission buildings one strong way to reduce the energy demand—if aligned with the available share of renewable energy. Zero-emission buildings are relatively underdeveloped in Poland—but despite this, houses are becoming more energy efficient with a steady decrease in heating consumption per square metre experienced throughout recent decades.[252] However, the growth of zero-emission buildings can radically decrease the consumption further, yet so far, there are insufficient reports on how to implement a passive house in the Polish climate conditions.[253] Unlike in Norway, there are no special regulations for energy efficient buildings, although there are standards set for buildings to be known as 'low energy' or 'passive'. These follow lesser criteria than those of Norway, but this is intuitive given Norway's colder climate.[254] Poland is also characterised by concrete-based constructions, with wood constructions only accounting for 1% of new builds.[255] Although the concept of wooden houses has been growing steadily since then—with an increase in new residential wooden buildings between 2019 and 2020—it is still a relatively niche approach in the Polish construction sector.

Poland and Norway can collaborate to progress to a more circular built environment for housing. Given Norway's experience in low-emission building standards, there is a strong opportunity for knowledge exchange between the countries—both in terms of construction practices and regulation. Although specific design details will differ in different climate conditions, the principles and best practices remain largely the same. Polish workers boast a strong presence in the Norwegian construction industry, and Poland's deeply-rooted woodworking tradition and skilled craftspeople could prove beneficial in both the Norwegian and Polish construction industries. Given the more favourable labour costs of Polish workers, this presents Poland with an opportunity to be a significant supplier of human capital as Norway vastly increases its stock of wooden buildings and maintains its existing stock.



NORWAY HOSTS THE WORLD'S TALLEST WOODEN BUILDING, MJØSTÅRNET (BRUMUNDDAL, NORWAY)

Standing at 85.4 metres tall, Mjøstårnet showcases that tall buildings can be built using bio-based materials such as wood. The building was constructed with glue laminated timber (glulam), from local resources and suppliers. It is an eco-friendly, load-bearing and flexible material with strength comparable to steel. Its impact, however, is far lower: manufacturing glulam takes two to three times less energy and six to 12 times less fossil fuels than manufacturing steel beams.[256] Tall, load-bearing structures therefore have a very low carbon footprint. What's more: wood can be reused and recycled many times, is a high-strength material when it comes to bearing weight, is highly durable when used correctly, regulates internal humidity and temperature and has beneficial insulating properties.

CHALLENGES

The current construction financing model, coupled with a lack of favourable regulations, hinders circularity. The roles of users and investors are typically divergent, with the former interested in long-term costs, and the latter concerned with short-term profit. This creates an incentive for investors to use cheaper, less durable or less efficient construction methods and materials.[257] At the same time, the lack of information limits the user in fully realising how unsustainable some consutrctions are, which in turn reduces the demand for using circular practices and materials. Furthermore, there are no circular regulations to correct the market forces that deem the linear approach the dominant one. It is most probably this mechanism that has resulted in the virtual lack of household energy efficiency improvements for almost two decades in Poland, compared to relatively high efficiency gains in industry and transport.[258]

Breaking the linear tradition in construction will be difficult unless demand for circular products scales up. The lack of circular regulations, asymmetry of information, and distrust of circular products directly affects investment and public procurement decisions, while the relatively high price of circular products and materials results in lower demand for such products. As a consequence, it is hard to achieve economies of scale, which hinders a possible drop in price—which should be intuitive as circular goods are often produced from used parts or waste, which is usually considered 'worthless'. To break this vicious cycle, it's necessary to introduce a large-scale system for handling end-of-life construction elements or waste, such as reuse platforms and enhanced logistics.

ENABLING FACTORS

As material and energy prices rise, so does interest in sustainable construction and refurbishment. The rising price of gas, coal and electricity, also stemming from increased carbon pricing, has led to a growing interest in limiting heating usage, improving insulation and incorporating renewable energy sources. This is especially clear in individual residential construction: for example, as of July 2022, over 1 million Polish households already had a photovoltaic installation, and the number is continuing to grow rapidly.[259] It is expected that the price of construction materials will also facilitate circularity, mostly by encouraging the use of reclaimed materials.

The pursuit of self-sufficiency in light of global trade issues and war could boost circular construction. Both the covid-19 pandemic, as well as the Russian invasion of Ukraine, have led to global value chain failures and spiking resource and commodity prices. These issues have emphasised the importance of self-sufficiency. Currently, this is mostly visible in consumer products, but there is also high potential for the reuse of construction materials.

Increasing knowledge on the benefits of circular construction and overall sustainability awareness leads to more sustainable consumer choices. One of the basic mechanisms that influences the use of circular materials and construction methods is better access to information, while growing ecological awareness enables their application. For example, the increased use of product or construction certification to track sustainability across the value chain contributes to more sustainable purchasing decisions.[260] The same applies to the availability of lifecycle cost analyses studies that clearly show the savings, increased efficiency and resilience that circular strategies and materials can bring.

2. MOBILITY

- Poland's transition to e-mobility necessitates management and infrastructure as the products reach their end-of-life.
- The circular transition needs to occur in tandem with the electrification of mobility.
- Most vehicles and vehicle parts (79%)[261] are still manufactured from virgin materials.
- Electric vehicles contain batteries that are complex configurations of materials that are both expensive and difficult to recycle. Furthermore, electric vehicles are currently much heavier than their conventional counterparts, although developments in battery technology are expected to reduce this weight difference.

OPPORTUNITY: DEVELOP A MARKET FOR CIRCULAR E-MOBILITY

In order to enhance circularity in the sector, the development of the secondary market for electric vehicles and their parts along with maintenance, refurbishment and recycling operations would be advantageous. Considering the R-strategies (see the text box on page 64), reuse and refurbishment are favoured over recycling, and thus opportunities related to reuse—such as reusing batteries with the fewest modifications possible—should be explored further. Given that one of the main barriers to electric vehicle adoption in Poland is the upfront cost[262] (as opposed to limited battery range or charging infrastructure), the availability of more affordable, secondhand alternatives could help overcome this and provide residents with cars that are potentially cheaper to operate. Poles are not strangers to purchasing second-hand cars from abroad, with over 1 million vehicles imported annually from abroad at its peak in the last decade.[263] This presents market opportunities to repurpose vehicle components and resell them, simultaneously creating economic value, and new employment opportunities due to the labour intensity of these approaches—boosting circularity in the meantime.

Norway is the biggest consumer of electric vehicles in the world in per capita terms. In 2020, 75% of newly registered cars in Norway were electric or plug-in hybrid electric vehicles, whereas in Poland this was just 2%.[264] The problem looming over this rapid uptake is how these vehicles and their components will be managed at their end of life, given that soon many will become redundant and batteries have less mature markets for refurbishment and recycling.

Poland is a leader in vehicle and vehicle parts manufacturing. Vehicle parts are Poland's biggest export product (4.8% of total exports), and cars and electric batteries follow closely (2.1% and 2% of total exports, respectively). Concerning exports to Norway, ships and buses are of particular importance.[265] The country's impressive production capacity provides facilities and expertise that can serve as a great starting point to move towards more circular practices, such as the remanufacturing, refurbishment, maintenance and repair of vehicles and vehicle parts. Poland can leverage its skilled workforce and capitalise on the labour-intensive activities of both domestic and imported vehicles and parts due to its lower labour costs, as compared to Norway, whilst boosting employment in the area.

The strong trading relationship can help shift towards more circular practices. Norway and Poland are well suited to capitalise on their existing vehicle and vehicle part trading partnerships by expanding the secondary market of such products, as well as their technical capabilities for battery recycling. Such markets are characterised by high labour intensity; this favours the Polish market given its cheaper labour costs—making it an investment case as it could also greatly boost employment rates. An expansion of the battery market in Poland could also provide Norway with additional waste management capacity—likely serving as a lower cost alternative.

NORWAY LEADS THE WAY WITH EUROPE'S LARGEST ELECTRIC VEHICLE BATTERY RECYCLING PLANT (FREDRIKSTAD, NORWAY)

While switching to electric vehicles can cut end-of-the-pipe emissions, it's still highly material intensive. It's important that electrification becomes as circular as possible. This is why the Hydrovolt recycling facility has massively scaled up its operations: it now processes 12,000 battery packs per year, in a bid to meet the ever increasing demand for battery recycling in Norway. The technology is able to recover 95% of the materials from the battery for recycling.266 This project is addressing the urgent need to tackle the vast consumption of virgin materials to meet the demands of electrification. This is especially important for critical earth metals that current lithium-ion batteries are dependent on.

CHALLENGES

The electrification of transportation requires rapid growth in associated circular activities. Electrification must go beyond the vehicle fleet, and also include improvements in infrastructure, specifically charging stations, and the development of auxiliary services, such as vehicle repairs. Poland has only just embarked on its path to e-mobility, clearly shown by the low saturation of charging stations (74 per million inhabitants)[267] compared to countries more advanced in the e-mobility transition such as Norway (almost 3,500 charging stations per million inhabitants).[268] Therefore, the concurrent development of a secondary market for electric vehicles, maintenance and refurbishment services is also in its infancy.

Currently, there are no open standards to verify the condition of electric vehicles. Successful refurbishment operations and secondhand electric vehicle sales critically depend on the condition and status of the battery. To date, there is no standard method for verifying the condition of battery packs to assist the development of the secondhand market. This is even more troubling when international trade in secondhand cars or parts is brought into the equation.

Strong concerns remain on the affordability, long-term efficiency, durability, warranty, and residual value of electric cars. This is largely tied to how Polish consumers view electric vehicles. This challenge will most probably diminish as the market matures. However, alleviating consumer doubts will likely be necessary to push a circular agenda in the e-mobility sector.

ENABLING FACTORS

Although its e-mobility transition is young, Poland is one of the biggest suppliers of e-mobility products and components. Poland is home to the largest battery factory in Europe (the third biggest in the world) and is the largest European producer of electric buses. Furthermore, it has a considerable network of car repair shops that are indispensable in developing a secondary market for electric vehicles. This positive business environment is well suited to develop a strong, circular e-mobility setor.

Electric vehicles and their batteries have long lives with parts that can be optimally cascaded—and could facilitate sustainable transport, as well as the energy transition. Poland may be a suitable market for the secondary use of electric vehicles and their batteries, including those imported from Norway. This could fuel demand for refurbishment operations, and lower the financial barrier to implement e-mobility. The batteries could be also repackaged and used in electricity storage applications to facilitate sustainably sourced electricity supply. Only then should these devices be considered for recycling.

Battery recycling is already gaining momentum, especially in Norway. The new lithium-ion battery recycling facilities in Norway already have the capacity to process the entire end-of-life battery market for the country, while it is expected to grow dynamically in consecutive years. The current recycling process can supposedly recover 95% of the materials used in batteries. Poland has also started making lithium-ion batteries circular, with a new battery recycling facility in the works using technology from SungEel HiTech—particularly pertinent considering the country houses Europe's largest battery production facility. Furthermore, next generation batteries are currently under development—solid state batteries, for example—which are intended to be more recyclable, and constructed from cheaper and more abundant materials.

3. AGRIFOOD

- It is estimated that Poland produces 127 kilograms of food waste per capita.[269] The situation is substantially better in Norway, with 75 kilograms of food waste per capita[270]—however, data consistency is questionable for these figures.
- Looking beyond food, the entire agrifood value chain requires huge amounts of resources, from water for growing, to fuel for transportation. Tackling agrifood waste and improving its valorisation is a key lever in reducing resource use and thus minimising environmental impact.

OPPORTUNITY: REDUCE AGRIFOOD WASTE GENERATION WHILST IMPROVING ITS VALORISATION

This opportunity can involve a plethora of strategies that can be simultaneously deployed. From applying agrifood techniques that minimise resource inputs during the production phase, to minimising resource intensity throughout the value chain of producing, packing and transporting food, and reducing food waste throughout the production chain. Such strategies should also aim to regenerate natural systems rather than to deplete them, making resource efficiency much more difficult in the long term. The fish market is an important part of this opportunity given its significance in exports from Norway to Poland.

Increased food waste monitoring can help reduce waste. The first step to reduce food waste is to monitor it. Having a transparent, digital overview of waste throughout the economy can help businesses create opportunities to plug 'leaks' in the system, and governments to provide effective support to these opportunities. Such a monitoring system requires the collaboration of all stakeholders involved in waste management—from municipal waste collection businesses to restaurants—to follow standardised data collection methodologies. A food waste tracking database can also help spur innovation for small businesses as well as improving research for developing new business models and evaluating effective policy instruments.

The value in food waste can be extracted in numerous ways. For example, food waste can be converted to bio-based products (such as ethanol), used directly as animal feed or to fuel an anaerobic digester to produce biogas for energy purposes. Promoting technological innovations and new business models using food waste can open up new market opportunities, whilst boosting circularity in the sector.

There is much room for development in both countries. Both countries generate significant amounts of food waste. By developing innovations, knowledge and strategies to both reduce food waste and valorise its value are key for both countries to reach a more circular food system. Knowledge exchange of best practices can be a key lever here, as well as engaging the experienced Polish agrifood workforce who make up a large share of the labour force in the country. Both countries have the potential to grow employment in food waste monitoring activities, by collaborating to develop technologies as well as facilitating and maintaining collection, separation and treatment processes.

CHALLENGES

Achieving a balance between safety, preserving nutritional value and limiting waste can be difficult. Virtually all agrifood products are perishable goods that are prone to spoilage—especially fish, a prominent Norwegian export. Therefore, specific care is required during harvesting and throughout the supply chain to preserve nutritional value, avoid contamination, loss and waste, and to deliver high-quality products to the consumer. These distinct goals are hard to attain, which is exemplified by the amount of waste caused by expiry dates, the controversy connected to unnecessary packaging and difficulties regarding the consumption of non-seasonal food.

Consumers, as well as regulators, still lack trust in new food sources. Many by-products and waste materials from agrifood processing can be very nutritious. These, along with new sources of protein—such as seaweed and insect protein—are not used to the extent possible due consumer aversion. Furthermore, the EU's regulatory framework considers many of these agrifood by-products unsuitable for

STATE-OF-THE-ART WASTE MANAGEMENT SYSTEM TRIALS THE INCLUSION OF FOOD WASTE (BERGEN, NORWAY)

The municipality of Bergen houses one of the world's most advanced waste management systems, which boasts an underground system of pipes connected to waste collection stations. The underground nature of the system means that local residents enjoy more street space, better hygiene and reduced risk of fire. In addition, the system has boosted the recycling rate within the city. Currently set up to handle household waste, paper, plastic and cardboard, new trials are now underway to also separately process organic waste at a number of test locations.[271] It is hoped that these trials will be successful, and followed by wide-scale implementation to further boost the city's recycling rate and allow for replication in other cities. To complement Bergen's waste management system, the startup Carrot is now tracking what waste enters the system, also introducing a 'pay-as-you-throw' scheme in which users must pay to dispose of waste. This scheme has already seen an increase in sorting rate as well as a 9% reduction in residual waste. A lot of work is also going into ensuring that waste is valorised as efficiently as possible at the other end, by engaging with other startups and linking them with investors.[272]

human consumption, which results in suboptimal valorisation and more waste.

ENABLING FACTORS

Solutions that make use of by-products that not only reduce waste but also create additional revenue streams are increasing. New technologies that can extract value from biomass resources, rather than wasting them, are emerging every year. The development of this approach is already arising in Poland, as exemplified by the rapid increase in bio-waste energy generation. Newer substrates with high-energy efficiency and low acquisition costs are sought to develop the field further. A solution that meets the above criteria is the use of expired food and agrifood production waste[273]—in fact, the types of biomass used to produce energy in the agricultural sector alone rose from 15 in 2011 to 35 ten years later.[274] Of course, the combustion of biomass is the last and final resort of the waste hierarchy. Nevertheless, it is hoped that the cascading use of bioresources may become more efficient in the future. The improvement in the valorisation of biomass will inevitably also reach the fish market, where the waste material constitutes a source of valuable biological components that could be utilised in production of value-added products for human consumption, animal feed, fertiliser production, and more.

Poland is already a top export destination for Norwegian agrifood products—especially for items in need of manual processing. The processing of fish is still demanding and costly in Norway, due to the labour-intensive nature of production. Therefore, today, Poland is the top importer of salmon for processing it into fillets for redistribution. There have been discussions about whether more secondary processing should be performed in Norway as opposed to abroad.[275] However, innovative digital tools, appropriate guidance and supervision could actually assure the effective and sustainable use of fish caught. Optimising the use of raw materials by maximising yield could significantly cut waste in the sector through, for example, improving the grading, portioning, filleting, cutting, skinning and trimming of fish on production lines as well as earlier transportation could be attained through strengthened Polish-Norwegian cooperation.

Municipal waste system technologies and regulations enable better biomass management. Digital tools that are being implemented in cities around the world enable the separation and collection of biomass to a far greater extent than previously possible. This, along with regulations to separate municipal biomass fractions, will likely contribute to the better valorisation of food waste, as in Poland, for example, 60% of total food waste is generated by households.[276]

REDUCING FISH WASTE AND LOSS REQUIRES INNOVATION ALONG EACH STEP OF THE VALUE CHAIN

Non-fillet fresh fish represent a significant portion of Norwegian exports (7.53%) with Poland being the top destination.[277] The Food and Agriculture Organisation (FAO) reports that 35% of harvested fish and seafood is lost or wasted along the entire value chain, with other studies reporting this to be as high as 50%—it's likely that fish loss and waste is occurring in Norwegian-Polish trade. But where does this waste actually occur? Potential for waste exists along all stages of the value chain: capture, sorting, processing, distribution and consumption. In the first stage, many species of fish are often caught unintentionally—known as bycatch—and if they are already dead or damaged then they will simply be discarded. As this bycatch is generally not accounted for, the extent of the issue isn't clear. While improved equipment and fishing techniques are already helping reduce the amount of bycatch in the first place, extracting value from already dead or damaged fish may also yield opportunities. Once on land, fish are also in danger of going to waste if not properly refrigerated and protected throughout the processing and transport stages. This must be done to ensure safety standards and prolong shelf life—or else the fish will be discarded, never reaching the plate.[278] Solutions must be found throughout every stage, from catch to consumption, to minimise waste and loss whilst valorising waste that does arise.

4. CONSUMER GOODS

- In recent decades, while the production of consumer goods has gotten cheaper, their design makes repair more difficult and their lifetimes shorter.
- Such production and design trends are a consequence of industrialisation and a shift from local production to globalised value chains.
- In addition, many consumer goods are made with complex material configurations, and often include ecologically harmful materials (such as glue). This makes the repair, refurbishment and recycling of such goods more difficult or, in some cases, impossible.
- Poland is a key producer of many types of consumer goods—from being the sixth largest furniture manufacturer in the world,[279] to hosting some of the largest textile sorting facilities in Europe with an overall capacity to sort 200,000 tonnes of used textiles each year.[280] As a renowned import and export hub for used textiles and clothing rags, Poland is both amongst the top ten major importers and exporters of these goods worldwide,[281] whilst many of their imports come from other Western European countries such as Norway.

OPPORTUNITY: SHIFT AWAY FROM 'FAST-FURNITURE' CULTURE

People are buying more furniture than ever before due to its increasing affordability in recent decades. Many of these products are produced from virgin materials, lack the quality to sustain a long life and are designed in such a way that makes it difficult or impossible to repair. These virgin materials are often sourced from all over the world and transported great distances to the end user, creating a complex and inefficient system. These factors yield a sector with great environmental impact attached to it. Poland produces one of the highest furniture waste generation rates in the EU, at almost 500,000 tonnes of waste generated per year.[282]

Long tradition and leaders in furniture design and manufacturing. Poland and Norway both have a traditional furniture-making industry with great expertise. This knowledge can be used to incorporate circular principles into their design and manufacturing. Economically, Poland has a leading position in furniture production in Europe.[283] This can be leveraged to diversify the business profile to offer services beyond production, providing an example to other countries.

Opportunities for new business models and joint ventures. Circular business models can be implemented to prolong the life of furniture, such as repair and maintenance, whilst increasing job opportunities in this area. Both countries have a good foundation of skills and expertise to incorporate circular principles and boost the sector beyond only manufacturing activities. For example, in the services needed to track, distribute and take back furniture for repair and refurbishment. New retail services like these will also call for jobs to shift, moving from sales-dominated roles, to repair, marketing, customer service roles that are geared towards supporting the repair economy.

CHALLENGES

Consumers typically prioritise the short-term cost of furniture over long-term economic and environmental outcomes. Liquidity barriers also play a role, as they disable customers from buying circular or sustainable products and services that offer better long-term value. This is an extremely important challenge as it is influenced by a host of factors, including consumer behaviour itself: how the furniture is treated at home, for example. Therefore, circular furniture would require behavioural change in the form of better maintenance, use of repair services, and more.

Furniture reuse is small scale and usually takes place with social, rather than environmental and economic, goals in mind. Scaling furniture reuse will require better design and the use of higher quality materials. It could be facilitated by a shift towards more rental-based furniture businesses, which would benefit from such design improvements. Going back to solid wood and metal furniture that does not restrict the potential for a successful second life would be recommended, for example. The availability of spare parts must be also assured. Companies would also have to establish collection and reverse logistics infrastructure to achieve the economies of scale needed to make repair and refurbishment viable. As of now, furniture resale lies in the hands of individual consumers, recycling centres which sell other commodities such as clothes and tableware, and smaller vintage or antique shops.

NORWEGIAN COMPANY VESTRE MAKES SUSTAINABLE OUTDOOR FURNITURE A REALITY (NORWAY)

Vestre has embraced circularity through its range of outdoor furniture. The items encompass all aspects of circularity, from durable design to potential for disassembly. The furniture series, which includes park benches, chairs, picnic tables, litter bins and bicycle racks (to name a few), has been manufactured using locally-produced or recycled aluminium combined with locally-sourced wood. The materials are well suited to last for decades and have the potential to be reused or recycled in the future.[284]

A few chains largely interested in price competitiveness dominate the global furniture sector. Poland is one of the most important suppliers to some of these furniture chains, and currently the focus is on meeting the demand at the lowest cost with little attention paid to the sustainability of materials. Therefore, to support circularity in the furniture sector, consolidation of trade should be counteracted. The same applies to the monopolisation of suppliers of raw materials and semi-finished products (such as chipboard and upholstery foam).

ENABLING FACTORS

Poland is one of the world's biggest furniture producers and the largest exporter in Europe.[285] The industry could tap into the global consumer demand for more sustainable products. Local desire for furniture is also increasing, driven by the growing purchasing power of Polish society and the booming Polish construction and real estate sectors.

Small- and medium-sized furniture producers have the greatest ability to adapt to new processes. The industry is dominated by small- and medium-sized enterprises, which have the greatest ability to absorb new technologies and manufacturing techniques, as well as adapt their production structures to changing external conditions. A considerable number of small, local enterprises are family businesses that are very flexible and can deliver 'made-to-measure' orders, for example.

Introducing repair, refurbishment and remanufacture activities into upmarket furnishing, along with maximal valorisation of resources, is a promising potential business route. This would allow for value recovery, while saving on resources and helping the environment. This is particularly important in highly affluent markets, like Norway. Beyond product design and manufacturing, circular companies in the furniture sector may also innovate to maximise the value of their waste, such as using sawdust from the manufacturing process in bio-alcohol production, or using pulp as filling for cat litter and compost. This cascading use of the various forms of wood by-products can lead to close to zero-waste processes.

Product customisation is a strong feature in the circular value proposition of the furniture industry. Beyond selling furniture, circular furniture companies often use their sustainability and circularity expertise as an added-value to reach customers in need of an improved sustainability impact. Such products could be offered specifically to ecologically-aware individuals and commercial consumers in particular.

5. ENERGY

- The current energy system is complex. It is dependent on commodity costs, political decisions, environmental concerns and geographic factors. For this reason, every country needs to tackle the issue in its own way—but the room for collaboration is great.
- The EU is leading the way with energy policy, taking concerted action to facilitate collaboration between countries, given the inter-country dependency. There is a strong focus on renewable energy—yet this is increasingly being challenged due to the intermittency of most sources and the lack of viable energy storage possibilities.

OPPORTUNITY: OPTIMALLY TRANSITION TO RENEWABLE ENERGY SOURCES

All energy systems come with an environmental impact, so assessing the entire lifecycle of technologies is essential for selecting the best option. Renewable energy technologies, such as solar photovoltaic and wind turbines, do not produce any direct emissions—but they do contain embodied carbon from the production of materials. Circularity can be boosted by manufacturing energy equipment and infrastructure from secondary materials and managing these resources at their end-of-life to maintain as much material value as possible.

Norway is a trailblazer in renewable electricity but some sectors still rely on fossil fuel energy. The electricity system in Norway is primarily based on hydropower (92% of total electricity production)[286] due to the suitable water resources in the country. Despite the highly decarbonised electricity system, Norway still relies heavily on fossil fuels for activities such as heating and fueling industrial activities: fossil fuels account for 28% of the total energy consumption.[287] In addition, Norway is one of Europe's largest fossil fuel exporters, with oil and gas having an export value of US$37 billion (zł141 billion) in a normal market.[288] Norway must innovate further to decarbonise more difficult sectors that still rely on fossil fuels, such as metal and chemical production.

Poland's energy system is largely based on fossil fuels. Just over 40% of Poland's total energy supply is based on coal—one of the most polluting fuels.[289] Poland also relies heavily on other countries for oil and gas to power industry, transport and heat homes. A shift away from fossil fuels and more towards renewable energy will require significant investment and infrastructure changes. Poland's plans to improve coal technologies—making them less polluting—are likely to only hinder this shift and slow down emissions-reduction potential.

Poland and Norway can work together to decarbonise their economies. Poland's oil and gas imports mostly come from Russia—and following the Russian invasion of Ukraine, there is an increased desire to reduce reliance on Russia for energy. The construction of a new gas pipeline (Baltic Pipe Project) from Norway to Poland aims to enable this, while the development of an offshore wind plant in the Baltic Sea is being conducted in partnership with Norwegian firm Equinor—a heavyweight in the offshore sector—to begin reducing dependence on fossil fuels.[290] Another initiative, the Northern Lights project,[291] intends to connect Norway to other countries, such as Poland, to transport and store CO_2 to help decarbonise industries facing decarbonisation challenges in the short- to medium-term. In both countries, the shift away from fossil fuels will mean making a significant amount of equipment and infrastructure redundant, from offshore oil platforms to coal power plants: here, many opportunities lie to coordinate the reuse and recycling of these assets and their materials. Generally speaking, research and pilot projects should continue to focus on difficult-to-decarbonise sectors, to collaboratively develop new solutions with workers and employers, including working together to establish how the workforce can be trained to accommodate new practices and projects. As employment in carbon-intensive industries will continue to decline as Poland increasingly decarbonises its economy, efforts to safeguard and reskill workers will be essential for a just transition in Poland.

CHALLENGES

The tendency to keep the current status-quo limits active support of the renewable energy transition. Politicians, as well as society, are slow to act on the renewable energy transition—despite offering vocal support for it. In Poland, for example, this is exemplified by the government's recent struggle to decrease consumer costs for fossil fuels by using central budget funds,[293] or by artificially supporting the coal mining sector for the past few decades.

The intermittency of renewable energy sources is a great challenge. A significant part of the renewable energy generation capacity installed in Poland is based on sources that depend on weather conditions, such as wind, sun and water. To combat this, Poland needs

NORWAY'S LARGEST ENERGY STORAGE SYSTEM POWERS THE LOCAL COMMUNITY AND INDUSTRY WITH SUSTAINABLE ENERGY (SENJA, NORWAY)

Norway is set to launch its largest battery energy storage system on Northern island Senja. The battery system is said to be able to power the entire local community, including its fish farm, for around one hour. This will help to stabilise the power supply in the area, as growing energy demand is creating a mismatch with supply.[292] By incorporating this technology, the community will also be able to make use of more renewable energy sources—which often have intermittent supply, which puts a further strain on the growing energy demand.

to have reserve capacity and increased flexibility, which can impact the overall cost of power generation. Therefore, solutions should be developed to enable progress in energy storage (for both electricity and heat). Failure to adapt the reception and balancing capabilities may have a negative impact on energy security: interim solutions, such as continuing to use gas, are necessary. In addition, the increasing desire to reduce energy dependency from Russia makes the Baltic Pipe from Norway, operational in 2022, ever more important.

Modifications to the current energy infrastructure are desperately needed. Changes in energy market regulations, as well as the progressing share of new energy sources, necessitate the need to ensure the flexibility of the power system. For this reason, grid infrastructure and its capabilities should be expanded while energy storage should be developed. Gradual replacement of the passive grid (one-way) with an active network (two-way) and smart energy management systems is necessary.

ENABLING FACTORS

Global turbulence, carbon pricing and the consequential energy price spikes facilitate a faster transition to renewable energy. Currently, the energy sector in Poland is based mainly on conventional, centrally dispatched units, generating energy from coal. This is carbon-intensive, which burdens energy generation with high costs from the EU Emissions Trading System (ETS)—expected to rise further in the future. This, together with the outcomes of the Russian war in Ukraine, would most probably lead to a faster transition to local, less carbon-intensive energy sources and an interim solution of employing carbon capture technology.

Prices are falling and support is growing for renewable energy generation. Aside from falling prices of equipment, the financial support to purchase them has led to rapid growth in renewable energy generation, particularly for solar photovoltaic and heat pumps. This concerns individuals in particular, as already over 1 million households in Poland have installed photovoltaic panels. The financial support to interrelated sectors, such as the 'My Electric Vehicle' programme, will also contribute to the rise in the number of prosumers.

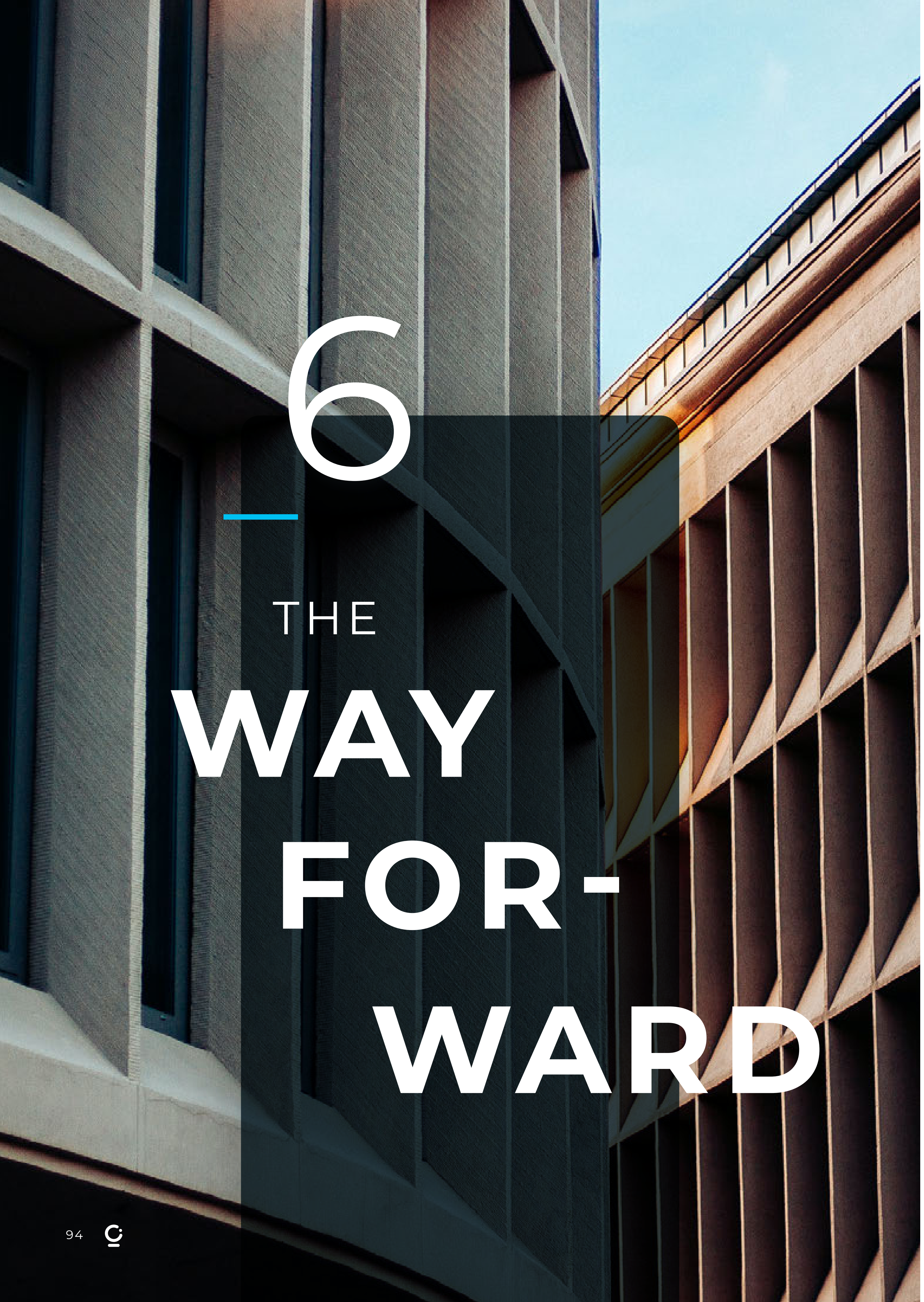
Increased active participation of end consumers and new technical capabilities enables a more local, sustainable and reliant energy supply. The development of the energy distribution systems will contribute to the gradual transition of the passive grid (one-way) into an active grid (two-way). This, along with the implemented solutions for grid flexibility improvement, will enable the development of distributed generation, active participation of end consumers and the use of charging points and energy storage (in the form of specific facilities or electric vehicles). This concerns electricity in particular, however, solutions for more sustainable heating, such as hydrogen technologies ('power to gas' technologies), are also strongly sought after.

Biogenic feedstock could be used to aid the transition to a more renewable energy mix. Biogenic feedstocks and unused byproducts of biogenic production indicate that biogas production might be at least a partial answer to the question of attaining a more renewable energy mix. It seems that the agrifood sector has already taken note of this opportunity, as the production of biogas in this sector alone rose by nine-fold in the 2011–2021 period. Nevertheless, according to some estimates,[294] current installed capacity is only 16% of the current potential, meaning there is room for the sector to grow sixfold if all waste feedstocks become available and are capitalised on.

OPPORTUNITY POTENTIAL, IMPACT AND FEASIBILITY

Each opportunity comes with its own impacts and challenges. To get a better understanding about how these differ per opportunity, an assessment was conducted based on **socioeconomic potentia**l (for example, job creation and economic value), feasibility (the difficulty of pursuing the opportunity in the economic, political and societal context) and the **impact on material footprint and Circularity Metric** (reduction potential for the material footprint and increase potential for the Circularity Metric). The assessment was conducted based on expert judgement, and considers the scenario analysis with validation from local stakeholders in both Poland and Norway.

SECTOR	OPPORTUNITY	SOCIOECONOMIC POTENTIAL *Employment and economic growth in circular sectors	FEASIBILITY	IMPACT ON THE MATERIAL FOOTPRINT AND CIRCULARITY METRIC
Housing	Introduce and scale up zero-emission buildings, wooden constructions and use of secondary materialsi	High	Medium	High
Mobility	Develop a market for circular e-mobility	High	High	Low
Agrifood	Reduce agrifood waste generation whilst improving its valorisation	Medium	High	Medium
Consumer goods	Shift away from 'fast-furniture' culture	Medium	High	Medium
Energy	Optimally transition to renewable energy sources	Medium	Medium	High



6 THE WAY FORWARD

Poland's economy has transformative potential: it can almost double its circularity and nearly halve its material and carbon footprints. This report has laid out a first approximation of how resources are used to meet Poland's societal needs and wants, and in which amounts. It lays out the strategies the country could put into practice to drive its circularity from 10.2% to 19.9%. By swapping out the material- and emissions-intensive processes embedded in the current linear economy for ones that keep materials in use at their highest value, minimise waste generation, and regenerate natural systems, Poland could reshape its economy. It has the potential to cut its material footprint by 40.4%, bringing it down to 308.7 million tonnes, while lowering its carbon footprint by 49.1% (excluding direct emissions), bringing it down to 174.8 million tonnes. While these changes would require a total overhaul of the way Poland extracts, processes, produces and consumes materials and products, their impact would be massive—ushering in benefits for society and the economy as well as the environment. While the steps suggested to transition to a circular economy aren't a silver bullet, they're a crucial first step.

The circular transition will not take place overnight, and will require concerted efforts that span sectors and organisations. While the strategies laid out in Chapter four have transformative potential, their implementation will be met by numerous challenges—a number of which have been addressed in Chapter five. We also know where the biggest pay-offs lie: interventions for the built environment, such as optimising building stock expansion, prioritising deep retrofitting and creating a more resource-efficient building stock, will have the largest role in the transition, cutting the material footprint by 26.4% and the carbon footprint by a whopping 36%. For the agrifood sector, shifting to mineral-free fertilisers and championing seasonal, local produce, endorsing a balanced, plant-based diet, and reducing food waste will slash the material footprint by 7.9% and the carbon footprint by 9.1%. Our new Poland-specific scenario for powering the country with clean energy also found massive potential: by cutting coal use for electricity and heating, the material footprint could drop by 12.5%. In other words: these three sectors alone have potential for deep impact, although getting there will be difficult. Reshaping regulations to favour more circular construction, embracing weather-dependent renewable energy modes and mobilising the Polish population away from emissions-intensive animal-based protein in favour of plant-based options, for example, will be significant hurdles. Overcoming these will require changes across regulatory, financial and cultural spheres.

All stakeholders have a role to play in realising a Polish circular economy. As discussed, our suggested changes won't take place overnight—nor will they take place in a vacuum. The transition will require massive mobilisation and joint efforts across facets of society, from (local) governments and businesses to academics and consumers. As of yet, this mobilisation isn't clearly mapped out: while the Polish circular economy roadmap provides a good starting point, explicit agreement on action points and concrete steps forward are needed. What's more: Poland is lagging behind EU targets, especially regarding its dependence on coal. Moving forward, a focus on dialogue and reskilling workers in 'dying' industries, such as coal mining, will be crucial to ensure the shift to new energy sources is as socially just as possible. Corporations must be appropriately incentivised to drive change within their sectors, embracing circular strategies and adopting circular business models. Here, creating an enabling regulatory and financial environment will be critical. Individuals will also have a role to play in the transition, by shaping demand for goods and services that help—rather than harm—the planet.

Genuine investment will be needed to scale circular solutions and retain Polish talent. Making secondary materials available for reuse is a crucial component of going circular: to do so, Poland must invest heavily in improving its waste management capacity, which will serve sectors from the built environment to agrifood to manufacturing. Current plans—such as the National Waste Prevention Programme,[295] which lays out strategies to cut waste in the industrial sector—should be reshaped to truly match circular ambitions: currently, it centres on stimulating economic growth rather than cutting resource use. Investments may also be directed at scaling up renewable energy infrastructure—already taking off through plans for offshore wind plants—reverse logistics, and new business models, along with the expertise and labour needed to do so. By investing in service-oriented roles, such as design, in addition to labour-intensive roles, Poland can also prevent so-called 'brain drain': currently, its emigration rate is among the highest in Europe, mostly due to the exit of highly-educated professionals as well as workers with the knowledge and skills needed for a circular economy to flourish—repair, construction and refurbishment, for example. Pouring financial resources and human capital into the circular transition will be necessary to provide the Polish workforce with novel, engaging and innovative opportunities—shaping, retaining and inspiring talent within the country.

A global truth: current solutions are grossly inadequate for the challenges we face today. As global income, consumption-driven lifestyles and populations continue to swell, our natural environment will be stretched beyond its breaking point. Observing human history—and the trajectory of our current linear system—serve to underscore how affluence is tightly linked to material use, waste generation and emissions: in other words, richer societies breed greater consumption.[296,297] The myth of a 'sustainable' world that coincides with unfettered economic growth, however, prevails. While Poland's consumption is moderate compared to some of its European neighbours, it still surpasses the already-steep world average: the way forward must entail cutting excess consumption by shaping a resource-light economy that operates within planetary boundaries while serving residents' wellbeing. As a country that concentrates many of its environmental impacts within its own borders—for example, through high per capita levels of extraction—it will be crucial for Poland to reshape its relationship with the materials that have driven its economy over the past several decades: coal, for example.

All countries are critical change agents: Poland has the power to make an impact beyond its borders. With a global economy that's just 8.6% circular, it's clear that linearity is embedded in societies worldwide—especially in higher-income countries like Poland. These nations often tend to run ecological deficits and externalise environmental burdens to lower-income nations that are often rich in resources. Poland must recognise its position in the global context: while the country is more self-sufficient than other EU nations, it's still currently responsible for significant raw material extraction abroad, with nearly half of its raw materials imported from other nations. More than one-third of its consumption-based material footprint can be attributed to materials or processes originating in other countries spanning the globe. On the other hand, more than half of Poland's extracted natural resources are exported—largely non-metallic minerals and biomass—which have a far greater material footprint than their 'final' physical weight may suggest: in essence, Poland is an exporter high-impact goods—be they in the form of minerals or fertiliser—that will have a significant effect on other countries' consumption-based accounting. To this end, Poland has a strong responsibility as a player in the global market to drive circularity and cut its negative impact—both domestically and abroad.

A huge opportunity for Poland. The country has a long way to go: its consumption and extraction well exceed what our planet can provide. Although ambitions are not yet up to par, Poland will benefit from upcoming wins—such as the eventual phase-out of coal. As an EU country, the steps forward—and end goals—have been sketched: it's up to Poland to move towards targets in a way that accounts for its context and benefits its people. Embracing circular strategies to achieve these targets will provide win-wins: subsidies for better insulation of homes, for example, can serve to reduce energy poverty while also boosting circularity and lowering energy consumption. Poland must take bold action along its upcoming journey: the risk of missing out on the opportunities a circular economy could deliver is one too great to take.

THREE STEPS TO BRIDGE THE CIRCULARITY GAP THROUGH LEADERSHIP AND ACTION:

1. Drive national progress toward circularity forward with metrics and goals. Our analysis demonstrates the complexity of Poland's economy and has made clear where linear conduct is embedded; these can be focus areas. Practical pathways that are aligned to the local context, incentives and mandates are crucial. Poland must also set goals to keep its progress thoroughly on track and measurable. Progress can be actionable and focused. The Metric also presents a measurement of progress toward a circular economy which can be revised.
2. Ensure a national coalition for action is both diverse and consumer-centric. This will bring together frontrunning businesses, governments, NGOs and academics to collectively boost capacity and capability to better serve societal needs and wants more sustainably. It will work to ensure that consumers are actively involved with circular economic activities. A national circular economy can be fully supported and realised if avenues facilitating consumer consumption become more circular.
3. Strengthen global knowledge and pace toward circularity and consumption reduction. Poland can learn a lot from other countries' national journeys toward circularity. Peer-to-peer learning and knowledge transfer will increase the pace towards global circularity: for example, in spite of their vastly different demographic profiles, Poland's collaboration with nearby-Norway will help provide input in shaping Poland's path forward. When it comes to the circular economy, we are all still developing.

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