THE CIRCULARITY GAP REPORT

Sweden

Closing the Circularity Gap in Sweden

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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.

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.

RISE is Sweden's research institute and innovation partner. Through its international collaboration programmes with industry, academia and the public sector, it ensures the competitiveness of the Swedish business community on an international level and contributes to a sustainable society. Its 2,800 employees engage in and support all types of innovation processes. RISE is an independent, State-owned research institute, which offers unique expertise and over 100 testbeds and demonstration environments for future-proof technologies, products and services.

RE:Source is one of 17 Swedish strategic innovation programs. The program is funded by the Swedish Energy agency, the innovation agency Vinnova and the agency for research, Formas. RE:Source supports research and innovation leading to the sustainable use of materials, and since its launch in 2016 the programme has funded more than 200 different projects.

IN SUPPORT *OF THE CIRCULARITY GAP REPORT SWEDEN*

UWE FORTKAMP
Head of Resource Efficiency at the Swedish Environmental Protection Agency

'The *Circularity Gap Report Sweden* clearly illustrates the underutilised potential of the circular economy in Sweden. Although the Circularity Metric has limitations, this report doesn't distract from the need for material efficiency and sustainable resource use. The content of the report will be useful for those driving circularity in their fields of work.'

EVA KARLSSON
CEO at Houdini

'This eye-opening report addresses the fact that we are only 3.4% circular and have a massive and urgent journey ahead. We should not underestimate the opportunity we have for an exponential shift in mindset, lifestyle and consumption in order to bridge the Gap during this critical decade. Thank you for providing a reality check and guiding Sweden and the world forward.'

PÄR LARSHANS
Director of Sustainability at Ragn-Sells Group

'This report highlights the need to recover and reuse resources that we have already extracted—not just focus on minimising waste. In a truly circular economy there is no waste: only resources that have not yet been sorted and reused. Maximising resource recirculation will also reduce the risk of overshooting any one of the nine planetary boundaries.'

DARJA ISAKSSON
General Director at Vinnova

'Driving the transition to a circular economy is essential, and this report is an important reminder of the magnitude of the task. It highlights the important potential of innovation by illustrating game-changing opportunities for policy and partnerships. Sweden is well-positioned to show the world how innovation can contribute to the optimised utilisation of resources and create resilient and circular value chains.'

JONAS CARLEHED
Sustainability Manager
at IKEA Sweden

‘This report gives us valuable insights on why a circular economy is an important part of the solution for tackling the urgent climate crisis. The authors have an inspiring view of Sweden as a key contributor to a positive narrative for a better, healthier and more circular life, lived within the ecological boundaries of our planet.’

JOHAN LUNDÉN
Senior Vice President for
the Project & Product
Strategy Office at Volvo
Group Trucks Technology

‘In progressing toward a circular economy, it is most important to guide action with tangible data and measurements. This report provides actors with a clear sense of what needs to be done, and charts a path forward to reach a more circular Sweden.’

VANESSA BUTANI
VD Electrolux

‘The *Circularity Gap Report Sweden* is a fascinating read. It is also an eye-opener: it illustrates the vast amount of materials used to sustain Sweden’s economy, the resulting emissions and Sweden’s low level of circularity. The report demonstrates how cutting material consumption can help battle the climate crisis and contribute to a more socially just world—and shows us how to get there.’

ÅSA DOMEJI
Chairman of the Delegation
for Circular Economy
and Sustainability
Manager at Axfood

‘This report shows that our society has barely started the transition from a linear to a circular economy. But it also points out different avenues for change. Even those who have already engaged in the circular economy world will gain new insights.’

MARIA SMITH
Secretary General at
Axfoundation

‘Challenging times are not ahead; they are already here. Nevertheless, the potential to solve complex sustainability problems has never been greater. In order to do so, we must move from talking, to innovative, circular and collaborative doing. As Axfoundation works for—and as this insightful report states—”The time for transformational change is now.” ’

INGMAR RENTZHOG
CEO at We Don’t Have Time

‘Our organisation focuses heavily on solutions—so I find the *Circularity Gap Report Sweden* to be very important. Because if our economy is only 3.4 % circular, we have almost endless room for improvement. There is enormous business potential in the circular economy—and a staggering volume of greenhouse gas emissions to be cut. This report is a great call to action. Let’s get to work!’

JONAS KJELLBERG
Founder of Nornorm

‘This report strongly highlights the massive challenge we have in front of us as a society. But it also shows that any challenge also represents an opportunity for those willing to tackle it. So while the report makes me sad in many ways—it also sparks the entrepreneurial spirit in me, fills me with energy and further cements my belief that going circular is the only way forward.’

ANDERS WIJKMAN
Chairman at Circular Sweden
and Chairman at Climate-KIC

‘The *Circularity Gap Report Sweden* raises awareness about a production system that is utterly wasteful. More importantly, the report gives priority to solutions, exploring how to meet human needs while reducing ecological pressures—rather than greening the current system. In doing so, the report offers hope for a better future.’

EXECUTIVE SUMMARY

Sweden is 3.4% circular—leaving a Circularity Gap of more than 96%. This 'Gap' simply means that the vast majority of resources Sweden uses to satisfy its needs and wants come from virgin sources. The country's complex, highly-interconnected economy is relatively low-carbon—but also largely linear. More than 266 million tonnes of resources are funnelled into the economy each year, amounting to nearly 25 tonnes per person—a figure that has continued to swell over recent years. Sweden takes vast quantities of materials from the land and sea to feed demand both domestically and abroad. Domestic resource extraction—which tops 265 million tonnes annually—is the fourth largest worldwide, per capita. While high rates of consumption and extraction are common for an industrial trade nation, it calls for an approach that goes far beyond cycling. To this end, this report also highlights avenues to slash Sweden's hefty material footprint while boosting its circularity.

The material footprint behind Sweden's resource use. This report analyses how resources—metal ores, non-metallic minerals, biomass and fossil fuels—are used to meet the country's needs, from Housing and Mobility to Food and Consumer Goods. A significant portion of its demand is met through products imported from outside of Sweden's borders: around 130 million tonnes of resources are extracted abroad to satisfy the country's needs, making up just under half of its consumption footprint—which is typical for a high-income trade nation. While electricity is largely fueled by low-carbon sources, Sweden's high material consumption is still deeply interlinked with emissions-intensive processes. Its current consumption-based carbon footprint is around 84 million tonnes, which is much larger than its territorial emissions (54 million tonnes)—meaning that the country is importing carbon embodied in materials and products. Domestically, Sweden is marked by some of the highest extraction rates in the world: the country funnels one-third of what it mines and fells into construction, to meet a strong demand for new housing, and another significant portion into the manufacturing of products as disparate as pulp and paper and vehicles and machinery.

Opening up the Circularity Gap. Sweden's Circularity Metric of 3.4% doesn't mean that 96.6% of the materials flowing through its economy go to waste or are inherently 'bad'. The Circularity Gap is composed of a range of elements: many materials (40%) are added to stock in the form of buildings and infrastructure, while around 36% of materials are represented by biomass with the potential for cycling, such as wood products and food crops. While materials in both these categories can be cycled, quite some time will pass before this is possible—good design is crucial to ensure that end-of-life cycling will be feasible and of high value. Inherently non-circular flows, such as fossil fuels, and non-renewable inputs together represent approximately 20% of the Gap. Sweden's most critical goal will be cutting this 20% while boosting its Circularity Metric—especially as stock build-up will continue to grow due to population growth, the country's geography and an appetite for bigger houses, among other factors.

A circular roadmap to narrow the Circularity Gap in Sweden. To bridge the Gap, this report explores six 'what-if' scenarios that apply strategies to strengthen circularity, cut material use and transform the Swedish economy. The scenarios are 1) Construct a circular built environment, 2) Cultivate a thriving food system, 3) Make manufacturing circular, 4) Reshape extractive industries, 5) Drive clean mobility forward and 6) Design conscious consumables. While individual scenarios may have limited impact, all together, they can more than double Sweden's circularity—bringing the Metric to 7.6%—while cutting its material footprint by a highly significant 42.6%.

The Swedish economy is full of potential—but there are limitations to how much we can increase its Circularity Metric. Sweden's rate of consumption drives vast resource extraction and waste both domestically and abroad, as it exports materials like iron ore around the world and consumes finished and semi-finished goods imported from around the globe. It is difficult to control the circularity of imports—and some of Sweden's strongest industries,

from mining to forestry, are extractive, and in some cases, non-circular. Extractive industries generate vast quantities of waste—about 90% of Sweden's total waste composition—and the majority of these industries, particularly for mining, are in remote northern locations This makes cycling economically and environmentally unviable for the most part and contributes to the low Metric. Even perfect reuse and recycling of other materials—such as construction waste or consumer goods—will have a limited (yet important) impact on the Circularity Metric as long as extractive waste remains high. What's more, the nation's expanding population and typical lifestyle—with larger houses and the highest proportion of single-occupancy residences in the EU—call for the continued build-up of residences and supporting infrastructure. This means that huge quantities of materials will be locked into stock, diminishing current cycling potential. So, while an increase from 3.4% to 7.6% seems slight, the Swedish economy will have to undergo a massive evolution to make it a reality. Recognising that full circularity is unfeasible, we also know that even a small jump in the Metric will have a transformative impact: our *Circularity Gap Report 2021*, for example, found that doubling global circularity to just 17% could reduce global GHG emissions by 39%, thereby limiting the worst effects of climate breakdown.

The circular economy is a means to an end: a safe and just space for people and the planet. Narrowing the Circularity Gap and slashing material consumption serves this higher objective by relieving environmental pressures in Sweden, while mitigating social inequality. Circular strategies and circular business models are also a means to enhance emissions abatement and reduce extraction—thereby improving supply security and price stability when materials are kept in circulation. And by encouraging greater access and even distribution of resources, circularity also has a role to play in safeguarding social equality. The circular economy is a means to achieving the end goal of a world—and nation—that is ecologically safe and socially just.[1]

The time for transformational change is now. With environmental efforts currently centred around decarbonisation, Sweden is already world-renowned as a global leader in combating the climate crisis. But in spite of its growing low-carbon energy sector and stringent carbon pricing measures, material use remains high—and the bottom line can't be ignored: consumption needs to drop for Sweden to become a true sustainability champion. Fortunately, Sweden is well poised to spearhead a circular transition: it holds the knowledge and innovation power needed to drive circularity forward, immense regenerative capacity from its swathes of forest land and high levels of domestic extraction. These offer a huge opportunity for change given that many impactful activities occur within Sweden's borders. Our analysis and circular roadmap can assist the Swedish government—and other relevant stakeholders—in making the circular agenda a top priority. Sweden's sustainability goals are bold and ambitious—and necessitate a bold and ambitious transformation: the circular economy.

SAMMANFATTNING

Sverige är 3,4% cirkulärt—vilket innebär ett cirkularitetsgap på mer än 96%. Det betyder att den stora majoriteten av resurserna som Sverige använder för att tillgodose sina behov och efterfrågan kommer från jungfruliga källor. Landets komplexa, integrerade ekonomi är relativt koldioxidsnål, men också i stor utsträckning linjär. Mer än 266 miljoner ton resurser tillförs ekonomin varje år, motsvarande nästan 25 ton per person—en siffra som har fortsatt att öka under de senaste åren. Den inhemska resursutvinningen är i samma storleksordning och överstiger 265 miljoner ton årligen. Det innebär att Sverige har den fjärde största resursutvinningen i världen, räknat per capita. Sverige använder stora mängder material från land och hav för att möta såväl inhemsk som internationell efterfrågan. Ett stort konsumtionsfotavtryck och stor utvinning av jungfruliga råvaror, vilket är vanligt för en industrination, kräver en strategi som sträcker sig betydligt längre än till hur man ska återvinna material. Därför ger denna rapport konkreta förslag på hur Sverige kan minska sitt stora materiella fotavtryck samtidigt som cirkulariteten ökar.

Det materiella fotavtrycket bakom Sveriges resursanvändning. Den här rapporten analyserar hur resurser—metallmalmer, icke-metalliska mineraler, biomassa och fossila bränslen—används för att möta landets behov, från bostäder och mobilitet till livsmedel och konsumtionsvaror. En betydande del av landets efterfrågan tillgodoses genom produkter som importerats: omkring 130 miljoner ton resurser utvinns utomlands för att tillgodose landets behov, vilket utgör knappt hälften av Sveriges konsumtionsfotavtryck—typiskt för en utvecklad handelsnation. Medan elen till stor del baseras på energikällor med låga koldioxidutsläpp, är Sveriges höga materialförbrukning fortfarande tätt sammankopplad med utsläppsintensiva processer. Nuvarande koldioxidavtryck på cirka 84 miljoner ton är mycket högre än Sveriges inhemska utsläpp (54 miljoner ton), vilket betyder att Sverige importerar koldioxid som släppts ut i samband med tillverkning av material och produkter i andra länder. Sverige kännetecknas som ett av de länder i världen med högst utvinning av råvaror. Landet använder en tredjedel av vad som bryts och avverkas till byggnation, för att möta en stor efterfrågan på nya bostäder, och ytterligare en betydande del till tillverkning av olika typer av produkter som pappersmassa, papper, fordon och maskiner.

Förklaring av cirkularitetsgapet. Sveriges cirkularitet på 3,4% betyder inte att 96,6% av de material som strömmar genom landets ekonomi går till spillo eller till sin natur är ‘dåliga’. Cirkularitetsgapet består av en rad delar: mycket material (40%) lagras upp i samhället i form av byggnader och infrastruktur, medan cirka 36% av materialen utgörs av biomassa med potential för att cirkuleras som exempelvis träprodukter och matgrödor. Även om material i båda dessa kategorier kan återvinnas, kommer det att ta relativt lång tid innan detta är möjligt—bra design är avgörande för att säkerställa att återvinning går att genomföra med ett högt värde på återvunnen råvara. Tillsammans utgör icke-cirkulära flöden, såsom fossila bränslen, och icke-förnybara resurser cirka 20 % av cirkularitetsgapet. Sveriges mest kritiska mål kommer att vara att minska dessa 20 % samtidigt som cirkulariteten ökar—särskilt eftersom upplagringen av material i samhället kommer att fortsätta att växa på grund av faktorer såsom befolkningstillväxt, landets geografi och en efterfrågan på större hus.

En cirkulär färdplan för att minska Sveriges cirkularitetsgap. För att sluta gapet utforskar denna rapport sex ’tänk om’-scenarier, genom att tillämpa strategier för att öka cirkulariteten, minska materialanvändningen och omvandla den svenska ekonomin. Scenarierna är 1) Bygg cirkulärt, 2) Värna om ett sunt livsmedelssystem, 3) Tillverka cirkulärt, 4) Omforma utvinningsindustrin, 5) Hållbar mobilitet och 6) Ansvarsfull design av förbrukningsvaror. Även om de individuella scenarierna kan ha begränsad påverkan, kan de sammantaget mer än fördubbla Sveriges cirkularitet till 7,6%—samtidigt som de minskar det materiella fotavtrycket med betydande 42,6%.

Den svenska ekonomin har stor potential—men det finns begränsningar för hur mycket cirkulariteten kan öka. Sveriges konsumtionstakt ökar såväl resursutvinning som uppkommet avfall både inhemskt och utomlands, eftersom Sverige exporterar material som järnmalm och konsumerar produkter och material som importeras från hela världen. Det är svårt att styra cirkulariteten för importerade varor. Dessutom är några av Sveriges dominerande industrier, som gruvdrift och skogsbruk vilka båda tar ut resurser, i vissa fall icke-cirkulära. Utvinningsindustrin genererar enorma mängder avfall—omkring 90% av Sveriges totala avfallsmängder—och majoriteten av dessa industrier, speciellt gruvindustrin, finns på avlägsna nordliga platser, vilket gör återvinning olönsam för majoriteten av volymerna och bidrar till den låga cirkulariteten. Även fullständig återanvändning och återvinning av andra material, som byggavfall eller konsumentvaror, kommer att ha en begränsad inverkan (men ändå viktig) så länge som stora mängder avfall från utvinning uppkommer. Dessutom innebär landets växande befolkning med nuvarande livsstil, med större hus och med EU:s största andel ensamhushåll, en fortsatt utbyggnad av bostäder och tillhörande infrastruktur. Detta innebär att enorma mängder material kommer att låsas upp i samhället, vilket ytterligare minskar nuvarande återvinningspotential. Även om en ökning från 3,4% till 7,6% verkar liten så kommer den svenska ekonomin att behöva genomgå en omfattande förändring för att detta ska bli verklighet. Och även om det inte går att uppnå en cirkularitet på 100% så kommer en liten ökning i cirkularitet att ha en omvälvande effekt. I rapporten *Circularity Gap Report 2021*, fann man exempelvis att en fördubbling av den globala cirkulariteten till bara 17% kan minska de globala växthusutsläppen med 39% och därmed begränsa de värsta effekterna av en klimatkatastrof.

Den cirkulära ekonomin är ett medel till ett mål: ett säkert och rättvist samhälle för människor och planeten. Att sluta till cirkularitetsgapet och minska konsumtionen av material tjänar detta högre mål genom att minska miljöbelastningen och samtidigt minska den sociala ojämlikheten. Cirkulära strategier och cirkulära affärsmodeller är också sätt att minska utsläppen och utvinningen och därigenom förbättra försörjningstryggheten av råvaror och prisstabiliteten när material cirkulerar. Och genom att uppmuntra till en ökad tillgång och en jämnare fördelning av resurser har cirkulariteten också en roll att spela för att värna social jämlikhet. Den cirkulära ekonomin är ett sätt att nå slutmålet med en värld som är ekologiskt trygg och socialt rättvis.

Tiden för omvälvande förändring är nu. Sverige är redan globalt känt som ett ledande land i kampen mot klimatförändringarna, med insatser inom miljöområdet som traditionellt kretsar kring att minska koldioxidutsläppen. Men trots att landets energisektor domineras av en ökande andel energikällor med låga utsläpp av fossil koldioxid och omfattande styrmedel för prisåtgärder för att minska koldioxidutsläppen, är materialanvändningen fortsatt hög. Slutsatsen kan inte ignoreras: konsumtionen måste minska för att Sverige ska bli ett sant föregångsland gällande hållbarhet. Som tur är, är Sverige väl rustat att bli ledande i en cirkulär omställning: det finns kunskap och innovationskraft för att driva cirkulariteten framåt, en enorm potential i stora och förnyelsebara skogar och stor inhemsk utvinning av resurser, vilket ger en enorm möjlighet till en avgörande förändring. Vår analys och cirkulära färdplan kan hjälpa den svenska regeringen—och andra relevanta intressenter—att göra den cirkulära agendan till högsta prioritet. Sveriges hållbarhetsmål är djärva och ambitiösa—och kräver en djärv och ambitiös omställning: den cirkulära ekonomin.

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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 the Swedish economy as a whole. In this report, when we talk about consumption we are referring to absolute consumption.

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 the 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]

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 (for instance, the mass of goods imported or exported). Air and water are generally excluded. [Source]

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

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 reused 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 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]

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

1. INTRODUCTION

We are living in the Anthropocene: a geological epoch where our human imprint on the planet has caused increasing devastation to the natural world.[2] According to our *Circularity Gap Report 2020*,[3] our planet is only 8.6% circular: much of what we consume is wasted. Meanwhile, our latest Report[4] found that on the road from COP25 in Paris to COP26 in Glasgow, we have collectively consumed more than half a trillion tonnes of materials.[5] Our linear 'take-make-waste' economy has made throw-away culture the norm, putting increasing pressure on natural resources and our climate. Our analysis finds that Sweden's Circularity Metric sits well below the world average at 3.4%. While the nation has made great strides in the sphere of sustainability—often praised for its relatively low-carbon economy[6] and high rates of waste collection—it is highly material-intensive; in essence, Sweden is more linear than it looks. The country's material footprint is the third-highest among EU countries, coming in at 24.8 tonnes per year per capita. Its strong economy is tied to its openness and export-dependent trade profile. Our analysis provides an avenue for change: one that can maintain the Swedes' high standard of living while reducing pressure on material resources. This big shift is the circular economy.

THE RISKS OF THE LINEAR ECONOMY

Much of the globe functions within the linear economy: our dominant economic model characterised by 'take-make-waste' processes powered by fossil fuels. The global economy consumes over 100 billion tonnes of materials a year, with a Circularity Metric of 8.6%. It relies on heavy extraction and emissions-intensive processes to fulfil societal needs—be they Housing, Nutrition or Mobility. Sweden is no different: while the nation has been hailed for its environmental actions—regularly placing at the top of sustainability rankings,[7, 8] owing to its clean energy and high rates of waste collection—its economy remains linear in practice. Despite being relatively low-carbon, our analysis reveals that Sweden must look to manage materials in a new way. Consumption and extraction rates per capita are among the highest in the world; and while Swedish citizens meticulously sort their plastic from their rubbish and enjoy efficient waste collection services, what often happens afterwards reduces the country's circularity: incineration. With the goal of a circular economy being to eliminate waste and pollution, keep materials in use at their highest value and regenerate natural systems,[9] Sweden is missing out on key opportunities to cut resource extraction and consumption.

THE ROAD TO CIRCULARITY

With a Circularity Metric of 3.4%, Sweden is far from circular. Of the 266.7 millions of tonnes of materials the nation consumes, 96.6% are not cycled back into the economy: they are either locked into stock (like buildings or infrastructure), dissipated into the environment or wasted (see page 22). But low cycling only represents one part of the picture: the nation is also characterised by extremely high consumption rates: 24.8 tonnes per capita. While this is typical of a high-income trade nation, its consumption rates are almost double the global average. In satisfying the needs of its population—and exporting elsewhere in the world—Sweden extracts 26.4 tonnes of resources per capita per year within its borders, making the relatively small nation the fourth largest extractor in the world. Ultimately, Sweden hosts just 0.13% of the world's population, but is responsible for 3% of its material footprint: the materials needed to satisfy a country's demand, including imports. Sweden's geography (it's the third largest country by area in the EU, with low population density) coupled with the fact that it is relatively resource-rich and highly-developed helps explain this high per capita figure. The core tenets of a circular economy[10] will allow Sweden to pivot away from this linear pattern, bringing social progress within planetary boundaries.

Sweden's economy is largely linear and consumption is high; but across the globe, the impetus to change is surging. Glasgow's COP26 saw world superpowers scramble to update their national climate pledges in efforts to limit warming to 1.5-degrees; yet many fell short. Research estimates that all updated national climate pledges, if fully enacted, will lead to a warming of 2.4-degrees by the end of the century.[11] We know from the 2021 edition of the *Circularity Gap Report*[12] that 70% of emissions stem from material use and handling: decreasing consumption through circular strategies is inextricably tied to emissions reduction. But a focus on climate change—just one of nine planetary boundaries—isn't enough: already a relatively low-carbon economy, Sweden's priority should be to

add circularity to its arsenal of environment-saving strategies to cut material extraction and consumption. This is essential for achieving and maintaining healthy ecosystems, clean air and water, and flourishing biodiversity. While concrete action plans—such as the government's 2020 *National Strategy for a Circular Economy*—give some direction, there is ample room for new and reformed plans, policy instruments and material reduction targets.

A SOCIAL AND ECONOMIC CROSSROADS

The circular economy is a means to an end. And in reaching its end goal—an ecologically safe and socially just space for people and planet[13]—Sweden should continue to put social considerations, like decent employment opportunities and citizens' livelihoods, front and centre. The nation is well poised to do so: it's known as a generous welfare state and harbours ambitions to become the first fossil-free welfare nation in the world.[14] While reaching this safe space is necessary, the path there won't be straightforward. Conflicting interests exist across sectors and there is a deeply entrenched focus on GDP-based economic growth: strong commitments will be needed to steer action. A deeper understanding that current lifestyles, marked by high consumption, are unsustainable is crucial—necessitating a mindset shift away from the idea that all we need to do is recycle. Notions of progress must also be broadened beyond GDP growth—incorporating social and environmental indicators in our definition of wealth, prosperity and well-being.[15] While the absolute decoupling of resource use and economic growth is theoretically ideal, it is unattainable. And although Sweden has achieved relative decoupling—its GDP is growing at a higher rate than its material use—efficiency gains won't be enough if they're met by ever-rising extraction and consumption, domestically or abroad. Relieving environmental pressures will require the optimal transformation of extracted resources into goods that benefit society. A circular economy will require Sweden to reimagine and redesign its systems, ensuring the ecologically safe and socially just space it strives for.[16]

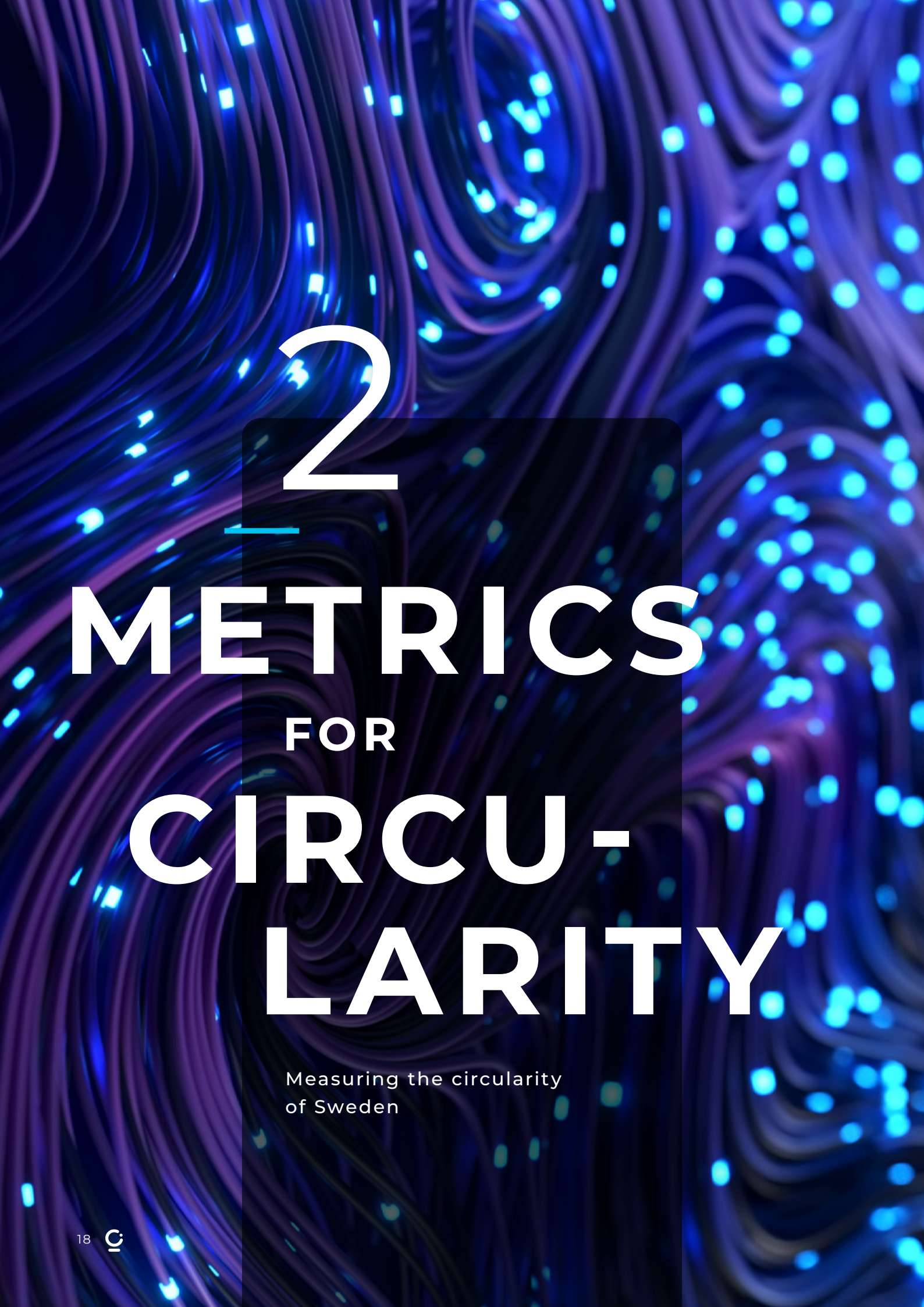
AN ECONOMY FULL OF POTENTIAL

Despite Sweden's low Metric, its cultural and economic makeup is rife with opportunity. And as rates of domestic extraction are particularly high, the country holds a lot of agency to cut its footprint—especially compared to other countries whose consumption mainly stems from extraction abroad. The country also has the progressive nature needed to ensure this process is just. Our analysis finds that there are several avenues to boost Sweden's Metric, from rethinking the way housing is built to transforming the food eaten and processes for manufacturing goods. These strategies could more than double the Metric, from 3.4% to 7.6%. While this increase may seem slight, the true remedy comes in slashing material consumption: with our strategies, Sweden could cut this figure by 42.6%, relieving environmental pressures and bringing benefits beyond emissions reduction and increased cycling.

Sweden has a strong foundation to implement our strategies: nearly all of its electricity comes from low-carbon sources,[17] it boasts the economic environment needed to shift to circular business models, and it's open to innovation and change. Yet currently, action is limited, and political voices largely support single-issue solutions, like increasing recycling or transport electrification.[18] This is not enough to achieve the absolute decoupling of economic growth and resource consumption needed to fight climate change and relieve environmental pressures. The circular economy provides a holistic approach to these seemingly disparate issues: change that cuts across sectors and targets every aspect of materials' lifetimes, from extraction to processing to use to disposal (or reuse). This report presents six scenarios that will help Sweden cut its material footprint by nearly half, double its Metric and bring the country from theory to action: the true transformative, systemic change a circular economy requires.

AIMS OF THE *CIRCULARITY GAP REPORT SWEDEN*

1. Provide a snapshot of how circular Sweden is by applying the Circularity Metric methodology.
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 Sweden'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. Communicate a call to action based on the above analysis, to inform future goal setting and agendas.



2

METRICS FOR CIRCU-LARITY

Measuring the circularity of Sweden

Measurements are critical to understanding the world around us. As it becomes more urgent for us to adapt our economic system and become more circular, we need to provide a tactical approach to measuring something so abstract and complex. 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 Sweden'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. And staying within this safe space is key, coming above maximising economic growth. 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.[19] 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 of physical systems such as road infrastructure, technologies, and their efficiencies[20] and social systems, which include government institutions, businesses, communities and markets.[21] 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 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 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 Sweden, we worked with RISE Research Institutes of Sweden as a local partner and SCB (Statistics Sweden) as a data provider.

MATERIAL FLOWS AND FOOTPRINTS

Figure one provides a schematic depiction of the socioeconomic metabolism of Sweden. It depicts the amounts of materials (clustered into four key resource groups—excluding water and air) 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, for example).

We also see on the left the volume of resources entering the provincial 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) of a national economy (read more on this on page 26).

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 the 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.

* You may notice that the footprint of Swedish societal needs is given as 276 million tonnes, rather than the 257.5 million tonnes mentioned earlier in the report. This figure is Domestic Material Consumption (DMC): the physical consumption of an economy, which doesn't distinguish between intermediate demand and final demand for materials. This differs slightly from Raw Material Consumption (RMC), the figure given elsewhere: our modelling approach requires that RMC is used to calculate values for the societal needs (explored on page 30), while the indicator framework (explored on page 22) and overall mass balance are dependent on DMC.

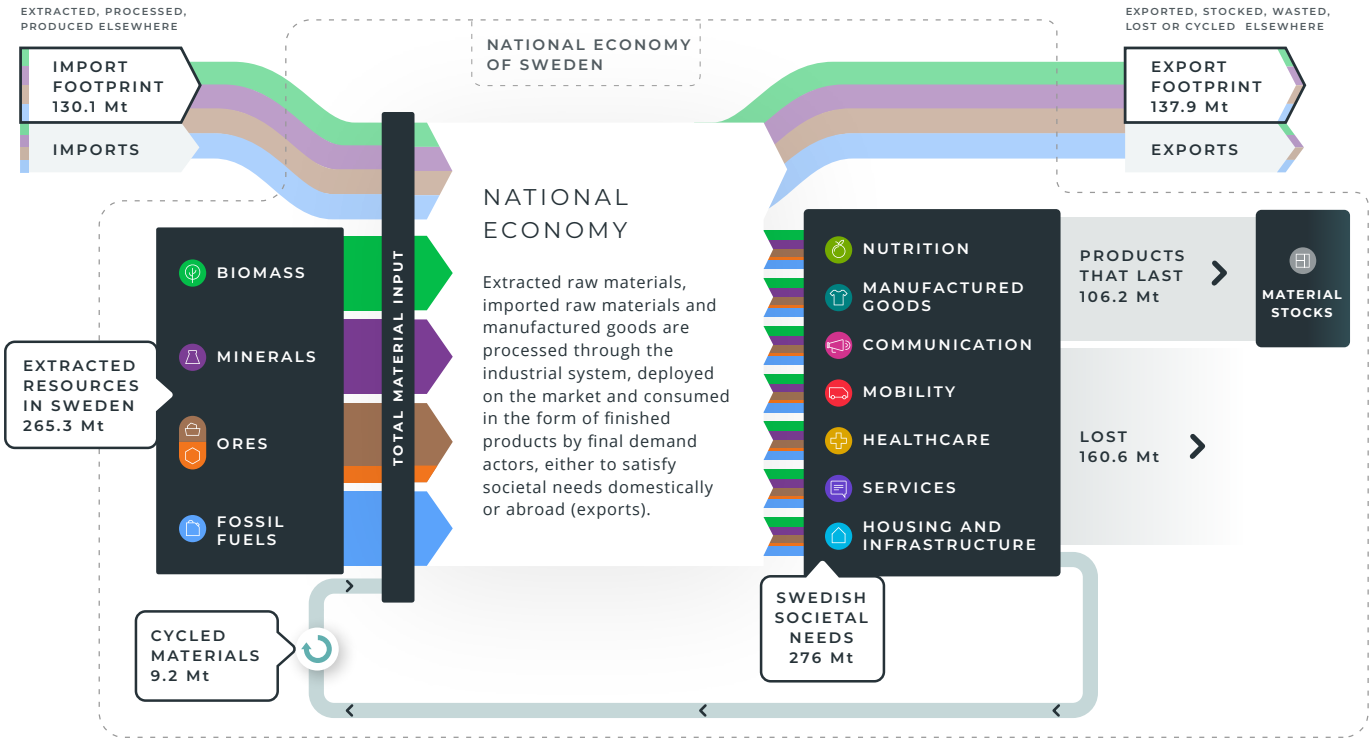


Figure one shows a schematic overview of the socioeconomic metabolism of a country. Note: material stock and cycled material flows are not scaled to proportion.

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. (2015).[22] (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).[23]

The core objectives are:

- **Objective one:** Resource extraction from the Earth is minimised and biomass production and extraction is regenerative;
- **Objective two:** The dispersion and loss of materials is minimised, meaning all technical materials have high recovery opportunities, ideally without degradation and with optimal value retention; emissions to air and dispersion to water or land 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, 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:** This encompasses the recycling and/or reuse of products and materials. 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. Downcycling, while still a form of cycling, is the least desirable option. In practice: Design for recyclability (both technical and biological), design for disassembly, recycling, upcycling, reuse.

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 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 into 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. Additionally, it should provide direction as to how Sweden 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 dependent are we on imports to satisfy our basic

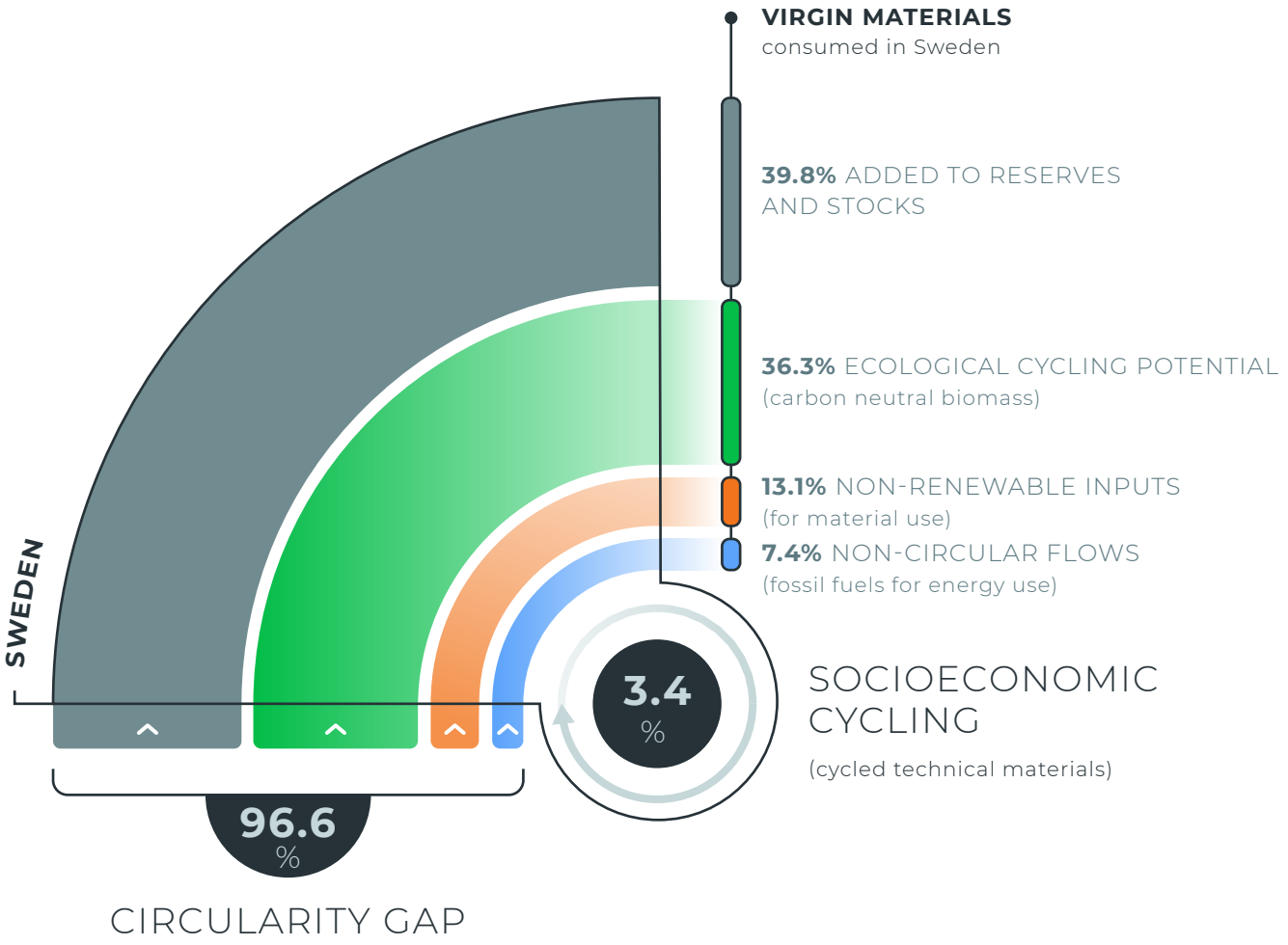


Figure two shows the full picture of circular and non-circular materials that make up Sweden's Circularity Gap.

societal needs? How much material is being added to stock like buildings and roads every year? How much biomass are we extracting domestically, and is it sustainable? These categories are based on the work of Haas et al. (2020).[24]

Circular inputs (39.7%)

1. Socioeconomic cycling rate (3.4% in Sweden)

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 recycled cement and metals) and biological cycles (such as paper and wood). In Sweden, this number is well below the global average of 8.6%, totalling 3.4% of total material input.

2. Ecological cycling potential (36.3% in Sweden)

Ecological cycling concerns biomass, such as manure, food crops or agricultural residues. To be considered ecologically cycled, biomass should be wholly sustainable and circular: this means it must, at the very least, guarantee full nutrient cycling (read more in the text box on the following page)—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, land-use change and forestry (LULUCF) 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. The huge volume of forested area in Sweden that is economically and socially sustainably-managed provides a significant basin for carbon sequestration, meaning that Swedish LULUCF emissions are certainly negative, and the biomass consumed within its borders can be considered carbon neutral.

Non-circular flows (7.4% in Sweden)

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 emitted into the atmosphere as greenhouse gases, are inherently non-circular. They combust and disperse as emissions in our atmosphere: circular economy strategies are not applicable here, as the loop cannot be closed on fossil fuels. At 7.4%, Sweden's rate of non-cyclable inputs is relatively low. This is in line with the low-carbon character of the Swedish economy. While the majority of electricity and heat comes from renewable sources, Sweden is still dependent on fossil fuels for other processes such as industrial energy use and transport.

Non-renewable inputs (13.1% in Sweden)

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. Sweden's non-renewable input rate stands at 13%, suggesting that there is room for the improved cycling of non-renewable materials.

Net additions to stocks (39.8% in Sweden)

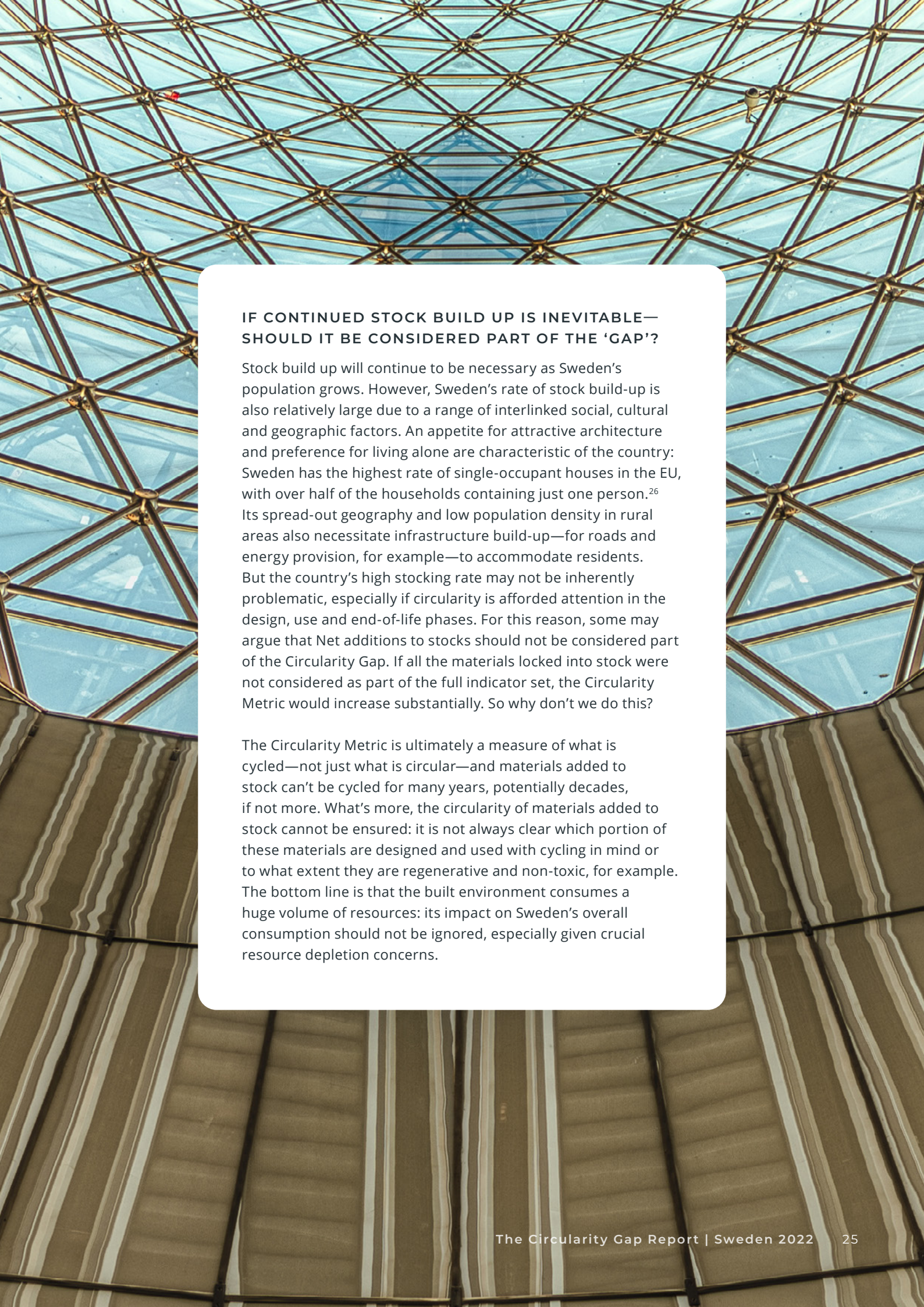
The vast majority of materials that are 'added' to the reserves of an economy are 'Net additions to stock'. Countries are continually investing in new buildings and infrastructure, such as to provide Mobility and Housing, as well for renewable energy, such as building wind turbines. This stock build-up is not inherently bad; many countries need to invest to ensure that the local populations have access to basic services, as well as buildup infrastructure globally to support renewable energy generation, distribution and storage capacity. These resources do, however, remain locked away and not available for cycling while in use, and therefore weigh down the Circularity Metric.

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 the only condition: nutrients (including both mineral and organic fertilisers) must be fully circular as well. Nutrient cycling is like biological recycling: it is the process by which matter decomposes and is transformed into new matter at the end of its lifetime. As of yet, we have methodological limitations in determining nutrient cycling: for example, we cannot track where Swedish timber products end up around the world, or how they are managed at end-of-life. To this end, we have not included ecological cycling in our calculation of Sweden's Circularity Metric—even though this could potentially boost the country's circularity rate to an impressive **39.7%.** We take a precautionary stance with its exclusion, with the knowledge that its impact on the Metric may not be totally accurate—we cannot track biomass extracted in Sweden to its final end-of-life stage, so it's difficult to ensure that the nutrient cycle has closed. If this were the case, however—and the sustainable management of biomass becomes the norm—circularity could greatly increase.

EXPLORING THE GAP: HOW DOES SWEDEN MEASURE UP AGAINST A SIMILAR ECONOMY?

In 2020, Circle Economy explored the full indicator set for the first time in the *Circularity Gap Report Quebec.*[25] With a vast forestry sector, high levels of mineral extraction, and a developed, open, and export-oriented economy, Quebec's analysis provides useful figures for comparison. At 3.5%, its Circularity Metric is almost the same—but this is where the similarities end. In spite of forests being a significant resource for both economies, Ecological cycling potential is much higher for Sweden: 36% versus Quebec's 26%. This can be explained by the greater prominence of forestry in Sweden's economy. Sweden also boasts a lower-carbon economy than Quebec: less dependent on fossil fuels, Non-circular flows only make up 7% of its Gap, compared to Quebec's 17%. A similar trend exists for Non-renewable inputs. Sweden sits at 13% for this indicator—far below Quebec's 36%, illustrating its high cycling rates for materials like metals, plastics and glass. Contrastingly, Quebec's rate of Net additions to stocks is nearly half that of Sweden's at 19%: stock build up is booming in the nation, owing to population growth, its spread-out geography and other structural factors.



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

Stock build up will continue to be necessary as Sweden's population grows. However, Sweden's rate of stock build-up is also relatively large due to a range of interlinked social, cultural and geographic factors. An appetite for attractive architecture and preference for living alone are characteristic of the country: Sweden has the highest rate of single-occupant houses in the EU, with over half of the households containing just one person.[26] Its spread-out geography and low population density in rural areas also necessitate infrastructure build-up—for roads and energy provision, for example—to accommodate residents. But 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, some may argue 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 Sweden's overall consumption should not be ignored, especially given crucial resource depletion concerns.

A COMPLEX UNDERTAKING: SCOPING AND TRADE DYNAMICS

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.[27]

In assessing a country or region, we first decide to either take a production or consumption perspective. In a production perspective, we consider all the materials involved in any sort of processing of production activity, regardless of whether they are exported or consumed domestically. In a consumption perspective, we consider only the materials that are consumed domestically. Whether we apply the Metric from a consumption or production perspective will yield different results. Our *Circularity Gap Reports* take a consumption perspective in a bid to generate actionable insights for the economy and consumption on the ground, and to enable comparison between countries. However, there are some limitations to our approach: Sweden's 'open' trade profile—marked by plentiful imports and exports—means it is 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? Well, 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 circular economy waste management hierarchy) wherein reduction of production and consumption is always the preferred and most effective strategy.

Thirdly, when considering what Swedish citizens 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 raw material equivalents (RMEs) coefficients in this study. As an open economy with high purchasing power and a large consumption footprint, doing so in the case of Sweden is more complex than for a smaller economy.

Finally, the Circularity Metric considers all secondary materials as adding to a country's level of circularity. These secondary materials can be part of those cycled within the country, as well those that are imported or exported, either as waste destined for recycling or as secondary materials embedded in traded products. However, estimating the shares of traded secondary materials is a difficult undertaking, so we introduce an important assumption: in order to estimate the volume of secondary materials imported, we apply the average Global Circularity Index (GCI)—calculated per resource group—to the net direct imports of the country (aggregated by resource group). Because the GCI includes waste for recycling and partially also secondary materials, we assume that this is a good proxy for the estimation of the total amount of secondary materials in the system. The underlying assumption is that—although varying in terms of volume—imports of every country have the same average share of secondary materials per resource group. To determine which share of secondary materials are consumed domestically, rather than exported, we make a second assumption. This is that the share of secondary materials in the total consumption of raw materials is equal to the share of imported and domestically cycled secondary materials in the total input of raw materials.[28]

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 cycling.** A circular economy strives to keep materials in use and retain value at the highest level possible, while decreasing material consumption. The cycling of materials measured in the Circularity Metric is only one component of circularity.
- **The Metric doesn't capture all aspects of sustainability.** Our Circularity Metric focuses only on material use: the share of cycled materials in 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-use stage are weak, presenting challenges in quantifying global material flows and stocks.
- **Quality loss and material degradation.** The Metric focuses on the end-of-use cycling of materials that re-enter the economic system but does not consider in what composition, or to what level of quality. As such, any quality loss and degradation in processing goes unconsidered.
- **Relative compared to absolute numbers.** The Circularity Metric considers the relative proportion of cycled materials as a share of the total material input: 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.

For a more exhaustive look into the methodology behind the *Circularity Gap Report*, you can visit our website: www.circularity-gap.world/methodology

3 SIZING SWEDEN'S GAP

The resource reality of meeting societal needs

Sweden is 3.4% circular: of all the materials flowing through its economy, only a small portion are secondary. 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 Sweden's weighty material footprint: at 257.5 million tonnes, Sweden consumes more than twice the global per capita average—claiming 3% of the world's material footprint despite representing just 0.13% of its population. Key themes have emerged that paint a picture of the country's resource use: Sweden, while relatively low-carbon, is marked by heavy extraction and thriving trade, with material- and emissions-intensive activities in the mining, forestry, manufacturing and construction sectors. Extractive waste was revealed to weigh particularly heavily on the Metric. 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 *Circularity Gap Report* found that, for the first time in history, we're consuming more than 100 billion tonnes of materials every year. But as global material 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 are threefold: high rates of virgin material extraction, ongoing stock build-up to house a ballooning population and low levels of cycling. Our 2022 *Circularity Gap Report* illustrates the extent of our material use: since the 2015 Paris Agreement, the global economy has consumed more than half a trillion tonnes of materials, causing emissions to spiral upwards.[29]

The consumption of materials varies across geographies, however. Based on analysis in our 2020 Report, we see that Sweden is the exemplification of the *Shift* country profile—alongside most other high-income countries (see the textbox). This means that it scores very highly on the UN Human Development Index (HDI), between 0.8 and 1, but its Ecological Footprint—an indicator that accounts for human demand for natural capital—reflects its mammoth level of consumption. If everyone on earth were to live like the Swedish, we would require the resources of almost four planets.

In this way, the classic profile of a *Shift* country is one of high impact: these countries produce 66% of GDP while housing only 20% of the global population. They also consume the largest share of the globe's materials and are major world traders. The pressure is on them to 'shift' away from the over-consumption that services 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 of their environmental and social costs incurred elsewhere. It's clear that cutting Sweden's material footprint is top priority, while maintaining a socially just and prosperous nation—but this will imply major lifestyle shifts, from changes in diet, consumption patterns and travel behaviour. Movements to do so already exist: the flight-shaming social movement *Flygskam* (shame of flying due to climate impacts) has contributed to a 4% drop in Swedes' air travel—9% for domestic travel—a rare trend for a European country,[30] while recent years have seen a boom in the number of young adults cutting meat consumption or adopting a vegetarian diet.[31, 32]

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

Despite clear divergences between countries, suitable circular economy strategies can be developed based on discernible common needs. Based on the two dimensions of Social Progress—indicated by an HDI score—and Ecological Footprint, countries fall into three broad profiles:

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

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 tenfold that of Build countries. Fossil fuel extraction is relatively high, as is participation in global trade. So despite high HDI scores, these countries have a ways to go in cutting consumption. Country examples: USA, EU Member States, Japan, Argentina.

SOCIETAL NEEDS & WANTS

HOUSING AND INFRASTRUCTURE

The biggest category in terms of resource use is Housing and Infrastructure. The construction and maintenance of houses and infrastructure accounts for **125 million tonnes** (46.9%) of the country's total material consumption.

NUTRITION

Agricultural products such as crops and livestock require **29.6 million tonnes** (11.1%) per year. Food products have short life cycles in our economy, being consumed quickly after production.

MOBILITY

A considerable share of Sweden's total material consumption is taken up by the need for mobility; **24.6 million tonnes** (9.2%). In particular, two resource types are used: the materials used to build vehicles like cars, trains and aeroplanes; 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 **35.7 million tonnes** (13.4%) worth of resources.

SERVICES

The delivery of services to society ranges from education and public services, to commercial services like banking and insurance. The total material consumption is the fourth largest, **29.2 million tonnes** (10.9%) in total, and typically involves the use of 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 resource groups include use of capital equipment such as X-ray machines, pharmaceuticals, hospital outfittings (beds), disposables and homecare equipment. This accounts for **13.6 million tonnes** (5.1%) in Sweden.

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 such as laptops and smartphones to data centres, communication antennas and fibre-optic cabling. 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 **8.9 million tonnes** (3.3%).

THE MATERIAL FOOTPRINT SATISFYING SOCIETAL NEEDS IN SWEDEN

Domestic extraction

The Figure on the next page builds on the schematic material footprint diagram in Figure one on page 20. It dives into the socioeconomic metabolism of Sweden; linking how four resource groups (minerals, metal ores, fossil fuels and biomass) satisfy the seven key societal needs and wants shown on page 30. From left to right, the figure shows the domestic extraction of resources (Take) which amounts to **265.3 million tonnes,** through the mining of minerals and metal ores, or the production of agricultural crops for food or forestry to produce timber for construction, for example. These extraction processes result in raw materials like wood or sand. 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 **90.3 million tonnes.** Re-exports—products that are imported and without any processing are exported again—do not make up a significant part of Swedish 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 26, we see that Sweden imports 39.8 million tonnes of RMEs for a total import footprint of **130.1 million tonnes.** 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 2017, Sweden exported some 89.6 million tonnes of final products with an associated RME of 48.3 million tonnes, resulting in an absolute export footprint of **137.9 million tonnes.**

Waste generation

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 **257.5 million tonnes** of raw material consumption: Sweden's consumption footprint. In Sweden, the total amount of physical waste generated amounts to **99 million tonnes**, out of a total 169 million tonnes of Domestic Processed Output—the remainder of which comprises emissions, gases and dissipative flows. Of the total of physical waste, 6.6 million tonnes came from Products that Last and 29 million tonnes from short-lived Products that Flow.

Waste management

Sweden's waste management system is well-equipped to handle small volume, high-value waste streams—such as common metals—while treatment of high volume, low-value waste streams such as minerals (for example, waste rock and tailings from mining operations) is suboptimal, with landfill representing the main option. For household waste, incineration remains prominent. Of the total **99 million tonnes** of waste being treated, 8.3% are recycled, while the remainder is lost indefinitely. Of the latter, just 0.13% ends up incinerated (without energy recovery) while another 82.6% is landfilled, including extractive waste. Energy recovery plays a significant role: waste-to-energy represents 9% of waste management. Remarkably, about **90%** of the waste generated stems from mineral extraction: when excluding extractive waste, the rate of recycling jumps from 8.3% to 28%, the rate of energy recovery jumps from 9% to just over 30%, while landfilling figures are slashed in half—41% (see more on extractive waste in the text box below). Aside from materials going to waste, **106.2 million tonnes** of materials are added to stock (Net additions to stocks) in the form of capital investments such as buildings and infrastructure, machinery and equipment. Another **19.7 million tonnes** are released into the environment as emissions mostly of fossil origin: this figure is relatively low, which confirms the low-carbon character of Sweden's economy. The remaining **5.2 million tonnes** are dispersed into the environment as a deliberate, or unavoidable consequence of product use. This includes fertilisers and manure spread on fields, or salt, sand and other thawing materials spread on roads and the erosion of metals.

EXTRACTIVE WASTE: WHAT IS IT, AND HOW DOES IT IMPACT THE METRIC?

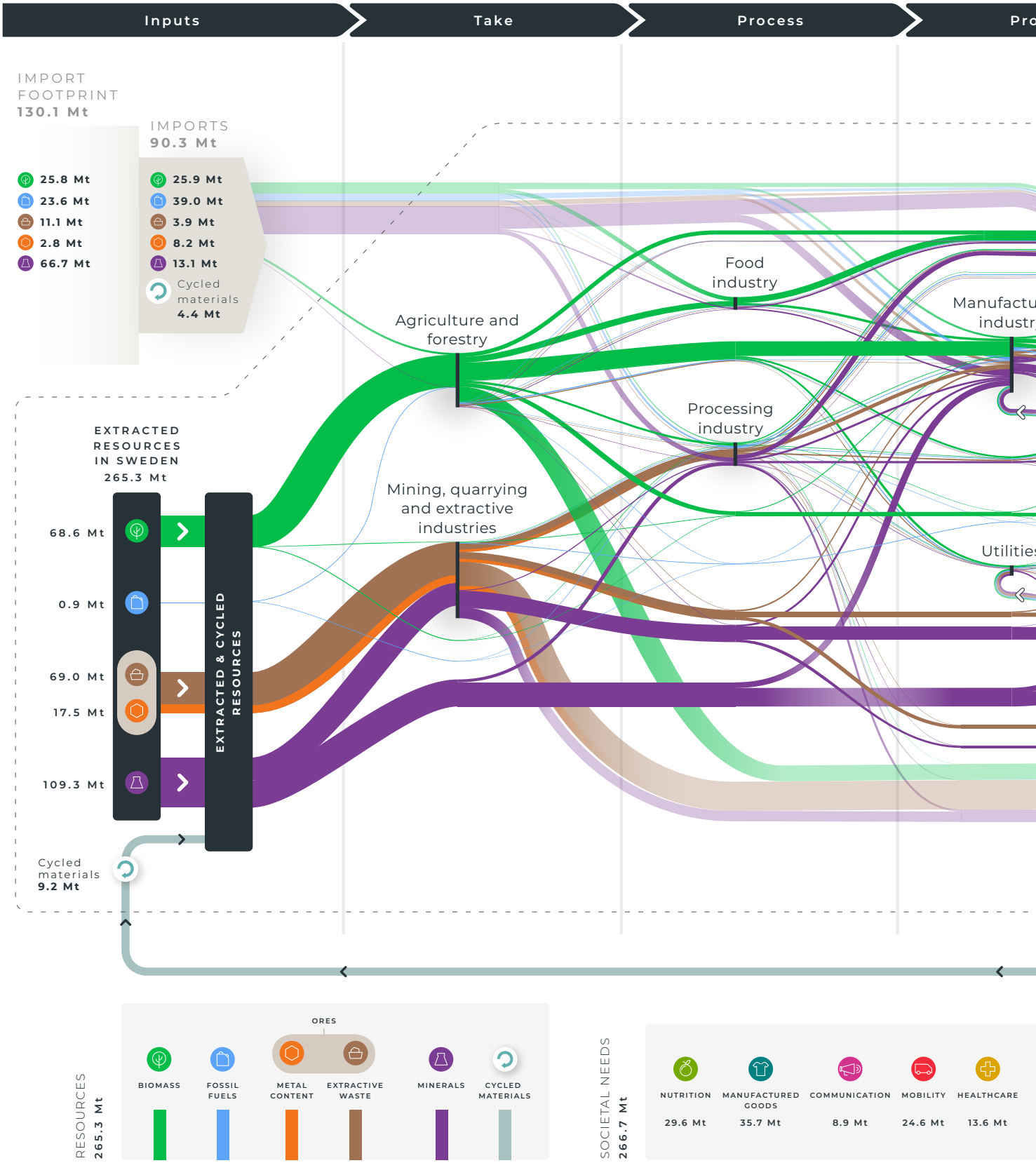
Extractive waste is generated as a consequence of extractive industrial processes: the prospecting, extraction, treatment and storage of mineral resources. The mining of metal ores and minerals generates huge quantities of extractive waste—representing around 90% of all waste generated in Sweden. 70% of this can be attributed to the mining of ores—primarily waste rocks and tailings. When we don't account for soils, dredging spoils and waste from the mining industry , overall recovery and recycling rates increase dramatically—from 16% and 23% to 44% and 92%, respectively.

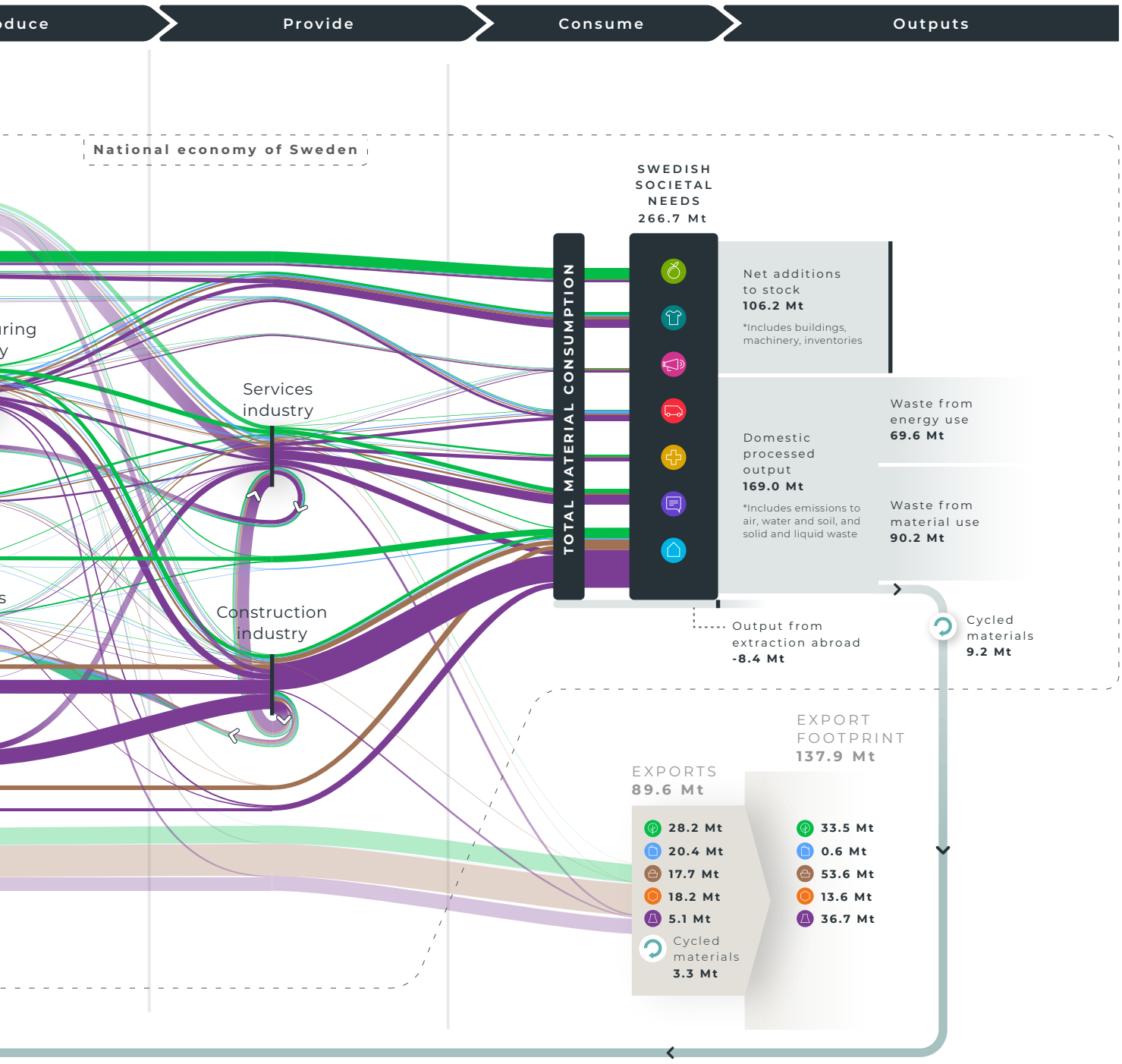
The fact that extractive waste represents the vast majority of Sweden's waste has a substantial—and negative—impact on the Metric. When accounting for all waste flows, Sweden's recovery and recycling rates seem unimpressive, sitting at 23% and 16%, respectively. Mining activities are largely confined to the remote northern regions, making reuse applications for extractive waste for construction purposes economically unviable. While such waste could be crushed and used for construction activities, particularly when rocks are not suitable for other activities, doing so would be costly and energy-intensive—resulting in a large proportion of extractive waste being landfilled close to extraction sites. In the future, the 're-mining' of valuable materials from extractive waste via recovery and valorisation could prevent new mining sites from being opened.[33] Using waste rock to backfill open pits is another option, although results vary widely depending on the specific site, and such reclamation strategies have limited environmental benefits.[34]

In past national *Circularity Gap Reports*, our modelling of various scenarios and their impact on the Metric have always included extractive waste. However, we recognise that its inclusion weighs heavily on the Metric in the Swedish context: even dramatically increasing the cycling of other materials—from food waste to textiles to plastic packaging—will have a limited impact given the vast quantity of extractive waste. To this end, our analysis has also included figures modelling scenarios' impacts excluding extractive waste.

X-RAY OF SWEDEN'S ECONOMY

Figure three shows an x-ray of Sweden's economy: the resources that feed into meeting key societal needs.





SERVICES
29.2 Mt

HOUSING AND INFRASTRUCTURE
125.0 Mt

The extractive waste is not shown as a flow by itself, but rather is integrated into the Ores flows.

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.

FAMOUSLY LOW-CARBON—BUT ALSO HIGHLY MATERIAL-INTENSIVE

Sweden's reputation as a global leader in decarbonisation is well known: it's the first country in the world to introduce carbon pricing, and currently boasts the highest carbon price—both factors that have contributed to its relatively low-emissions society.[35] Still deeply entrenched in linear practices, however, its consumption footprint remains high: standing at **257.5 million tonnes,** Swedish residents consume **24.8 tonnes** of materials each on an annual basis. This is a strong driving force behind the Metric of 3.4%, which sits well below the global average; indeed, the Metric is even more affected by a country's material footprint than its secondary material consumption. Sweden's Metric can't grow until its consumption drops: but trends are not progressing in their favour. While the country's consumption is lower than other major Nordic economies—like Norway and Finland—it still remains high. The impact of this is significant as material use is closely tied to emissions: the carbon footprint of Swedish consumption measures up to **84.2 million tonnes**—about 63% larger than its territorial emissions, which stand at **54.2 million tonnes**. In essence: the country is importing embodied carbon.

Slightly less than one-third of Sweden's consumption-based carbon footprint occurs within territorial borders: imports from Russia (8.7%), China (7.3%), Germany (4.8%) and other Asian (5.4%) and Middle Eastern (3.8%) countries embody the greatest proportion of emissions. These emissions can be largely attributed to five clusters: the built environment—including residential and non-residential construction—is the most emissions-intensive by far, contributing 36%, followed by vehicles and machinery manufacturing at 5%, food manufacturing and services at 4.1%, chemicals at 4% and forestry at 3%. Sweden could continue to slash its emissions—as well as material—footprint by favouring domestic production, or prioritising the import of secondary over virgin materials. This is characteristic of most *Shift* countries: as an importer of materials, Sweden is an exporter of impacts.[36]

A GLOBAL STANDOUT FOR MINERAL, METAL AND BIOMASS EXTRACTION

Sweden is characterised by very high rates of extraction: from minerals and metals to biomass, the nation extracts **265.3 million tonnes** of resources within its borders—in per capita terms, this is **26.4 tonnes**; the second-highest in Europe after Norway, and the fourth-highest worldwide. Extraction is spread fairly evenly across resource groups, with non-metallic minerals coming in first at **109.3 million tonnes**, followed by metal ores at **86.5 million tonnes**—of which the majority, **69 million tonnes**, are extractive waste and **17.5 million tonnes** are metal content. These figures are double and triple world averages, respectively. Biomass trails slightly behind, with extraction hovering around **68.6 million tonnes**—also double the world average. Conversely, fossil fuel extraction is relatively low: only about **900,000 tonnes** are extracted—a wholly different picture than neighbouring Norway, or that of other fossil-rich nations.

These figures may seem abstract—aside from the knowledge that they top world averages, what can these extraction rates tell us about the Swedish economy? Slightly less than half (48–49%) of the country's total domestic extraction feeds into meeting its own societal needs—while around 52% meets foreign demand. For non-metallic minerals and metal ores the picture is slightly different: Sweden, known as a successful mining country by European and global standards, exports the vast majority of this resource group. With metals and minerals representing nearly one-tenth of the nation's total export value,[37] Sweden is the main source of Europe's iron ore production, and provides smaller but significant quantities of zinc, cobalt and copper.

In addition to its abundant mineral resources, Sweden is known for its vast forests: covering around 70% of the country's area, Swedish forests are largely actively managed, making the nation a world leader in paper, pulp and sawn wood production. Despite its international reputation, slightly over half of Sweden's biomass extraction fulfils national

demand—especially owing to the increasing use of biofuels for transport, power generation and heating since the advent of the 21st century. Largely driven by policy decisions, solid biomass fuels—such as wood and pellets—have contributed substantially to district heating generation: around two-thirds of the total in 2016.[38] Indeed, our analysis finds a comparatively small proportion of biomass waste ends up incinerated (without energy recovery) or in landfill—the vast majority is rather used for energy recovery. Biomass extraction is considered carbon neutral, to a degree—which is driving rapid extraction rates. This is not without consequences: the loss of old growth forests, driven by an interest in maximising production and timber yields, is catastrophic for biodiversity—especially when replaced by new monoculture plantations.[39] Extraction rates outpacing reproduction is putting increasing pressure on land use.

EXPANDING BUILDING STOCK AND THRIVING MANUFACTURING INDUSTRY

As noted, Sweden's domestic extraction is among the highest in the world—and almost **one-third** of it feeds into meeting the country's societal need for housing and infrastructure. Over the last decade, business has been booming for the construction sector.[40] Net migration has fed a growing population, while lifestyle and cultural trends have put further pressures on demand—Sweden maintains the highest share of single-occupancy households in Europe and secondary homes (such as summer houses) are common. The sector's resource use, from materials and water to energy—is spiralling upwards, driving domestic extraction and inflating Sweden's material footprint. Sweden's abundance of non-metallic minerals, primarily sand and gravel, are largely used for concrete production—and consequently, almost half (48%) of Sweden's total material consumption, **125 million tonnes**, is linked to the building stock. This isn't only due to population growth, however: Sweden's area is the third largest in the EU, and population density is very low—necessitating spread-out infrastructure that connects rural communities and provides civil amenities and services.

Similarly, the rapid expansion of the building stock during the last years has locked vast amounts of materials into stocks. Currently, roughly 40% of virgin materials imported to or extracted in Sweden, around **106.2 million tonnes**, are considered Net additions to stock annually—most of them in the form of buildings or infrastructure. This, in turn, delays possible cycling of these materials, and hikes up energy demand and emissions through construction processes and building use. Even efficiency gains in the way buildings are erected and operated are dulled by stock expansion:41 more circular construction won't cut the sector's material footprint if building rates continue to grow.

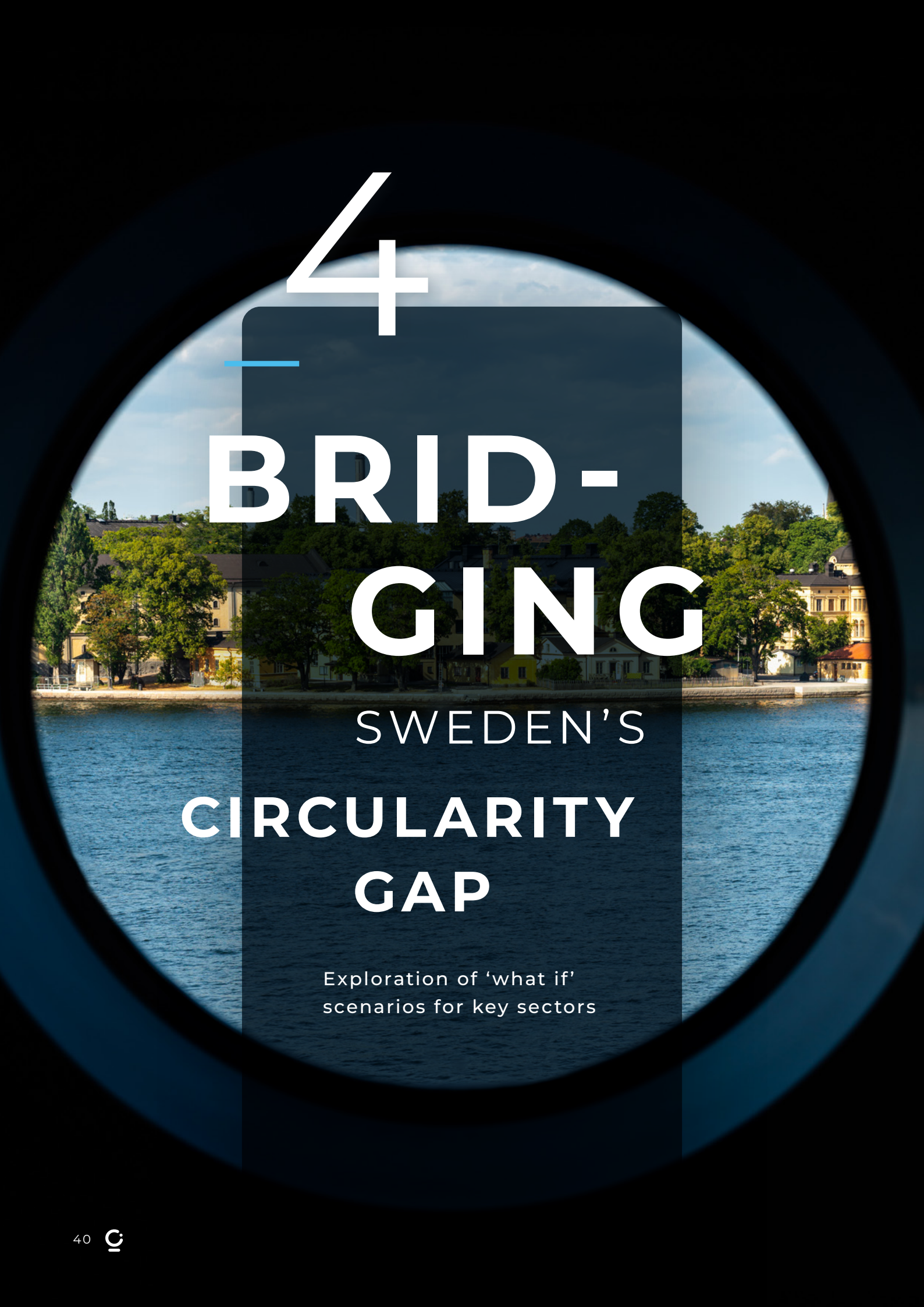
The manufacturing sector also drives Sweden's extraction, by requiring materials to process into the goods that represent 13.4% of Sweden's total material consumption: **35.7 million tonnes**. Despite a shift towards services during the last decades, manufacturing is still considered the backbone of the Swedish economy—a key sector in terms of value creation, employment and especially trade.[42] The most important export sector, Swedish manufacturing is innovative, dynamic and high-tech, with unique characteristics that has allowed it to remain strong and competitive despite some important disadvantages.[43] It is this core economic importance that, along with construction, largely influences Sweden's extraction: logging, for example, provides materials for a range of energy-hungry sub-sectors, from pulp and paper to timber production and chemical processing. Ores and other minerals are similarly processed and fed into sectors such as industrial engineering, and machinery and vehicle production—one of the export sectors Sweden is particularly known for.

A KEY PLAYER ON THE GLOBAL SCENE WITH THRIVING TRADE

A relatively small country of 10.4 million, Sweden is prosperous, with an open, highly-interconnected and complex economy.[44] It's a strong trade nation: despite ranking 88th in the world based on population, it sits in 32nd place for exports and 31st place for imports by value, and ranks 8th in the world for economic complexity—characterised by diverse productive capabilities and strong competitiveness. As a result, Sweden is highly trade-dependent and export-intensive: in 2019, trade as a percentage of GDP reached 91%[45] and the export of goods and services as a percentage of GDP was roughly 48%.[46] With strong trade partners in Europe, such as Norway, Denmark, Finland, Germany and the United Kingdom, but also in the Middle East, China and the United States, Sweden's reach extends around the globe.

Sweden supplies much of the EU with raw materials such as iron ore and other minerals, also exporting valuable products like vehicles and car parts, packaged medicaments, refined petroleum, and broadcasting equipment.[47] By weight, its exports amount to **89.6 million tonnes**, primarily composed of biomass (pulp, paper and sawn timber) at **28.2 million tonnes**, fossil fuels at **20.4 million tonnes** and metal ores at **18.2 million tonnes**. The export footprint, however—meaning the embodied weight of all materials used to create final export products—is significantly larger at **137.9 million tonnes**. We know Swedish domestic extraction per capita is among the world's highest—yet the majority of what's extracted is eventually exported. For example, the extraction of metal ores primarily satisfies foreign demand, with 78% of these materials being embodied in products for export. Contrastingly, the majority of biomass (51%) and non-metallic minerals (66%) extracted are used to meet domestic demand.

Conversely, of Sweden's **90.3 million tonnes** of imported goods, the majority are fossil fuels (**39 million tonnes**), followed by biomass (**25.9 million tonnes**) and minerals (**13.1 million tonnes**). The small import weight of minerals does not underscore their importance: over half (54%) of Sweden's material footprint is fed by mineral extraction—and while this mainly occurs domestically, imports from China and Finland are also significant. It is also important to consider that the RMEs—the weight of all the materials used to create final products—of Swedish imports can substantially inflate import figures. Sweden's total import footprint—the resources extracted (together with the waste and emissions released) abroad to satisfy Swedish demand—stands at **130.1 million tonnes**. This represents about 49% of the country's total consumption: approximately half of its material footprint is embodied in imports, such as crude and refined petroleum, machinery and manufactured goods. The total import footprint of minerals, for example, is five times the weight of what is imported into Sweden, at **66.7 million tonnes**, while the import footprint is nearly equal for biomass (**25.8 million tonnes**) and lower for fossil fuels (**23.6 million tonnes**).[48] Its status as a large importer is a key determinant of its low Circularity Metric—the circularity of imports is difficult to control, and large quantities of waste are often generated abroad in the production of the final products Sweden enjoys.



4

BRID-GING SWEDEN'S CIRCULARITY GAP

Exploration of 'what if' scenarios for key sectors

Now that we have presented how Sweden's Circularity Metric and indicator set are derived and investigated the message they portray, it's time to analyse the findings and suggest a remedy. First, we identify some of the most impactful sectors of the economy, which we procure based on either a Mass, Carbon or Value level; as well as their potential to reduce the material footprint. For the chosen sectors, we then formulate scenarios that explore and entertain the 'what-if', allowing us to 'dream big' and imagine a more circular Sweden. 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 footprint.

SCORING SECTORS ON THE MASS-CARBON-VALUE NEXUS

We have funnelled our energy for the 'what-if' scenarios into six key areas that represent key leverage points for the Swedish economy. These scenarios are 1) Construct a circular built environment, 2) Cultivate a thriving food system, 3) Make manufacturing circular, 4) Reshape extractive industries, 5) Drive clean mobility forward, and 6) Design conscious consumables. By focusing on a few key sectors, we can dive deep and apply a diagnostic lens to identify where we can best apply interventions to increase the circularity and resource efficiency of Sweden.

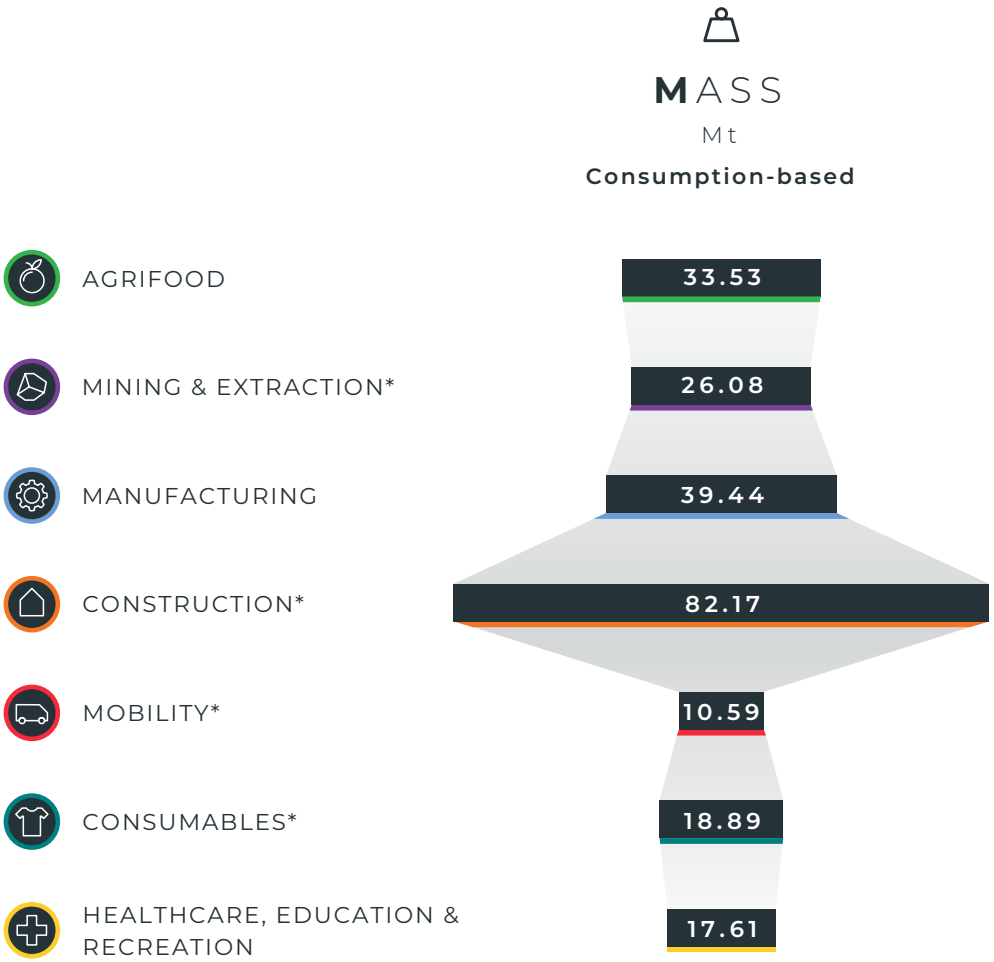
In selecting our scenarios, we zoomed into the key sectors contributing to Swedish economy, complementing this information with data on how the sectors score on their material consumption[49] (Mass), greenhouse gas (GHG) emissions[50] (Carbon) and financial value creation[51] (Value): the Mass-Carbon-Value (MCV) nexus. This holistic tool allows us to pinpoint the areas where we can make significant change by introducing circular strategies.

It is also worth noting that in our use of the term sector, we move beyond strict definitions and encompass a range of related areas under one umbrella 'sector'. The repair and recycling economies span across the four other sectors and therefore do not score on the MCV nexus. Lastly, due to the different classifications used, the MCV and the societal needs and wants attributions differ.

SUMMARISING THE MASS-CARBON-VALUE NEXUS

Firstly, **Mass** is consumption-based, shown in millions of tonnes, and represents the material footprint of each sector. It indicates where the most significant material consumption is taking place in the economy and thus where reducing consumption should be prioritised. Secondly, **Carbon** is consumption-based, shown in million tonnes of CO_2 equivalents (CO_2e), and gives us perspective on where the largest emissions mitigation potential may lie. Thirdly, **Value** is production-based, shown in billions of euros, and gives us information from an economic perspective. It indicates gross value added (GVA) per activity for each sector.

Before analysing each of these sectors individually, it is also helpful to consider their combined footprint to strengthen our understanding of their magnitude in relation to the rest of the Swedish economy. The mass of these seven sectors amounts to a total of 228.31 million tonnes, accounting for roughly 89% of total material consumption in Sweden. Their carbon footprint amounts to 79.59 million tonnes of CO_2e, representing about 84% of total GHG emissions in Sweden. Their value amounts to €222.12 billion, or about 47% of total GVA. This illustrates that the Swedish economy has other important sectors in terms of GVA, for example



*Includes biomass

*Includes real estate services

*Includes both freight and passenger transport

*Includes chemicals, plastics, textiles, furniture and small equipment

sectors that by nature are relatively less material- and carbon-intensive than those discussed below. This is in line with expansion of the share of services in the Swedish economy over the last few decades.

Unsurprisingly, the largest material footprint is claimed by the construction sector, representing 82.17 million tonnes (32% of the total footprint of the Swedish economy). Our first Scenario reflects attempts to slash this sector's large footprint—and indeed, shows the biggest impact for both cutting material use and boosting the Metric. Manufacturing (Scenario three) and agrifood (Scenario two) rank second and third for material footprint (15% and 13% of the total footprint, respectively), with other sectors trailing behind. Big-emitter Mobility ranks first for carbon footprint (with 23% of the total carbon footprint of the Swedish economy) and is the second highest in value—just behind Healthcare, Education and Recreation. It helped form the basis of our fifth Scenario: while its impact on the material footprint and Metric are relatively small, this Scenario's transport-related interventions will positively impact GHG emissions.

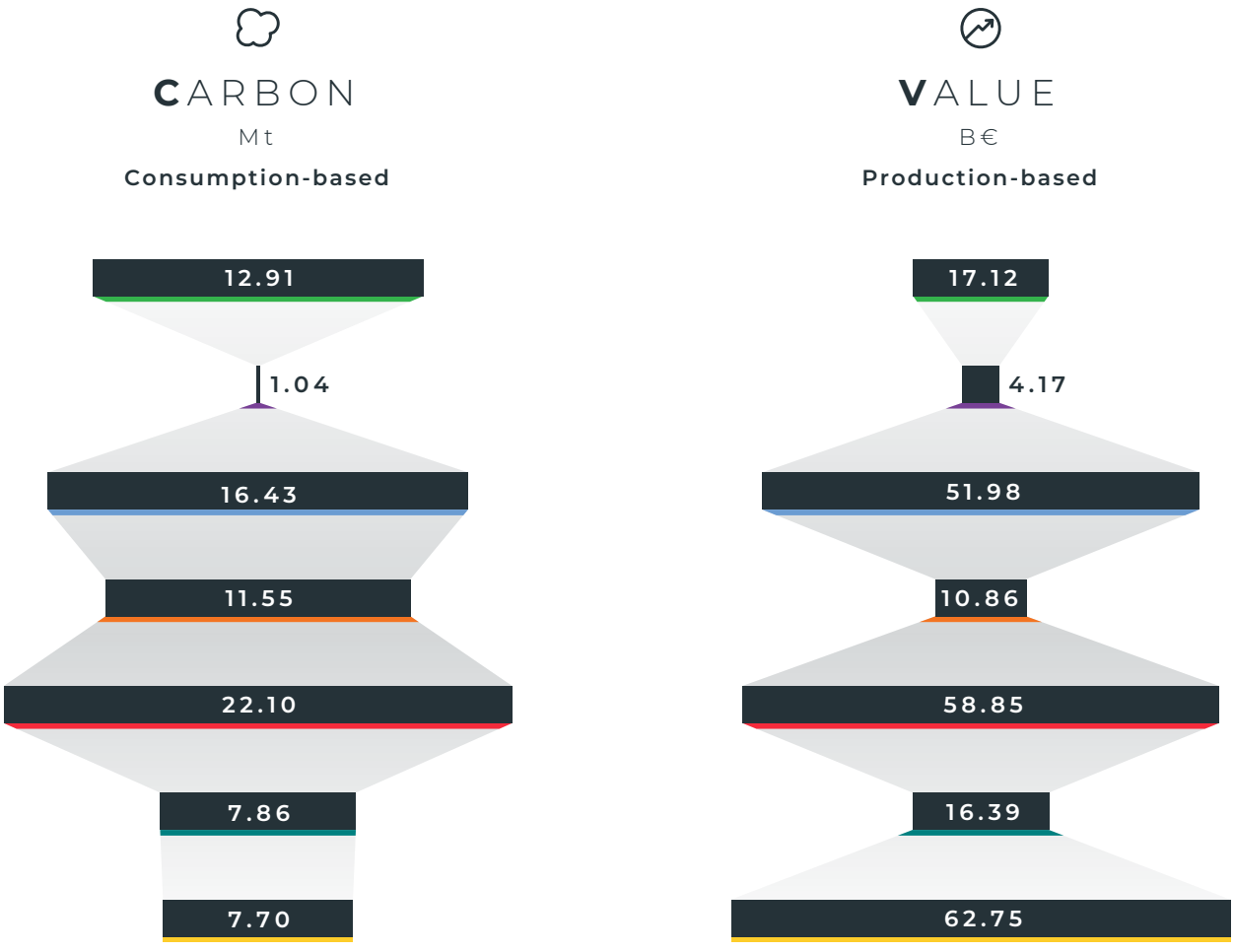


Figure four shows the impact of specific sectors on the Swedish economy in terms of Mass, Carbon and Value.

BRIDGING THE CIRCULARITY GAP: 'WHAT IF' SCENARIOS

In past national *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 were able to freely imagine our society could look with truly transformational change: a close to fully circular economy. Now, we have made our approach more grounded in reality: while we have not analysed political or legal hurdles, the scenarios presented are more technically feasible than in past analyses. What is presented below represents an implementable roadmap—while still allowing us to 'dream big' and sketch which type of interventions and levers are most impactful in terms of steering the Circularity Metric, as well as impacting the material footprint.

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. Input from expert stakeholders helped guide the selection, and tailored the scenarios to the Swedish context. In calculating the total impact of the scenarios on the Swedish economy, we can only measure the improvement to the Circularity Metric and material footprint, taking a Mass perspective. However, under each scenario, we also report the co-benefits of the circular strategies beyond only a reduction in the material footprint. 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 footprint 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 Sweden and beyond.

Our scenarios are informed and developed by the ultimate aims of slowing, narrowing, cycling and regenerating flows, as described on page 21, which provide a jumping-off point for the strategies needed to spur systemic changes.

1. CONSTRUCT A CIRCULAR BUILT ENVIRONMENT

The impact of the built environment on a global scale is enormous: 39% of all carbon emissions can be attributed to building and construction, including emissions from operation,[52] while our societal need for housing consumes 38.8 billion tonnes of materials—more than one-third of our material footprint.[53] And the sector's massive consumption is met by colossal volumes of waste: projected to reach 2.2 billion tonnes per year by 2025.[54] The case is no different in Sweden—construction is a resource-hungry and carbon-intensive sector that represents a large portion of the nation's material footprint, waste generation and emissions profile.[55] A growing population and high rate of immigration into the country, coupled with an appetite for more living space, are increasing the pressure on the need for housing and construction. As the country grows, the need for new homes, schools and hospitals grows in tandem. The country's geography and low population density also mean more infrastructure is needed to connect and accommodate residents. While still on the fringes of the mainstream, greater attention is being afforded to circular strategies, and the crucial role of the built environment in reaching Sweden's climate goals recognised: more than 100 public and private construction sector organisations have come together to develop a 'green deal' and roadmap for moving forward.[56]

In this 'what-if' scenario for the built environment, we outline opportunities for Sweden to boost its circularity while cutting the sector's substantial material use.

1.1 KEEP AN EYE ON BUILDING STOCK EXPANSION

The most impactful intervention for the built environment would prioritise cutting new material inputs, making use of strategies that both **narrow** resource flows and **cycle** materials. In this intervention, renovation will extend building lifetimes and fewer new buildings will be erected. This will limit the amount of virgin materials harvested by the construction sector—and a higher proportion of those that are built will use waste as a resource, putting waste from construction and demolition to good use. The reuse of building materials (like steel and timber) and components (such as doors and window frames) could flourish if Sweden's government was to mandate

disassembly—strictly limiting demolition—in the construction industry. This would create a repository of secondary materials in usable condition.

This intervention is particularly relevant given Sweden's rapid stock expansion: in 2009, for example, less than 23,000 residential properties were constructed—the figure jumped to 55,659 a decade later, following a steady upward trend.[57] In the next decade alone, it is estimated that 600,000 new homes will be needed to meet housing demand.[58] This new construction contributes to the country's largest waste stream (excluding mining waste): wood, concrete and metal waste tops 9.4 million tonnes—far surpassing that of Denmark (2.7 million tonnes) and Norway (2.5 million tonnes), even taking Sweden's larger population into account.[59] Huge opportunities exist in this realm: currently, a large portion of construction and demolition waste is not recycled.[60]

In modelling housing stock regulation, we assume that only half of Sweden's housing demand is met by the construction of new buildings with virgin materials—the remaining need is fulfilled through practices such as renovation or construction with secondary materials. This first intervention is the most impactful of them all: the only one that addresses both consumption and cycling, it would result in a 10% decrease in Sweden's material footprint, an additional 3.03 million tonnes of construction and demolition waste cycled, and a boost to the Metric of 1.5 percentage points (including extractive waste).

1.2 MAKE RESOURCE EFFICIENT CONSTRUCTION THE NORM

While the ultimate goal should be to cut construction figures overall and maximise the use of secondary materials, other circular strategies can be applied to lighten environmental pressures when construction does occur. Flows can be **slowed** and **narrowed** by making use of durable, long-lasting and lightweight bearing elements, like aluminium and steel. Currently, between one-fifth and one-sixth of materials are lost during construction processes.[61] This is due to, for example, dimensional adjustments, poor planning where materials are ordered in excess to prevent costly delays in construction processes, and incorrect storage and handling. In cutting these figures substantially, flows can be further **narrowed** by decreasing material intensity. Prioritising local construction materials would cut emissions from transport—**narrowing** flows—while ensuring construction materials come from secondary sources will serve to further **cycle** flows.

Sweden may be forced into more resource-efficient construction very soon: one of the country's biggest lime quarries failed to have its licence to mine extended on environmental grounds, due to a recent ruling from the Swedish Supreme Land and Environmental Court, with the company's appeal rejected in late 2021. While the government has now reversed the ban—giving temporary permission to continue mining until late 2022—the battle isn't over yet: the Swedish Society for Nature Conservation intends to appeal the decision.[62] The Cementa plant has consistently supplied three-quarters of the country's cement—and is the second largest point-source emitter of carbon dioxide equivalents in Sweden.[63] If the ban were to be reinstated, resulting cement shortages could be expected to nudge the construction sector towards crisis: other alternatives will be crucial.

In modelling resource efficient construction, we assume an increase in the lifetime of metals like steel and aluminium, a reduction in the transport of materials to and from construction sites by increasing the share of local materials and supply chains, and a sharp decrease in material losses during construction processes. Cement use would drop, instead substituted with ashes from incineration and energy recovery processes. This intervention would result in just a 0.2% drop in the material footprint, and a small boost to the Metric, of 0.2 percentage points (including extractive waste). This is due to rebound effects that lower overall impact: for example, lightweight and modular construction elements may cut the amount of steel and aluminium needed but may require more costly resource- and energy-intensive assembly and disassembly processes. This scenario's interventions also largely tackle the inputs of the construction sector, rather than investment in new buildings—the latter is far more impactful as limiting stock expansion precludes resource use.

1.3 SHIFT ENERGY CONSUMPTION TO OPTIMISE HIGH-VALUE CYCLING

Our third intervention firstly compiles an arsenal of strategies that **narrow** flows by cutting residential and non-residential energy use.[64] Implementing energy-efficient appliances and practising more efficient use, combining them with smart metres and lowering

room temperatures by 2-degrees will all boost energy efficiency. Another strategy aims to shift the source of building's energy consumption: currently, one-quarter of Sweden's district heating is represented by waste-to-energy—a portion of which is fed by potentially recyclable waste, such as food waste. This strategy **cycles** flows by decreasing the volume of recyclable waste fuelling waste-to-energy, with this portion of the energy demand instead being met through geothermal heat pumps. However, decreasing the volume of waste available for incineration will require substantial preparation, as well as adaptation of the district heating system to allow for these new circumstances. While we model the impact of substituting waste-to-energy with energy from heat pumps, there are numerous other possibilities: these are discussed in the textbox on page 47.

Sweden's history with waste-to-energy is long—and largely accepted despite being based on incineration. Currently, half of Sweden's household waste is fed to waste-to-energy plants,[65] with the nation even looking to meet demand for feedstock from other countries.[66] In a scenario where greater volumes of recyclable waste are sorted and cycled rather than incinerated, this situation could change: heating could instead be supplied by heat pumps powered by **regenerative** sources, such as renewable energy or geothermal power.

In modelling greater energy efficiency and autonomy, we assume that the electricity produced through burning recyclable biomass and waste is replaced by **regenerative** or low-carbon energy. We also assume that building owners and district heating companies invest in alternative heat sources—such as heat pumps—to reduce the volume of recyclable waste used as feedstock for incineration. Food waste is cycled, creating bioresources that can be directed to other uses (such as long-distance transportation), rather than burnt to create bioenergy. Under this intervention, the demand for electricity and heating in the building sector also decreases. This intervention, at first glance, has a negative effect on both the Metric and material footprint, pulling the Metric down by a slight 0.03 percentage points (including extractive waste) and increasing material use by 0.8%. Why? Increasing the use of heat pumps will require more materials to get off the ground—but an initial investment will yield greater benefits in the future, from both the perspectives of energy efficiency and increased cycling of currently incinerated, recoverable waste.

Impact on Sweden's circularity:
Implementing these circular strategies would increase the Circularity Metric by 1.5 percentage points (including extractive waste) (1.9 percentage points excluding extractive waste), while the material footprint would be reduced by 8.2%. Other benefits are plentiful: limiting the expansion of the built environment through strategies that extend lifetimes can cut costs and emissions, and create additional jobs in renovation.[71] Improved design and more careful material choice can usher in new circular business mdels.[72]

SPARKING HIGH-VALUE MATERIAL REUSE IN THE SWEDISH CONSTRUCTION SECTOR

Sweden is making strides to ensure its infrastructure build-up is based on green principles. Based on new policy instruments proposed by the Delegation for a Circular Economy,[73] the Swedish Environmental Protection Agency (EPA) is investigating how materials excavated during construction processes can become more circular.[74] As of August 2020, stricter regulations have been rolled out for construction and demolition waste: higher-value waste management practices are now prioritised over low-grade applications.[75] The reuse of building materials is being made even easier through, for example, the creation of the Center for Circular Construction (CCBuild). The Center offers several digital services to support a transition to circular flows, from a Product Bank and Inventory App to a digital marketplace to buy and sell secondary materials. Businesses are also able to make use of value analyses, including performance reports and quality criteria for secondary materials, to guide the process.[76] While these initiatives have sparked a paradigm shift in the building sector by targeting waste and increasing material reuse, strategies that address overconsumption and unsustainable materials still need to scale up.

CONTROVERSIAL AND COMPLEX: WASTE-TO-ENERGY AND DISTRICT HEATING

District heating is the largest energy source for building heating in Sweden: it supplies 90% of the heat demand of multi-family buildings and around 50% of total building heat demand.[67] The network is fed by many sources: from excess heat from industrial processes and data centres, to combined heat and power (CHP) plants and boilers.[68] Currently, however, waste-to-energy plants contribute approximately 25% of the district heating energy supply.[69] A well-established practice, Sweden recovers energy from half its household waste —meaning that in 2019, each Swedish resident sent an average of 235 kilograms of household waste to incineration, topping the EU rate by 20 percentage points. Sweden's 35 incineration plants supply electricity to 700,000 households—and district heating to 1.2 million.[70] And it's an efficient system: Sweden recovers more energy from waste than all other European nations. Domestic waste generation doesn't even fulfil its infrastructure's capacity, leading to plants treating more than 1.5 million tonnes of waste from other European countries: incineration plants require constant inputs to supply enough electricity and heat, even more so than other waste management facilities. But while this is firmly entrenched in Sweden, it has drawbacks that shouldn't be ignored: energy recovery from waste does not qualify as 'circular', and the EU has made moves to phase down the practice. While a portion of what's incinerated, such as hazardous or medical waste, doesn't have options for higher value retention, Sweden may aim to cut the use of high-value, recyclable waste in waste-to-energy by improving sorting and recycling infrastructure. Its district heating system is also already linked to electricity through heat pumps—meaning there is already an opportunity to produce heat through sources other than waste. Geothermal heat pumps can also be integrated into the district heating network as third parties; rather than being mutually exclusive, they are complementary and in theory, mutually reinforcing.

However, it may also be noted that the country is potentially 'locked into' a system that protects vested interests, and may reduce investment in higher-value cycling applications. While the capacity to recycle plastics and other forms of waste remains relatively low, CHP plants based on waste-to-energy remain the best option. This could be interpreted as a failure to establish strong markets for recycled materials, and the efficient recycling practices needed to do so. Yet the companies investing in waste-to-energy are often different from those that may invest in recycling infrastructure and technology.

While we model increasing the number of heat pumps in the district heating system, there are an abundance of other options to shift away from waste-to-energy. Locally generated renewable energy, for example, could be fed into district heating. This is already a reality in some places, as many combined heat and power plants operate in, or in the vicinity of, urban areas, making them more readily accessible to households; while several large scale heat pumps recover heat from the ground, sea or sewage water and feed it into the district heating system. Moreover, it could be possible to lower the temperature of the district heating grid, by making the least performing buildings more energy efficient; or feeding waste heat into the grid at lower temperatures, for example by cooling data centres. As more Swedish companies aim to produce fossil-free hydrogen—a major decarbonisation pathway popular among industry players—this technology may also play a more prominent role in the energy system in some parts of Sweden.

While the current system is complex, a realistic scenario could see a gradual shift away from waste-to-energy backed by public policy and regulatory changes and an understanding of electricity and heat production in a circular resource system. Using excess heat from industries and carrying out waste-to-energy processes for non-recoverable or hazardous waste remain valid opportunities to continue using Sweden's vast infrastructure.

2. CULTIVATE A THRIVING FOOD SYSTEM

Food production contributes to one-third of global GHG emissions[77]—and requires nearly 40% of our world's landmass to grow crops and animal feed and graze livestock.[78] The food we grow often travels vast distances around the world, meeting people's demand for out-of-season produce or goods not locally available. The Swedish situation is no different: while the country produces more than enough to feed its population, large quantities of food—around half of the total—are still imported to make up for lacking crop variety.[79] And while Sweden imports double the food it exports, exports are on an upwards trend. What's more: Swedes' consumption errs on the side of unsustainable, with emissions-intensive meat, dairy and processed foods featuring high on the menu—and just over half of the adult population is overweight, in line with the EU average.[80] In spite of this, the country has made efforts to restrict the impact its food system has on the environment: farming regulations for sustainability are stricter and more complex than in the EU,[81] and animal welfare sparked concern in the nation significantly earlier than other EU Member States. In recent years, the share of organic area (as a measure of total agricultural area) has risen, far surpassing the EU average: 20.4% versus 8.5%.[82] Sweden is, therefore, well-positioned to maximise the impact of strategies for the sector, especially as the topic gains more traction in public discourse for its connection to both human and environmental health.

In this 'what if' scenario for Sweden's food system, we outline opportunities for Sweden to boost its circularity while cutting the sector's heavy material footprint.

2.1 CONSUME LESS

This intervention centres around food consumption: in an effort to **narrow** flows, Swedes could limit their consumption to around 2,700 calories a day on average—typically more than enough for the average man or woman. This, in turn, would cut demand for food. The second strategy targets food waste, with the ultimate aim of preventing waste-to-energy—either by cutting food waste generation to begin with, or by directing food waste to anaerobic digestion, the more sustainable option.[83] These strategies serve to **narrow** and **cycle** flows.

Currently, Sweden's food consumption sits above levels needed to sustain healthy adults of both genders, and has been on a steady upwards trend: in 1980, consumption sat around 2,940 calories per capita per day, which increased to 3,275 calories per capita per day by 2018. Currently, the majority of this energy (78%) stems from the consumption of cereals, meat, dairy, sweets and alcohol—with only the remaining 22% contributed by vegetables and fruits.[84] Food waste is also a significant problem throughout the nation, with the average Swede discarding 133 kilograms of food waste per year in 2018—70% of which, or around 93 kilograms, is attributed to household waste. More than one-quarter of what households throw away is edible—or avoidable—waste:[85] massive quantities could be cut significantly by simply purchasing less food.[86] These figures sit well above the global average of 74 kilograms of household food waste per capita, and above other European countries' estimates, such as Germany (75 kilograms per capita), France (85 kilograms per capita) and Spain (77 kilograms per capita).[87] However, figures for these countries may be underreported in comparison with Sweden, which maintains high standards for measuring food waste.

This intervention assumes a flat reduction in food production—stemming from a cut in avoidable waste generation—across households, the largest source of avoidable food waste in Sweden. This will result in decreased food consumption. Doing so will see the material footprint decrease by a fairly significant 3.2%, with a slight boost to the Metric of 0.11 percentage points (including extractive waste). While its impact on circularity seems small, the real gains are shown in the decrease in material consumption—which will have a further positive impact on land use dedicated to farming, in addition to emissions and human health.

2.2 PROMOTE HEALTHY DIETS

While the previous intervention proposes a limit to the amount of food consumed, this one addresses the type: it would see a shift in Swedes' diets to vegetarian food, with high nutritional value. By cutting resource and emissions-intensive foods like meat—or those that go through heavy processing—environmental impact per calorie would be greatly reduced, therefore **narrowing** flows: getting more, for less.

Recent research on the city of London found that city-dwellers' diets consist of 23% meat and dairy, which accounts for nearly half of emissions from households' food consumption. Fruits and vegetables are eaten in nearly equal proportions by weight—yet account for a mere 4% of emissions.[88] These findings are particularly relevant to Sweden: between 1980 and 2018, meat consumption has risen steadily, growing by 32% to a total of 84 kilograms per capita per year.[89] Consumption of processed foods like confectionary and imported foods like chocolate have also spiked by 52%, along with soft drinks—which are consumed at a rate three times higher than in 1980.[90] From this, we see substantial opportunities for Sweden to improve the diet of its population, cutting resource consumption; from the extra feed, water and energy needed to raise livestock to the machinery, transport and packaging needed for processed goods.

This intervention assumes a sharp decline in the purchasing of meat and foods with low nutritional value, matched by an increase in the consumption of fruits, vegetables and cereals to match caloric intake. It would result in a sizable reduction of the material footprint of 4.8%, and a slight boost to the Metric of 0.17 percentage points (including extractive waste). The small increase in circularity is matched by the cut in material resources needed to feed the Swedish population.

2.3 PUT SUSTAINABLE FOOD PRODUCTION AND CONSUMPTION INTO PRACTICE

This intervention contains three strategies that target the way food is produced and consumed in Sweden. It models the impact of consuming local and seasonal food, in combination with scaling organic farming practices. Prioritising local food could cut transport distances for products—reducing the need for long-haul freight and thereby **narrowing** flows; while also opting for seasonal produce will cut the need for hot-housed fruits and vegetables, both **narrowing** and **regenerating** flows. Growing food organically—without the use of emissions-intensive artificial fertilisers—can also help **regenerate** nature. Forgoing artificial fertilisers in favour of natural options, like crop residues, food waste, and animal excrement will also open up new avenues for **cycling**, thus maximising the value of these materials often just considered waste. However: it should be noted that organic farming can be less efficient than conventional methods, with some studies suggesting it produces lower yields.[91] More land is needed to grow crops, and with less land available for carbon sequestration, organic crops may indeed produce higher emissions—despite being better for biodiversity.[92] This potential rebound effect is not captured by our model.

While Sweden produces a significant share of its total food domestically, the country relies heavily on imports for fresh fruit and vegetables.[93] However, as consumers become increasingly aware of the environmental impact of their food choices, local food purchasing is on the rise[94]—as is acceptance, with a 2019 study finding that 'locally produced' is the most important product feature for Swedish shoppers,[95] and that nearly three-quarters of consumers consciously choose foods produced in Sweden—an increase of 6 percentage points since 2014.[96]

The country has a well-established history with organic farming, which has been supported by the government since the early 1990s:[97] As a result, nearly one-fifth of cropped land area is now organic,[98] representing more than 10% of the food market. However, this surge over the last decades has slowed, owing to stagnant market growth and a loss of interest from retailers[99]—leaving room for improvement. Sweden's cultural makeup would support this intervention's strategies, with the farm-to-table movement gaining popularity and a clear desire among citizens for more fresh, local produce.[100]

This intervention assumes substantial reductions in mobility services for food products, as well as moderate cuts to the electricity funnelled into vegetable production through hot housing by eating seasonally, and a total decrease in fertiliser inputs. As a result, our analysis expects a decrease in the material footprint of 0.6%, with a very modest boost to the Metric of 0.02 percentage points (including extractive waste). These findings are in line with recent commentary on the irrelevance of 'food miles' and eating organic: a plant-based product transported from another country will still have a fraction of the embodied emissions of locally raised meat, for example, while organic farming can be seen as making less efficient use of land and resources.

Impact on Sweden's circularity:

Implementing circular interventions in the realm of food would have a small impact on the Metric—boosting it by 0.27 percentage points (including extractive waste) (0.34 percentage points excluding

extractive waste), and a more substantial effect on the material footprint, decreasing it by 7.3%. Shifting to a circular food system would also bring numerous co-benefits to Sweden: minimising the consumption of meat and processed foods—instead embracing plant-based diets—will have positive outcomes on health[101, 102] and greenhouse gas emissions, while sustainable production practices will bring numerous other benefits, from boosting biodiversity and soil health to supporting rural communities.[103]

POLICIES FOR FOOD SUSTAINABILITY TAKE ROOT IN SWEDEN

Sweden is already taking some action to cut the impact of its foods. In 2018, for example, the Swedish National Food Agency, the Swedish Board of Agriculture and the Swedish EPA launched an Action plan for food loss and food waste reduction by 2030. A list of 42 measures split into nine key action areas, the plan addresses needs from investigation and research to innovation.[104] Efforts to cut food waste have also permeated city-level governments, with Gothenburg leading the way with a new tool that slashes waste in municipal kitchens: *The Gothenburg model for less food waste*. The tool has gleaned promising results, with decreases in food waste of 50% between January 2017 and December 2018 and the vast majority (95%) of kitchens using the tool to measure their waste levels.[105] Waste hasn't been the government's only target: the Swedish Food Agency and the Swedish Health Agency have been given the mandate to develop and roll out objectives and indicators for sustainable food consumption. With a focus on boosting fruit and vegetable consumption over that of meat—and reducing overconsumption in general—the plan aligns with public health interests as well as Swedish environmental goals for the coming decade.[106]

3. MAKE MANUFACTURING CIRCULAR

The manufacturing industry is a massive global consumer of resources: making the machines we use to get through everyday life, the clothes we wear, the cars we drive and vast quantities of other products stocked on shelves around the world. Sweden has a strong and highly diversified manufacturing sector: it's pivotal for employment in the country, and it represents three-quarters of the value of Swedish exports—but its material and carbon footprint is substantial. Key sub-sectors—from steel, automotive, chemical and forestry to industrial machinery and food processing equipment—dominate the manufacturing landscape. The industry is already modernising, with the Swedish government encouraging circular production measures from digitalisation to resource-efficiency[107]—and notably, the service content of industrial goods has grown over recent years. More and more, the industrial sector is selling complete solutions rather than a simple product, indicating a dynamic spirit receptive to innovation. Sweden's progress in this area is largely supported by government policy, such as the *Smart Industrial Strategy*[108], and further mobilised by multi-stakeholder research such as the *Roadmap for Increased Uptake of Industrial Symbiosis in Sweden*[109]—in which goals to reach standards for sustainability are matched by aims to remain competitive. Efforts, however, largely focus on decarbonisation: strong strategies backing material efficiency—for example, via waste prevention and utilisation, and material savings—are largely lacking.[110] While circularity has a ways to go in permeating the Swedish industrial sector, a cultural tendency towards innovation and reception to new technologies supports this transition.

In this 'what if' scenario for Sweden's manufacturing sector, we outline opportunities for the country to boost its circularity while cutting the sector's heavy material footprint.

3.1 RAMP UP MANUFACTURING'S EFFICIENCY

Our first intervention combines strategies to improve manufacturing's resource efficiency—both at early stages, where materials are formed, and later stages, where products are created. Gains in material efficiency, which **narrows** flows, should be ingrained in early stages: cutting yield losses involves making the most of technological advances to get more from

less. This could be using less ore to create the same amount of steel (needed for production) and losing less raw material in the process, for example. Further along the value chain—where the steel will be used to make a car—process improvements will bring similar benefits. A reduction of scrap material—typically generated from standard procedure—would also boost efficiency and reduce the need for virgin material inputs, further **narrowing** flows. Unavoidable scrap is reused, **cycling** flows.

Research notes that in the Swedish context, financial, knowledge-based, managerial, engineering and communicative barriers limit the understanding of material efficiency in the manufacturing sector.[111] And while some initiatives to streamline processes have been spearheaded by innovative Swedish companies, there is substantial room for growth. Sweden has much to gain from actions that target internal processes in manufacturing companies—like education, improved communication and information sharing, and strategy deployment—and strong potential to optimise material efficiency in its manufacturing sector.

Our model explores the effect of process improvements on reducing yield loss and diverting scraps: we consider the reduction of metals going from manufacturing industries to recycling, in tandem with an equal reduction in the consumption of both virgin and secondary metals across other sectors. Instead of conventional recycling routes, we assume closed-loop recycling across particular industries: industrial symbiosis.[112] This intervention has the potential to cut Sweden's material footprint by 2.5%, and boost its Metric by 0.09 percentage points (including extractive waste).

3.2 DEVELOP DURABLE MACHINERY AND EQUIPMENT

This intervention makes use of a single strategy intended to slow material flows: the creation of long-lasting machinery and equipment, from construction vehicles and lifting equipment to inventory transportation and medical equipment. Developing more durable equipment could boost complementary services, like repair and remanufacturing, and concurrently slash the need for material inputs for new equipment, positively affecting both resource use and emissions.

While Sweden's government has launched a *Strategy for Smart Industrialisation*, the focus is largely concentrated on digitalisation, innovation and decarbonisation with some attention to resource-efficiency—the focus of our previous intervention.[113] Durability seems, as a strategy, to be relegated to the sidelines—yet the sector is well poised to add additional focus areas, with substantial investment in research and development and innovation enabling a smooth transition.

This intervention assumes a cut in machine sales, along with a boost in the repair and rental services needed to make extended lifetimes a reality. Circular business models, such as Product-as-a-Service systems, will play a crucial role. This lone intervention has a fairly significant impact on Sweden's material footprint, delivering a reduction of 2.8%—slightly higher than improving manufacturing's resource efficiency. The Metric would be boosted by a slight 0.10 percentage points (including extractive waste), as lengthening equipments' lifetime would effectively lock materials into stock, preventing frequent cycling.

Impact on Sweden's circularity:

Scaling resource-efficient manufacturing processes—run by durable, long-lasting equipment—could decrease Sweden's material footprint by 5.3%, with a concurrent boost in the Metric of 0.19 percentage points (including extractive waste) (0.24 percentage points excluding extractive waste). Efficiency gains would see the advent of many co-benefits, from decreased energy use to lowered emissions. Increasing durability would bring about several new employment opportunities, ranging across practices like repair, refurbishment and remanufacturing. Sweden manufacturing companies would benefit, too: already competitive, the uptake of circular business models, from servitisation and reverse logistics to leasing and rental models, could strengthen Swedish industries' position on the global market.

SWEDEN'S MANUFACTURING SUCCESSES, FROM SUSTAINABLE STEEL TO CIRCULAR BUSINESS MODELS

Sweden's steel manufacturing sector is known worldwide for its efforts in sustainability. In 2018, it launched a *Fossil free road map*[114] saturated with circular strategies, from cutting material consumption and extending product lifetimes, to maximising the use of recycled materials. Three years later, Sweden's manufacturers made headlines for producing the world's first 'fossil-free steel'. [115] Stockholm-based project H2GS is similarly using green hydrogen to produce 'green steel'[116]—and both projects show just how close collaboration among supply chain actors can give rise to impressive technological breakthroughs.

Swedish manufacturing companies are also increasingly integrating circular practices into their business models and offerings. Gothenburg-based SKF—a global giant in the manufacturing sector—has introduced an integrated solutions programme, SKF Rotation for Life, where clients can secure a performance-based agreement combining bearing technology, failure detectability and reliability services in one integrated package for rotating equipment.[117] Cleaning and municipal machinery supplier Hako has introduced an agreement where clients have access to fixed monthly costs for reparation and maintenance, spare parts and trainings for correct product use.[118] Epiroc, a world leader in the manufacturing of mining and construction equipment, is now embracing a Batteries-as-a-Service model for its battery-powered electric vehicles: the company claims full responsibility for batteries' certification, maintenance and upgrades.[119]

4. RESHAPE EXTRACTIVE INDUSTRIES

Resource extraction will continue to be necessary, even in a more circular world.[120] As the earliest stage of many supply chains, extractive industries feed into a range of other material and emissions-intensive sectors. As a resource-rich country and fruitful producer, Sweden's rate of resource extraction is among the highest in the world. Rich in iron ore, Sweden's 12 active metal mines produce over 90% of the EU's production,[121] in addition to its important shares of critical minerals like cobalt and zinc. It also feeds into other highly relevant sectors, such as manufacturing,[122] and plays a critical role for exports. Forestry is another key activity: forests cover nearly three-quarters of Sweden's landmass, and the country is one of the world's largest exporters of pulp, paper and sawn timber.[123] Forest products commonly feed into biofuel creation, powering the country's transport and heat, and meeting the manufacturing industry's demand for energy. It also satiates the growing demand for bio-based materials. But while Sweden is credited for managing its vast forests in an economically and socially sustainable way, the felling of old-growth trees for timber is becoming increasingly common and problematic: a major blow for biodiversity.[124] And as the mining industry is taking steps towards circularity, resource efficiency, decarbonisation and biodiversity, and addressing responsible production following the country's 2012 Mineral Strategy and subsequent roadmaps, a core focus lies in meeting these objectives while maintaining competitiveness and Sweden's leading position in the EU. As of yet, action to limit or optimise extraction has been limited: the country is well-positioned to make the most of its precious reserves of nature by putting circular strategies front and centre.

To this end, this 'what if' scenario for Sweden's extractive industries looks at the effects of cutting and regulating resource extraction—boosting its circularity while slashing its material footprint.

4.1 RESTRICT RESOURCE EXTRACTION

Some extractive industries—such as mining—are inherently non-circular, but tightly interconnected with the provision of societal needs: cutting extraction thus necessitates limiting raw material use and balancing supply and demand. From an environmental

perspective, priorities should focus on prolonging operations in sites already in use, rather than developing new sites. To this end, the only intervention for this scenario combines three strategies to **narrow** flows: limiting logging in the most overused forest areas, limiting the expansion of mining sites and limiting fishing in heavily exploited marine areas.

In Sweden, forest land has remained relatively stable since 2005, representing around 70% of the country's area.[125] However, logging remains prevalent—and commonly, old-growth trees are replaced with monoculture plantations that threaten biodiversity.[126] Sweden is also ranked the worst EU nation in terms of overfishing: over 52.4% of its total allowable catch exceeds scientific advice.[127] But tides may be turning: a recent court order, for example, commanded one of the country's biggest cement manufacturers to stop mining limestone to protect the groundwater.[128] Meanwhile, citizen surveys in 2019 found strong support for banning the fishing of endangered species.[129] While the country is well-poised to spearhead additional action in this realm, no concerted plans tackle the issue of extraction head on as of yet.

This intervention assumes a substantial reduction in the extraction of all metal-related materials, the amount of wood felled and the number of fish caught. New mining sites are not opened, and protected areas for forests and marine life are expanded. This could decrease the material footprint by 3.4% and boost the Metric by 0.12 percentage points (including extractive waste). As these industries are particularly relevant for trade, restricting the extraction of such resources could have an even greater impact on Sweden's domestic extraction, decreasing it by 12.8%, and export footprint, cutting it by 18.2%.

Impact on Sweden's circularity:

As noted above, our only intervention for this scenario would see a small decrease of 3.4% for the material footprint and a slight increase of 0.12 percentage points (including extractive waste) (0.15 percentage points excluding extractive waste). These strategies would bring other benefits, however: extractive industries have a significant challenge ahead in protecting biodiversity, and advancing the circularity of extracted resources is therefore crucial to safeguarding wildlife and natural systems. Resource efficiency for mining and logging also present economic benefits.

EXTRACTIVE INDUSTRIES GOING FOSSIL-FREE AND USING WASTE AS A RESOURCE

Over the last decade, extractive industries in Sweden have taken some steps to address emissions in their supply chains. Both the forestry sector[130] and the mining and minerals sector[131] have developed roadmaps to become fossil-free. The former is pursuing an increased role for the bioeconomy in the overall economy, while the latter aims to improve product design and bolster value chains that optimise metal and mineral reuse and recycling. Swedish state-owned mining company LKAB, the EU's largest iron ore extractor, is exploring the potential to extract phosphorus and rare earth minerals from mining waste, and reaping many benefits in the process.[132] In another project, ReeMAP, LKAB and Boliden aim to produce sulfuric acid from mining waste that can be used to extract rare earth minerals. By extracting useful concentrates from iron ore tailings, the need to open new mining sites is cut substantially—and the practice provides new economic opportunities, from the supply of rare earth elements vital for renewable energy technologies to fossil-free fertilisers.

In another innovative initiative, the forestry and fishing sectors joined forces to cut overfishing by transforming byproducts from biorefineries or sawmills—like branches and treetops—into fish feed. Results so far are promising: fish fed the wooden feed grow well, reducing the need to extract marine life from the sea for feed.[133] Evigas is undertaking similar efforts to transform residual materials into high-value commodities: using its process, any organic material—from wood or sawdust to straw and manure—can be used to produce BioCarbon, BioOil and Syngas suitable for a range of applications.[134]

5. DRIVE CLEAN MOBILITY FORWARD

Getting from A to B is one of the world's biggest contributors to both emissions and materials use—and the Swedish situation is no different, with transport accounting for the largest share of emissions in the country. The vast majority of these emissions—94%—stem from road transport. While fossil fuel-powered vehicles are still largely the norm,[135] the use of renewable transport modes is prevalent, with Sweden maintaining the highest use of biofuels in the EU and one of the world's highest shares of electric vehicles. Swedes are also more willing to walk or take public transport than their European counterparts, with 476 out of 1,000 residents using a car—well below the EU average of 530. The transport sector has been somewhat well-addressed by policy: as part of Sweden's goal to reach net-zero by 2045, the county has set an ambitious target to cut domestic transport emissions by 70% within the next decade. Yet mobilisation towards this goal has had limited success: certain actions have proven positive, such as a ban on the sale of new combustion engine cars by 2030, subsidised electric transport and significant investment in mobility infrastructure, from bicycle routes to public transport. Yet, others stand to improve—improving logistics, for example.

In this 'what if' scenario, we model the impact of three interventions to cut mobility's hefty material footprint and drive its circularity upwards.

5.1 PROMOTE CARSHARING

Our first intervention entails promoting carsharing, car pooling, trip-chaining and park and ride systems. By cutting the number of individually-owned cars on the road, Sweden will see a decrease in the materials (and resulting emissions) needed to manufacture vehicles, thereby **narrowing** flows.

Cars, on average, remain parked as much as 97% of their lives: the vast majority of the time, the resources poured into creating these products aren't being used at their highest value.[136] And while carsharing represents an avenue for optimising resource use, Sweden's regulations could hinder its realisation.[137] As of 2018, Swedes wishing to share their cars are required to declare income to the Swedish Tax Agency—and any income is taxed at 30%. Self-reporting is seen as a significant obstacle that could be relieved through an automatic income-reporting system. Owning a car in Sweden is also relatively cheap, especially compared to its neighbours, Norway and Denmark—both countries where carsharing is more widespread and accepted. Norway's policy even gives a tax allowance of up to nearly €1,000 for private car sharing, incentivising the process. For this intervention, we assume a substantial decrease in the number of cars on the road, prompted by disincentives such as, for example, a tax on car ownership. We also assume an increase in public transport use, acknowledging that this may be less efficient in rural areas. This intervention would see a slight decrease in the material footprint of 0.8%, matched by a small boost to the Metric of 0.03 percentage points (including extractive waste).

5.2 SUPPORT FLEXIBLE WORK-FROM-HOME ENVIRONMENTS

The advent of covid-19 has shown the world that a new way of working is possible; and telework has been on the rise across the EU even before the pandemic's outbreak.[138] Our second intervention proposes continuing along this trend once regulations are dropped. This will slash the number of vehicles on the road from residents' daily commutes, thereby **narrowing** material flows. However, it is important to note that there may be some moderate rebound effects from increased working from home, relating to changes in household energy consumption and mobility patterns:[139] our model does not consider these.

Work-from-home advice ushered in massive change: just five years ago, only 2% of the Swedish workforce were clocking in from a home office, with an additional 13% reporting working from home occasionally. During the pandemic, this rose to 43% of the workforce: a number which may indicate the potential of the labour force to work from home.[140] Now, numbers in Stockholm have surged to as much as 80%[141]—but is flex-work here to stay? This intervention is highly realistic: a Swedish study found that 70% of residents wish to continue working from home post-pandemic, with 52% noting they wouldn't be keen to return to an office-only working arrangement. Three-quarters of Swedish respondents also want their companies to support flex-work beyond the pandemic: working from home is on track to becoming the new normal.[142] Doing so will bring benefits beyond the sphere of mobility: less energy will be needed, for example, to heat and light unused rooms in office buildings, and underutilised office spaces could serve other community functions, relieving some pressures from the need for new building stock. Pressures may also be relieved on transport infrastructure, such as roads.

This intervention, however, solely models the impact of increased telework and more neighbourhood shared services on mobility, finding that doing so could bring material footprint reductions of 1% and a boost to the Metric of 0.04 percentage points (including extractive waste). While our model didn't account for other impacts—such as a reduced need for new buildings—it is likely that this could occur, supporting the realisation of Scenario 1.1. The impacts of this intervention also consider potential rebound effects, such as increased use of heat and electricity, stemming from spending more time at home.

5.3 PRIORITISE EFFICIENT AND DURABLE VEHICLES

Our final intervention for mobility encompasses several distinct strategies to make vehicles more efficient: firstly, incentivising the use of fuel-efficient vehicles and improving lightweight vehicle design. These strategies **narrow** flows by gleaning more from less: the same distance travelled from less fuel, and the same vehicle made from fewer materials. Material flows may also be **slowed** through strategies that increase the lifetimes of cars, planes and trains through circular business models like rental and Product-as-a-Service systems, and more preventive maintenance.

Currently, Swedish mobility policy centres on electrifying transport, with aims to scrap the sale of diesel or gasoline engine vehicles by 2030. This is already well underway with an incentive/disincentive system where electric vehicle shoppers receive a €6,000 bonus and buyers of cars with high-emitting combustion engines are required to pay a tax of up to €7,500.[143] Less focus, however, surrounds design improvements like lightweight, efficient vehicle manufacturing, or encouraging smaller vehicle sizes.

For this intervention, we assume a substantial decrease of 50% in the average weight of vehicles purchased and used. We also model a reduction of the weight of steel and aluminium used for trains and a low aircraft fleet mass. All weight reductions are matched by fuel savings due to driving lighter, smaller vehicles. The lifetimes of cars, planes and trains are substantially increased through increased preventive maintenance and rental models. These strategies bring the scenario's most impactful results: a material footprint reduction of 2.2% and an increase in the Metric of 0.08 percentage points (including extractive waste).

Impact on Sweden's circularity:

Cutting vehicle usage and boosting efficiency would cut Sweden's material footprint by 3.5% and improve the Metric by 0.12 percentage points (including extractive waste) (0.16 percentage points excluding extractive waste). Other benefits would be abundant: from decreased emissions and improved air quality, to less noise and more room for green spaces. Supporting telework could also improve well-being, with one Swedish study finding that home-workers sleep more and have more leisure time with family[144]—and bring additional benefits for Swedish women, who have reported improved productivity and job satisfaction working from home.[145] Less cars on the road could cut costs for consumers, who would enjoy lower fuel bills, as well as on a macroeconomic level, where trade balance would improve due to a cut in fuel imports.[146] However, some rebound effects may crop up: a drop in fuel prices may result in increased driving for purposes other than commuting, for example.

FROM LOW-CARBON TO REDUCED PRIVATE MOBILITY: SWEDEN'S SUSTAINABLE TRANSPORT PROGRESS

Until recently, sustainability efforts for mobility have centred around cutting carbon emissions. Sweden's *Roadmaps* for a fossil-free heavy road haulage industry[147] and passenger cars[148] have placed a focus on decarbonisation through electrification and biofuels. Now, this is beginning to evolve with the advent of updated initiatives aimed at removing cars from the streets by reducing the need for privately-owned cars.[149] M—a smart car sharing service launched by Volvo in 2019—boasts 1,200 vehicles,[150] and has set targets for an entirely electric or hybrid fleet by 2022.[151] First launched in Stockholm and Uppsala, and now in Gothenburg, the programme aims to extend throughout Sweden in the coming years. And as noted, the covid-19 pandemic has largely changed the way we work, causing the number of teleworkers to surge and the number of cars on the road during rush hours to fall.[152]

6. DESIGN CONSCIOUS CONSUMABLES

The 'consumables' sector encompasses short-lived Products that Flow, like single-use plastics, to more durable Products that Last, from furniture and textiles to appliances and machinery. As a country marked by high levels of consumption, this scenario explores options to significantly cut Sweden's high material footprint—and make a mark on sectors gaining global notoriety for their impact on pollution, emissions and biodiversity, such as plastics and textiles. Strategies relating to design are particularly relevant: manufacturers have a responsibility to develop long-lasting, non-toxic, repairable and recyclable products to boost Sweden's circularity. Some action has been taken in this regard, with the government implementing tax reforms in 2017 to lower the VAT of repairs for used items, incentivising users to keep materials and products in circulation for longer. Recycling is crucial in this domain—which luckily, Sweden is no stranger to: the country's can and bottle recycling scheme has existed since the mid-1990s. They have even created a verb for the action: *panta.*[153] The system is relatively successful: 84% of PET bottles are recycled when sorted by source. Sweden has exceeded EU standards for recycling, setting more stringent targets than required—with plans to increase ambitions even further in 2025. To this end, Sweden is taking steps to combat the overuse of one of the world's fastest-moving goods: plastics. However, the need for coherent policy that goes beyond plastic and incorporates circular strategies is clear.

In our 'what if' scenario for conscious consumables, we outline opportunities for Sweden to cut its material footprint and boost its circularity by changing the way we use and design four categories of consumables: plastic and chemicals, textiles, furniture and appliances.

6.1 LIMIT PLASTIC & CHEMICAL PRODUCTION

Our first intervention comprises two strategies: reducing the number of plastic items in circulation—**narrowing** flows—and prioritising the use of bio-based chemicals, **regenerating** flows. With this intervention, we are not aiming to cut plastic production entirely, but rather a shift away from single-use plastics and towards greater reuse and **cycling**. For this, radical changes to the way plastic is produced are crucial.

Acknowledging that plastic has some benefits (such as potentially being highly cyclable and energy efficient), this intervention also aims to tackle additional issues of chemical pollution and biodiversity protection: having now surpassed our planetary boundary for chemical pollution, scientists note that plastics are of particularly high concern.[154] Based on this, the EU has formed policy initiatives—on-going and planned for the future—both to curb plastic use and increase recycling.

Sweden has a strong plastic manufacturing industry, with the value of plastic and rubber production topping €5.35 billion in 2018,[155] matched by strong growth in the chemical, plastics and rubber industries as of 2021.[156] These industries maintain a dominant presence, producing goods that feed into one-fifth of the country's industrial offerings—as well as supplying foreign customers.[157] Plastic packaging producers create a substantial amount of waste—upwards of 200,000 tonnes.[158] Collection rates are low at just 47%,[159] with only 28% being actually recycled (both excluding PET bottles related to deposit refund schemes),[160] and another portion incinerated. This, hopefully, will change: Svensk Plaståtervinning has invested upwards of €97 million in a new state-of-the-art recycling facility, to be completed in 2023, with the goal of emissions-free recycling for all plastic packaging from households.[161] However, public policy targeting plastic producers—and other industries that make use of the material—is lacking. Conversely, manufacturers have been subject to a tax on certain chemicals—namely those used in white goods and other electrical products—since 2017.[162]

This intervention assumes a cut in plastic use. This could be achieved by, for instance, taxing plastic items bought by producers, and putting mandatory targets in place for reusability, recyclability and percentage of recycled content. It also models the impact of lowering fossil- and mineral-based chemical usage by swapping in bio-based alternatives, boosting the efficiency of chemical use through, for example, circular business models like chemical leasing, and the small-scale substitution of chemical fertilisers with organic options such as compost. Doing so could cut Sweden's material footprint by 3.3%, while bumping its Metric up by a modest 0.12 percentage points (including extractive waste).

6.2 TURN TEXTILES CIRCULAR

In an effort to transform textiles' impact, this intervention is composed of a wealth of strategies: ensuring textiles are free of animal products—which are extremely material- and land-intensive to produce—will serve to **narrow** and **regenerate** flows, as will cutting out petroleum-based fabrics. Boosting the content of recycled fibres will **cycle** flows, while encouraging high-quality, durable garment design, as well as do-it-yourself and clothing sharing, will serve to **slow** and **narrow** flows.

The global textiles industry has achieved infamy over recent years for its vast production of emissions, pollution to air and water, and waste. And in spite of Sweden's tiny levels of domestic production, the Swedish EPA has estimated that consumption within the country has a major impact on emissions and pollution via hazardous substances. Between 2000 and 2019, new textile purchases have jumped by 30%—an increase of around 3 kilograms per person per year.[163] Now, Swedes consume around 14 kilograms of textiles per year—ten of which are clothing—and throw away slightly more than half of that. The vast majority ends up in unsorted household waste and is largely incinerated.[164] What's more: EPA research has found that around 60% of what's discarded is in satisfactory condition for reuse, indicating that a change in consumer behaviour is key to boosting circularity in the industry. On the production side, tides are turning: following a government inquiry launched in 2020,[165] Sweden recently passed Extended Producer Responsibility laws for textiles and clothing—the second country in Europe to do so. The ongoing plans to implement these laws will hike up clothing prices by incorporating the environmental costs of production. However, plans for a tax on clothing and footwear to tackle hazardous chemicals and cut environmental impacts—planned to launch January 2022—have been dropped by the government:[166] a stumbling block for the industry's circular transition in Sweden.

This intervention models the impact of using vegan, natural fibres to create durable textiles—finding that such swaps could cut the country's material footprint by 0.05%. The Circularity Metric, however, would be minimally impacted, as domestic textiles production is very low: the increase is not captured by two decimal points, and would be less than 0.00 percentage points.

6.3 ENCOURAGE CIRCULAR FURNITURE DESIGN

Our intervention for circular furniture comprises two strategies, to **narrow** and slow **flows** respectively: encouraging the purchase of local and durable furniture. Local furniture cuts down on transport needs—lowering emissions—while furniture made to last will cut down on waste and keep materials in circulation for longer. Flows are also **cycled** through design that allows for components to be reused.

Sweden is famous worldwide for its contribution to design and affordable furniture—from ubiquitous brands like IKEA to more niche offerings marked by minimalist style and quality craftsmanship. Sustainability is already a top priority for Swedish furniture designers, with the country ranking first in the world, according to a survey by one design procurement consultancy.[167] Swedish brands already score high on local manufacturing, with more than 97% of production occurring within a 750 kilometre radius—and the vast majority of components sourced from local supply chains. Global giant IKEA is also looking to go circular, incorporating principles such as easy disassembly and repairability, and regenerative and recycled materials, in their designs, as well as platforms for second-hand shopping.[168] Moreover, the Swedish municipalities' and regions' central procurement function (Adda) has recently awarded a number of suppliers contracts with the intent of boosting circular furniture use within these organisations.[169]

In this intervention, we assume that furniture is produced locally—and that it's made to last through high-quality and sturdy materials.[170] We also assume a boost in furniture repair, reuse and refurbishing. These may all be enabled through new circular business models—and by increasing the demand for practices such as repair and remanufacturing, initial demand for such business models will grow. By employing these strategies, Sweden can lower its material footprint by 0.3% and boost its Metric by a small 0.01 percentage points (including extractive waste).

6.4 RETHINK APPLIANCE PRODUCTION AND USE

This final intervention compiles strategies for equipment and appliances. Appliance use should be minimised—**narrowing** flows—and items should be made as durable as possible to **slow** material flows. Take-back programmes should be employed to boost product repair and reuse, **cycling** flows. Products can also be made smaller and more lightweight: garnering the same function from less materials, thereby **narrowing** flows. Finally, reducing the need for equipment and appliances altogether through digitalisation will also cut material use and **narrow** flows.

The Swedish government's action plan, Think Twice!, encourages sustainable consumption within households—noting that the number of appliances in homes has spiked in tandem with technological developments. Energy-efficient appliances are promoted—yet no attention is afforded to other circular strategies that target material use over energy, such as lightweighting or durable design.[171] Nonetheless, some brands are piloting circular models on their own: Swedish home appliance manufacturer Electrolux AB, for example, has launched a subscription-based appliance-as-a-service system, allowing customers to pay to use its products rather than own them. The brand also aims to provide durable products, support maintenance and repair, and put refurbished appliances back to use.[172] While outcomes are yet to be assessed, the pilot indicates that Sweden's appliance sector is well-poised to embed circularity in its operations.

For this intervention, we assume a boost in the purchasing of long-lasting equipment, a cut in the purchasing of new appliances like televisions and personal computers, and an uptick in the purchasing of smaller, more lightweight devices. This intervention would have a relatively small impact on Sweden's material footprint—lowering it by 0.8%—and Metric, boosting it by 0.03 percentage points (including extractive waste).

Impact on Sweden's circularity:

Implementing these circular strategies for consumables could substantially decrease Sweden's material footprint—dropping it by 4.5%—while increasing the Circularity Metric by 0.16 percentage points (including extractive waste) (0.20 percentage points excluding extractive waste). Consumers stand to benefit from all interventions, receiving higher-quality, more durable products and therefore saving money. The proposed strategies will also create avenues for new business models, as well as circular goods and services.

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, Sweden reaches a Circularity Metric of **7.6%** (including extractive waste) (**9.9%** excluding extractive waste) and the material footprint is lowered by a remarkable **42.6%**, from 257.5 million tonnes to merely **148 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.

SWEDEN'S CIRCULAR CONSUMABLES SURGE

As a long-time subject of controversy, plastic has been afforded substantial attention in Sweden: the Swedish EPA, for example, has recently published a roadmap for the sustainable use of plastics,[173] as well as a slew of measures intended to increase plastic recycling in non-toxic cycles and improve conditions for chemical recycling process in the country.[174] Heavy investment into new technologies that enable better mechanical[175] and chemical[176] plastic recycling is taking place, while recently-launched digital marketplace Atomler offers a space for buyers and sellers to trade plastics online, diverting potential waste from waste-to-energy plants.[177]

Swedish textile companies are also taking concrete steps to boost circularity in the sector: fashion multinational H&M, for example, is aiming for climate positivity by 2040, through a circular ecosystem that addresses all business stages and actors: from product designers[178] to consumers.[179] And driven by digitalisation and strong innovation, smaller Swedish companies are driving important breakthroughs, too: from advanced rapid colour formulation, which significantly reduces ink waste and minimises water usage, to spray-dyeing lines that slash water use and virtually eliminate waste.[180] Similarly, ongoing project Circular Textile Innovations, headed by RISE, addresses critical points along the value chain by investigating alternatives to fibre blends and new yarn spinning techniques, exploring sorting techniques and recycling processes, and creating a roadmap to further cut textile waste and lower the use of fossil-fuel-based materials.[181] Consumers have options to go circular, too.

In Eskilstuna, for example, customers can visit ReTuna, the world's first recycling shopping centre where almost every product is repurposed or upcycled.[182, 183] With 14 stores, the shopping centre offers goods from clothing, furniture and electronics to sporting gear and toys—and now, even IKEA has opened a shop on the premises, offering second-hand furniture for sale after cleaning, renovating and getting it ready for a new life.[184]

SCENARIOS, INTERVENTIONS & STRATEGIES

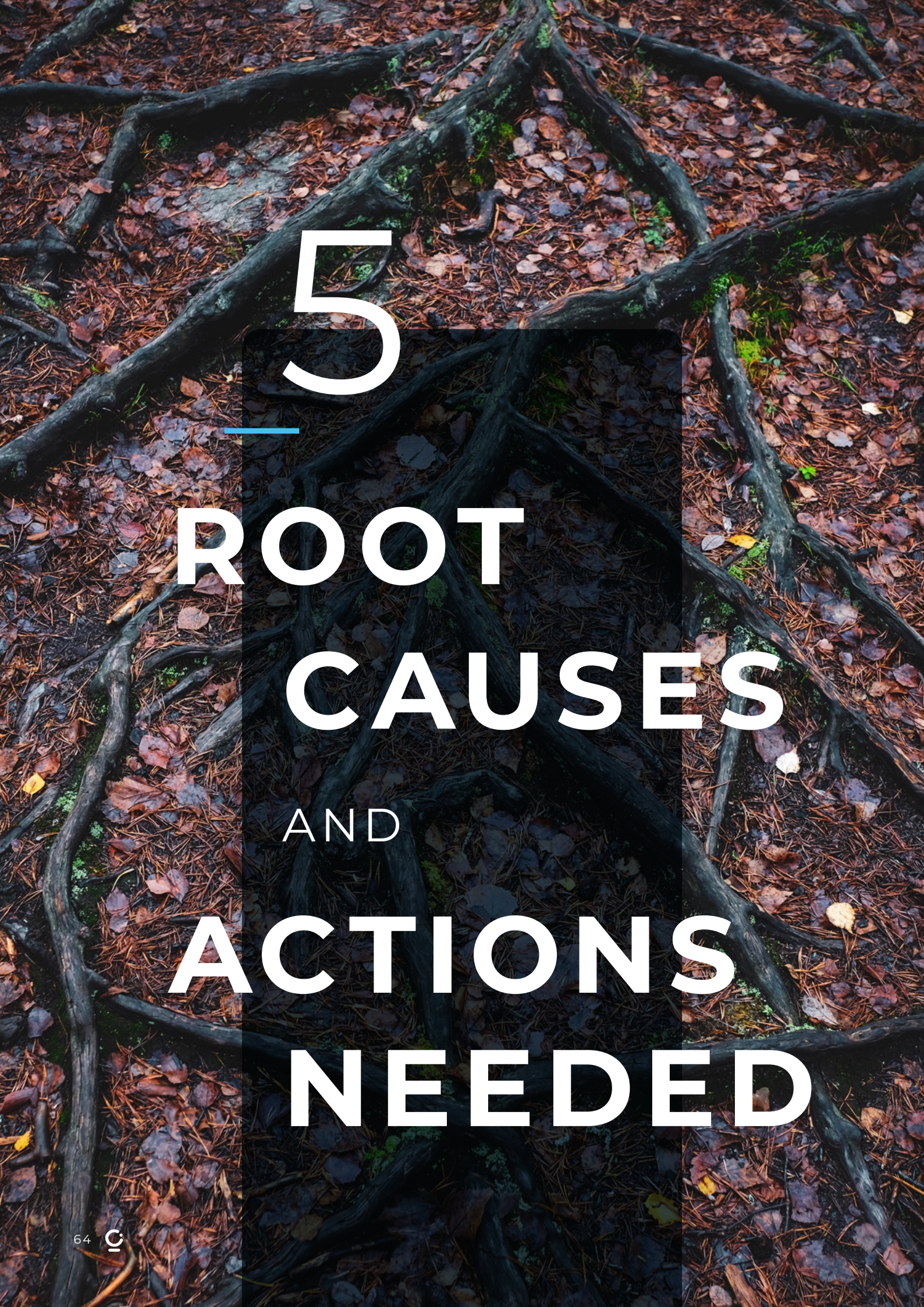
SCENARIOS	INTERVENTIONS	STRATEGIES	IMPACT AND MATERIAL FOOTPRINT
1. CONSTRUCT A CIRCULAR BUILT ENVIRONMENT	**1.1 Keep an eye on building stock expansion**	• Limit housing stock expansion • Increase renovation • Use secondary materials for new construction	Circularity rises from 3.4% to **4.9%** (including extractive waste) or **5.3%** (excluding extractive waste). Reduction of material footprint by **8.2%**, decrease to **236 million tonnes.** Co-benefits: Lowered costs and emissions, job creation, new circular business models.
	1.2 Make resource-efficient construction the norm	• Use lightweight and durable bearing elements • Reduce losses during construction process • Prioritise local and circular construction materials	
	1.3 Shift energy consumption to optimise high-value cycling	• Boost energy-efficient appliances and use • Lower room temperature by 2-degrees and employ smart metres • Decrease share of waste-to-energy in district heating network	
2. CULTIVATE A THRIVING FOOD SYSTEM	**2.1 Consume less**	• Limit food consumption to 2,760 calories per person per day • Avoid the incineration of food waste, by either preventing waste generation or redirecting waste to anaerobic digestion • Cut waste generation and produce less food	Circularity rises from 3.4% to **3.67%** (including extractive waste) or **3.74%** (excluding extractive waste). Reduction of material footprint by **7.3%**, decrease to **239 million tonnes.** Co-benefits: Less emissions, improved health, greater biodiversity and soil health, support for rural communities.
	2.2 Promote healthy diets	• Reduce consumption of meat • Reduce consumption of processed foods with low nutritional value	
	2.3 Put sustainable food production and consumption into practice	• Shift towards locally produced food in households and the hospitality and restaurant sectors • Reduce the need for hot-housing produce through seasonal food consumption • Grow food organically, without the use of artificial fertilisers	

SCENARIOS	INTERVENTIONS	STRATEGIES	IMPACT AND MATERIAL FOOTPRINT
 3. MAKE MANUFACTURING CIRCULAR	**3.1 Ramp up manufacturing's efficiency**	• Reduce virgin inputs for key manufacturing industries • Reduce yield losses • Divert scraps	Circularity rises from 3.4% to **3.59%** (including extractive waste) or **3.64%** (excluding extractive waste). Reduction of material footprint by **5.3%**, decrease to **244 million tonnes.** Co-benefits: Decreased energy use and emissions, new employment opportunities, stronger position for Swedish industries on the global market.
	3.2 Develop durable equipment	• Increase consumption of animal protein Increase the lifetime of machinery and equipment • Increase repair and rental services	
 4. RESHAPE EXTRACTIVE INDUSTRIES	**4.1 Restrict resource extraction**	• Limit the expansion of projected mining sites • Expand protected areas for forests and marine life to limit biomass and fish extraction	Circularity rises from 3.4% to **3.52%** (including extractive waste) or **3.55%** (excluding extractive waste). Reduction of material footprint by **3.4%**, decrease to **258 million tonnes.** Co-benefits: Improved biodiversity, protected wildlife, new business opportunities.
 5. DRIVE CLEAN MOBILITY FORWARD	**5.1 Promote car sharing**	• Incentivise car sharing and carpooling over ownership	Circularity rises from 3.4% to **3.52%** (including extractive waste) or **3.56%** (excluding extractive waste. Reduction of material footprint by **3.5%**, decrease to **257 million tonnes.** Co-benefits: Decreased emissions, improved air quality, less noise pollution, more space for urban greenery, improved worker well-being, economic benefits.
	5.2 Support flexible work-from-home environments	• Reduce the need for mobility by an increase in flex work	
	5.3 Prioritise efficient and durable vehicles	• Design vehicles to be lightweight, reducing material inputs • Spark fuel efficiency and reduction • Extend vehicle lifetimes through PaaS and preventive maintenance	

SCENARIOS, INTERVENTIONS & STRATEGIES

SCENARIOS	INTERVENTIONS	STRATEGIES	IMPACT AND MATERIAL FOOTPRINT
6. DESIGN CONSCIOUS CONSUMABLES	**6.1 Limit plastic & chemical production**	• Reduce the production and use of plastic items	Circularity rises from 3.4% to **3.56%** (including extractive waste) or **3.6%** (excluding extractive waste). Reduction of material footprint by **4.5%**, decrease to **246 million tonnes.** Co-benefits: Economic benefits for consumers, better quality products, avenues for new business models.
	6.2 Turn textiles circular	• Produce textiles that are free of animal products and petroleum • Use recycled fibres in textiles production • Create high quality and durable garments • Stimulate increased DIY and garment sharing	
	6.3 Encourage circular furniture design	• Increase production and purchase of local furniture • Build durable furniture	
	6.4 Rethink appliance production and use	• Produce less and more durable equipment and appliances • Promote producer take back programmes • Design equipment to be smaller and more lightweight • Promote digitalisation	

SCENARIOS	INTERVENTIONS	IMPACT AND MATERIAL FOOTPRINT
7. COMBINED	The power of combined interventions	Circularity rises from 3.4% to **7.6%** (including extractive waste) or **9.9%** (excluding extractive waste). Reduction of material footprint by **42.6%**, decrease to **148 million tonnes.**
8. COMBINED + SPECIAL WASTE STREAMS	The power of combined interventions, plus the cycling of impure hard-to-recycle waste streams such as household waste, mixed and undifferentiated waste, sorting residues and combustion waste.	Circularity rises from 3.4% to 11.1% (including extractive waste) or 13.9% (excluding extractive waste). Reduction of material footprint by 42.6%, decrease to 148 million tonnes.



5 ROOT CAUSES AND ACTIONS NEEDED

The previous chapter laid out a collection of circular strategies that Sweden may employ to cut its material footprint and launch its journey towards a circular economy. While it provides some anecdotal evidence of beneficial initiatives happening per intervention, it is clear that the actions needed aren't taking place at the scale or speed necessary to relieve environmental pressures. This chapter will explore why that is, diving into root causes—the key factors that have hindered the realisation of each 'what if' scenario in the Swedish context. It closes with a broad analysis of potential actions needed to bring the scenarios to life and enhance circularity in Sweden. This work has been based on Circle Economy's quantitative analysis in addition to qualitative literature reviews, interviews with in-house sectoral experts from RISE and input from reference group meetings conducted over the course of this study.[185] The root causes and actions needed have been clustered into four categories: 1) Legal and regulatory, 2) Economic and financial, 3) Technological and capacity-based and 4) Cultural and behavioural. The examples selected are non-exhaustive and are focused on the scenarios and underlying interventions that have an impact on the Metric. The cases provided are illustrative and may be relevant to multiple scenarios.

ROOT CAUSES: LEGAL AND REGULATORY BARRIERS

A narrow view of circularity is guiding regulatory discourse in Sweden

Sweden's relatively exceptional recycling rates for some waste streams—such as paper, metal and glass packaging—are reflected in its regulatory environment. Policy frameworks predominantly focus on waste recycling, reuse, or preparation for reuse from sources such as construction and demolition, food, discarded vehicles and packaging. Overall, less attention is afforded to consumption. Indeed: consumption-oriented targets exist only in a few cases, such as to cut avoidable food waste.[186] To reach the target set, more than 40 measures have been proposed along the food value chain: for example, increasing consumer awareness and knowledge and increasing collaboration among actors in the value chain.[187] Furthermore, dialogue around the circular economy in the country is focused on cycling materials, and to some extent, products, without a necessary focus on strategies that bolster reuse, repairability and efficient design and use. An issue in this regard is that no single Ministry or Agency has a clear and overarching responsibility for resources and resource efficiency, meaning that political development is uncoordinated. A plausible effect of this is that trade-offs and conflicts between circular and other societal goals may be missed or disregarded. A shift in mindset will be needed both politically and from businesses to drive the holistic approach needed, with special attention being afforded to stretching material- and product lifetimes and designing out waste and reducing consumption. While some initiatives—such as the Delegation for Circular Economy and Fossil Free Sweden—have driven the incorporation of circular principles, this has not yet occurred to a great extent. A better understanding of what truly constitutes a circular economy, and the formation of needed steps in the transition towards one, will be necessary to shape more fit-for-purpose laws and regulatory frameworks.

Legislation is largely guided by reducing emissions rather than material use

As a relatively low-carbon economy, Sweden already excels at cutting CO_2 emissions: owing to its climate-focused legislation, market-driven initiatives and industry-based fossil-free roadmaps. Environmental policy largely targets the use phase of products—from cars to buildings—with little attention to the ways such goods are produced. While this is important, this style of policy-making is becoming less efficient as more environmentally-friendly production processes have risen in popularity and affordability. Personal vehicles, for example, are taxed based on the carbon emitted from driving, without concern for the ecological footprint of the materials and production processes. If a holistic understanding of circularity—as described in this report—were to be prioritised, policy instruments such as taxation could focus on material use and functionality, secondary material use and component refurbishment, thereby incentivising smaller, more efficient vehicles—and more efficient vehicle use.

ROOT CAUSES: ECONOMIC AND FINANCIAL BARRIERS

Markets have been moulded to a linear economy

For a long time, spurring economic growth has depended on consumption, fueling heavy resource extraction and wasteful practices. And while things are changing, there is still a gap between supply and demand for 'circular' products and materials—as the market develops, distortions and failures may occur.

The market for recycled materials is a typical example: the *European Strategy for Plastics in a Circular Economy* saw a promising influx of pledges from recyclers, unfortunately not matched by those that could use recycled plastics.[188] As of yet, several secondary materials—such as plastics and building materials, but not including metals—have difficulties financially competing with their virgin counterparts, while second-hand options for consumer-facing items like clothing and appliances are still lagging in terms of accessibility and appeal. The relative inexpensiveness of waste management—especially compared to other production costs—also acts as a disincentive for key players in industries such as manufacturing and construction to cut waste.

Business models are still largely linear

Business models predominantly follow linear, 'take-make-waste' patterns—models such as rental, resale and servitisation are not yet fully mainstream, nor are considerations such as design for recyclability, repairability and reuse. And while movement is occurring at the fringes—with models like Everything-as-a-Service growing in popularity—change at scale is a slow and often costly process, requiring innovation and complex webs of resource flows and stakeholders. In Sweden, this will be particularly challenging: 99% of Swedish companies are small- and medium-sized enterprises,[189] which may lack the knowledge and support needed to undertake a circular transition. A true transition to a function or service-focused business model will demand an extensive shift in norms and practices, from accounting and budgeting to sales incentives and remanufacturing operations.

Opportunities for circularity lie in public procurement—but are largely unfulfilled

A large portion—around one-fifth—of Swedish GDP is represented by public procurement,[190] providing a substantial opportunity to boost circularity. In addition to bolstering the circularity of individual sectors and activities, circular procurement is essential for promoting a transition at the supplier level, by creating stable demand for circular goods and services. In this way, circular business models receive the necessary stimulation and incentives to grow and become more competitive. Although some initiatives in this area have cropped up,[191] currently, this opportunity is going largely unfulfilled in Sweden—largely due to gaps in knowledge by many public purchasers as well as a lack of sufficient incentives to change behaviour.

Without a system that accounts for externalities, producers aren't strongly incentivised to cut waste

Net-shape manufacturing—or the practice of planning production processes so that an item's initial production is as close as possible to its final form—is not fully embraced.[192] Manufacturing processes usually generate substantial amounts of waste for each product, largely owing to the use of a diverse array of materials as well as low production volumes. The construction sector is no different: as much as one-fifth of the materials used end up as waste.[193] When using cross-laminated timber, for example, holes for windows and doors are carved out on-site rather than during pre-production, resulting in unnecessary resource use.[194] These systems—and many others—are not geared towards cutting material use nor resulting waste: materials are cheap, relative to labour, meaning actors in neither sector are sufficiently incentivised to adopt innovative new practices for material purchasing or decreasing waste.

ROOT CAUSES: TECHNOLOGICAL AND CAPACITY-BASED BARRIERS

Technical challenges remain in sorting and cycling various waste streams to a high standard

From food waste[195] to metal scrap[196] (such as from discarded vehicles or the manufacturing industry) to plastic waste streams[197] (such as packaging), technical barriers remain for sorting and cycling. In this way, material quality deteriorates—in addition to the loss of economic value. For example, sorting alloying elements from bulk metal flows is hindered by technical challenges, as well as the inherent nature of the materials. Chemical recycling processes are similarly limited: technological investments are lacking, yet are needed to divert plastics—that often cannot be mechanically cycled—from waste-to-energy.

Verifying the properties of secondary materials presents issues

Technical capacity to assess secondary materials and products for reuse—in terms of their function, content and origin—is lacking. Without the assurance of a secondary material's quality—through official certifications proving content, origin or properties—product designers may be inclined to choose virgin materials, which are largely perceived as less risky and more cost effective and as with certainty meet the quality requirements set by manufacturers.[198, 199] In addition, material specifications covering non-virgin

materials (for example, plastics) as well as design guidelines which consider recycled alloys with different qualities have not been developed to a greater extent.

ROOT CAUSES: CULTURAL AND BEHAVIOURAL BARRIERS

High consumption rates prevail

As noted throughout this report, Swedish consumption rates are among the highest in the world: food consumption far surpasses physical needs,[200] for example, which is also linked to vast quantities of avoidable food waste.[201] Sweden also maintains one of the highest numbers of single-occupant households in the EU—resulting in significantly more space per person than multi-occupant residences.[202, 203] For housing, style and design are important priorities—and for this reason, renovation is prevalent among homeowners,[204] with many considering such upgrades to be important future investments.[205] Renovation is also prevalent before the arrival of new tenants in commercial buildings.[206] Increasing demand for comfort, safety and status has also shaped the way Swedes travel, resulting in increasing vehicle weights—the share of SUVs in the Swedish vehicle fleet has swelled over recent years.[207, 208, 209]

Product ownership is preferred to sharing—and is largely more convenient

Traditional, ownership-oriented mindsets result in products being used sporadically—an inefficient use of materials compared to if sharing were the norm. This is especially due to many sharing models being simply less convenient than ownership: consumers may be dissuaded by the time it takes to pick up and return borrowed or rented appliances or vehicles, for example. But the results of this are clear: in Sweden, the average car is used only 3 to 4% of the time,[210] while office spaces and public buildings like schools sit unused for large portions of the day and during long vacation periods.[211, 212, 213] Personal items—from power tools to home appliances and clothing—are also used infrequently: consumers may buy a product to use a handful of times, and then relegate it to storage for much of its lifetime. Swedes also commonly own holiday homes: the country boasts 607,000 of them, most in coastal municipalities, which sit unused for much of the year.[214]

Both consumers and producers have low levels of circular knowledge

Environmental messaging over the last decades has primarily centred around waste management, and especially climate impact—and is largely focused on the use phase of goods. Knowledge and awareness of the effects of resource consumption is moderate among consumers, as well as other actors along the value chain.[215, 216] Good resource management within the manufacturing industry has not yet become commonplace, either: there is a low consideration of aspects such as reuse and longevity, and tangible material efficiency strategies are lacking.[217]

Producers maintain a sales-driven mentality

Businesses are overwhelmingly driven by new sales and influenced by lower-cost competitors. This has resulted in a linear production style for goods—like machinery and equipment—where durability is not the norm and repair and remanufacturing are prevented. Suppliers and other actors are often resistant to change, which is compounded by insurance and financing practices geared towards traditional product sales. Consumers have a role to play, too: accustomed to products failing and simply being able to buy a new item, customers often let routine maintenance for these kinds of goods fall by the wayside.

Successful waste sorting depends on behavioural factors

Among Swedish residents, linear behaviours are deeply ingrained. Although the source sorting rates for several waste streams are relatively high, there are also several waste streams that have a great potential for improvement. Currently, less than half of food waste generated, for example, is sorted out for biological treatment,[218] and less than half of plastic packaging is sorted at its source for recycling.[219] Waste sorting in the construction sector is also inadequate,[220] although recent laws have provided more stringent requirements for source sorting.[221]

The challenges presented in this section are complex—and will require a more interdisciplinary evaluation and discussion in regards to forming solutions. Nonetheless, a preliminary assessment of the actions needed to realise our circular scenarios is given in the following section.

ACTIONS NEEDED: LEGAL AND REGULATORY

Update regulations to reflect a holistic approach to circularity throughout product life cycles

At the end of a product's functional life, regulatory support will be needed to ensure quality preservation and high-value reuse and recycling. While some end-of-the-pipe regulatory solutions—like waste collection and some level of recycling—are prevalent in our current linear economy, this could be shifted to reflect holistic circular solutions earlier in product life cycles, from design (design products to last or to be repairable, for example) to use (rental and sharing, for example). More comprehensive and ambitious policy instruments may be designed to incentivise these practices—going beyond current measures, such as VAT reductions[222] and funds[223] for repair. Options could include developing more stringent legislation and extended producer responsibility for varied product categories (including, for example, furniture, clothing, machinery and process equipment),[224] enforcing stricter eco-design requirements, and updating existing waste legislation to incorporate more circular principles[225] as well as labelling requirements for circularity targeted at consumers.[226] In this case, a systems-thinking perspective is needed to aptly consider the needs of all affected stakeholder groups, understand cross-cutting policy impacts and address potential synergies and trade-offs that will inevitably rise during such a large systemic change. It may happen that a balance will need to be struck between contradicting targets: the need for a non-toxic environment, for example, versus circularity prescribing the cycling of all materials, including chemicals—which could run counter to other environmental and product regulations.

Base policy also on material use—not just emissions

As the circular economy rises on the political agenda, greater acknowledgement must be afforded to the materials and resources embedded in products. Focus could be shifted from primarily addressing emissions generated in the use phase of goods to encompassing processes earlier in the value chain. Just as countries set emissions reductions targets, Sweden may embrace reduction targets based on material use, not just emissions—considering that certain policy instruments may become less effective as increasingly efficient production processes consequently cut embodied carbon, as well as other emissions and effluents.

Create mandatory targets for secondary material use—not just end-of-life cycling

In establishing material reduction targets, as addressed above, it is essential to shift away from measuring waste collection and sorting and instead focus on the proportion of waste that becomes high-value secondary material. To this end, the Swedish government may, in harmony with the EU and its policy developments, consider setting mandatory quotas for the inclusion of secondary materials in certain products: for example, building materials. This will encourage a change of mindset in product design—and have the added benefit of strengthening the market pull for secondary materials. Initiatives of this kind are already blooming, to an extent: the Swedish Environmental Protection Agency, for example, has recently proposed a quota obligation for products made of soft polyethylene.[227]

Champion a green tax shift from labour to virgin resources

Sweden has a positive view of green tax shifts that support a sustainable societal transition, having implemented them in relation to renewables and climate objectives. As circularity is projected to be labour-intensive, it makes sense to analyse how a tax shift could lower the cost of such labour while disincentivising the extraction and use of virgin resources. An additional benefit would be incentivising and increasing the competitiveness of secondary resources that are often more costly than their virgin counterparts.

ACTIONS NEEDED: ECONOMIC AND FINANCIAL

Shift away from linear business models

The transition from linear to circular in the Swedish business sector is sluggish, owing to unsupportive policymaking, the nature of the financial sector and a lack of knowledge and competencies. Research on the role of policy in promoting capacity building for circularity in SMEs—as well as the inclusion of larger companies and sectoral organisations—could aid businesses in the transition. This point is deeply linked to cultural aspects, as well: for circular businesses to become successful, a change of mindset and internal organisational structure and

Key Performance Indicators within companies will be needed. Redefining impact, value and risk for circular accounting will help support circular business models and allow financiers to see them are more viable.[228]

Support circular procurement

The role of public procurement in the circular transition should not be overlooked: actions could be taken that support public sector purchasers in adopting more circular principles, from promoting sharing and cycling to incentivising material-efficiency, durability and repairability in design.[229] The National Agency for Public Procurement will have a key role to play in strengthening knowledge and acknowledging actors' various capacities and roles.

Monitor and mitigate economic rebound effects

Circular strategies that increase resource efficiency and create economic savings for consumers may have a paradoxical consequence—increased spending on more products, resulting in equal or even increased resource use. This ideally could be monitored and addressed with relevant actions to mitigate rebound effects: for example, through policy instruments that weigh in rebound impacts.

ACTIONS NEEDED: TECHNOLOGICAL AND CAPACITY-BASED

Promote the continuous improvement of technology for high-value cycling

Although this report notes the importance of reducing consumption to boost Sweden's circularity, increased and improved material recycling also have a substantial role to play—yet these are often hindered by significant technical challenges. Plastic recycling, for example, is often complex: not all plastic can be mechanically recycled and polymer degradation and yield losses in the sorting process are inevitable, necessitating further innovative and technological improvement for chemical recycling.[230, 231] In addition to continued advancements for sorting and cycling of materials[232] and of industrial waste.[233] Retaining materials' value at the highest level possible is the ultimate goal—for instance, bolstering metal sorting and recycling technologies to allow for greater use of alloys and critical metals. The green energy transition—an important component of climate action—will inevitably require such complex materials, for example. These will eventually become obsolete and need to be recycled. Pretreatment processes for food waste may also be promoted to cut substantial losses of biological material. And furthermore, as demand for secondary materials increases, the quality of secondary raw materials will play an increasingly critical role: if high-value cycling is not made the norm, virgin materials will still be needed to meet quality demands. In tandem, for example governments and research institutions could continue to develop standards, methods and tracing systems—such as material and product passports[234]—to ensure a supply of high-quality secondary materials and products for reuse and encourage greater demand. Product designers could be further incentivised to use secondary materials through testbeds and pilot programmes that can validate their functions and benefits.

Strengthen circular capacity building

Going circular in a linear world is not a simple task, and businesses will need to adapt both to existing and upcoming national and EU regulations. While these are drivers in themselves, companies should also be equipped with the necessary knowledge to make the switch and comply with policy instruments. Companies may be supported in their circular journeys—for example, by facilitating extractive firms in mining and forestry sectors to make better use of by-products and recover waste; or by promoting technical developments for large scale remanufacturing practices through the development of knowledge and practices in financing, accounting and insurance for circular business models. Supporting investment in cutting-edge technologies will also be crucial to bolster resource efficiency and cut waste across sectors. Capacity building—particularly around knowledge of circularity—will be especially relevant for SMEs, which represent the vast majority of Swedish businesses.

Prioritise and incentivise actions to limit stock expansion

Some of the biggest leaps towards circularity—and in limiting resource consumption—can be made in the built environment. As of yet, it is not clear what effect the covid-19 pandemic will have on the need for office space. In the future, flexible work-from-home schemes, flexible office use and the conversion of unused spaces into housing could be considered to limit the expansion of the built environment.

ACTIONS NEEDED: CULTURAL AND BEHAVIOURAL

Change the way consumers think and shop—and the way manufacturers produce

Information campaigns and various incentives can be coupled to nurture a collective shift in consciousness—where sharing, shopping second-hand and decreased ownership and consumption are the norm. Research on how consumers think and act—or why they might be hesitant to try a new circular behaviour or product—may also be carried out to guide policy measures. The need for a mindset shift extends beyond consumers—and manufacturers should be similarly incentivised to adhere to principles of eco-design and incorporate circular practices into their processes.

Stimulate a broad social metamorphosis

Times are changing—and society must change along with it: a nation-wide shift in mindset will be needed to make the most of a circular economy, with support from policymakers, business leaders and civil society alike. Behavioural change will be crucial to implementing the most effective circular strategies: limiting building stock expansion, for example, will require a collective shift in the way people view space and overcome aversions to sharing. The systemic shift needed may be guided through a holistic lens of circularity and all the life cycle stages it touches, from design to production to use to reuse to end-of-life—while emphasising the importance of cutting consumption along with emissions. Throughout this process, collaboration within value networks and across industries will be crucial—from sharing best practices and knowledge to forming symbiotic relationships to valorise waste from different sectors. Collaboration is key to nourishing a healthy circular economy, increasing the economic viability of change and preventing unfair competition.

6 THE WAY FOR-WARD

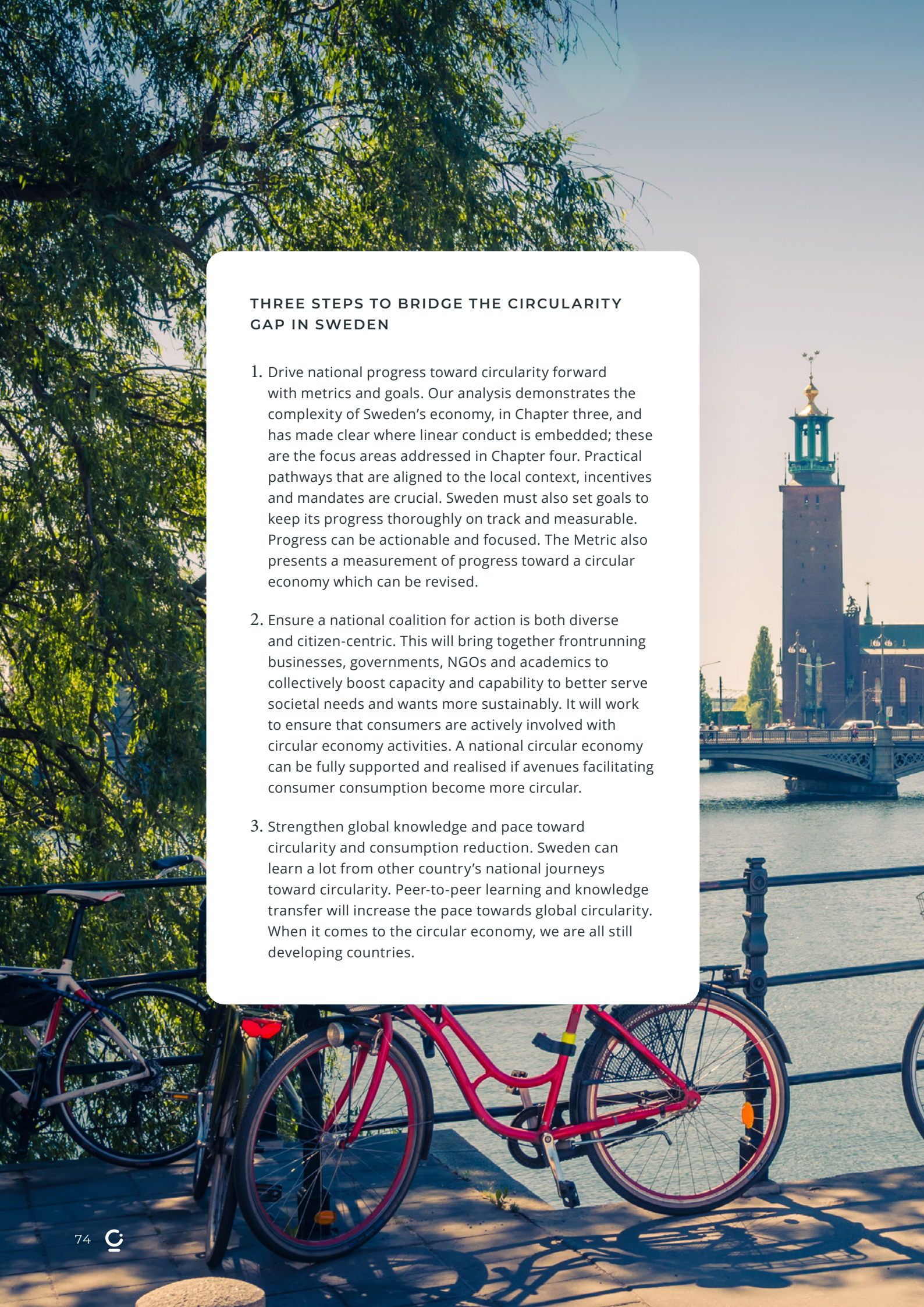
Sweden has transformative potential: by doubling its circularity, it can cut the volume of resources needed to fulfil its societal needs and wants by nearly half. This report lays out a first approximation of how resources are allocated to meet Sweden's needs and wants—and provides a roadmap for how the country can drive its circularity from 3.4% to 7.6%. In doing so, it can cut its material footprint by 42.6%—bringing huge benefits for the climate and biodiversity while cutting pollution and resource depletion. Through the scenarios presented, Sweden has the opportunity to overhaul its economy: moving from material-intensive processes to ones that make the most of materials, design out waste and regenerate natural systems. Although these massive changes result in only a relatively small increase in the Circularity Metric, the outcomes—for resource use, the climate, biodiversity and Swedish society—will be transformational.

Current solutions are grossly inadequate for the scale of the challenges we face today—but circular strategies have transformative potential. Our natural environment will be stretched to its breaking point as global income and population continue to swell. The trajectory of human history has made the link between material use and human well-being clear: extracting resources to transform into the goods we use—generating emissions and generating waste in the process—is largely tied to economic growth and higher living standards.[235, 236] Breaking this pattern—and achieving an ecologically safe and socially just space—will require innovation beyond material efficiency. It will require a radical transformation of how Sweden meets the needs of its people that can only be achieved through a restructuring of the current social metabolism—a distinct way of organising material, energy and capital flows. Transitioning to a circular economy isn't a silver bullet—but it is a crucial first step.

All countries are critical change agents. The global economy is just 8.6% circular: linear practices are embedded in societies worldwide. While this report takes a national perspective on circularity, it is important to understand Sweden's position in the global context. As a nation that embodies all the characteristics of a *Shift* country—high levels of consumption, extraction and waste, with prosperous living conditions for its residents—Sweden has a particularly strong responsibility to drive circularity and cut its per capita ecological impact. With a wide and diverse pool of resources locally abundant, the nation could shift its consumption to domestically sourced (where beneficial)—and sustainably produced—products, rather than relying on imports with hard-to-control circularity, sustainability and ethics. This also precludes environmental impacts from Swedish consumption being outsourced to other countries. At the same time, as a key global provider of raw materials—such as iron ore—and finished products—from cars to sawn timber—Sweden's role as an exporter of valuable commodities represents an opportunity for impact that extends far beyond its borders. Ensuring its vast stores of natural resources, from mineral deposits to forests, are managed sustainably, will have a crucial global impact: it's time for Sweden to leverage this opportunity, balancing and optimising the use of its domestic resources across the global stage. Efforts should also centre on raising the material-use agenda on par with emissions-reductions targets: akin to goals for slashing emissions, the Swedish government may drive circularity by putting material-use reduction targets into play.

Sweden's climate action must consider circularity. The energy transition and transition to a circular economy are two sides of the same coin—yet trade-offs still exist between them. Decarbonisation, which crucially involves the build-up of renewable energy infrastructure, is inherently material-intensive and requires the extraction of a range of metals to produce solar panels, wind turbines and lithium batteries, among others. Building up our inventories of these products also implies waste-creation further down the road: it's essential that Sweden applies circular thinking now to maximise the reusability, repairability and recyclability of these goods at their end-of-life. A holistic perspective that considers both emissions and material-reduction is crucial—and efforts towards decarbonisation must avoid the mistakes of the linear economy, with rampant extraction of virgin resources and waste creation.

A huge opportunity for Sweden. The country has a ways to go: it's more linear that it appears on paper, with levels of extraction and consumption beyond what the Earth can provide. But it's also well-positioned to take on the challenge of going circular: it boasts a low-carbon economy (with the significant presence of renewables in its energy mix), the strongest climate ambitions in the EU,[237] and the technical and behavioural capacity for change. Through systematic change permeating governments and businesses, and shifts in individual behaviour, Sweden has the opportunity to become a global leader for circularity.



THREE STEPS TO BRIDGE THE CIRCULARITY GAP IN SWEDEN

1. Drive national progress toward circularity forward with metrics and goals. Our analysis demonstrates the complexity of Sweden's economy, in Chapter three, and has made clear where linear conduct is embedded; these are the focus areas addressed in Chapter four. Practical pathways that are aligned to the local context, incentives and mandates are crucial. Sweden 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 citizen-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 economy 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. Sweden can learn a lot from other country's national journeys toward circularity. Peer-to-peer learning and knowledge transfer will increase the pace towards global circularity. When it comes to the circular economy, we are all still developing countries.

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50. Own calculations based on Exiobase v3.8.2.

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