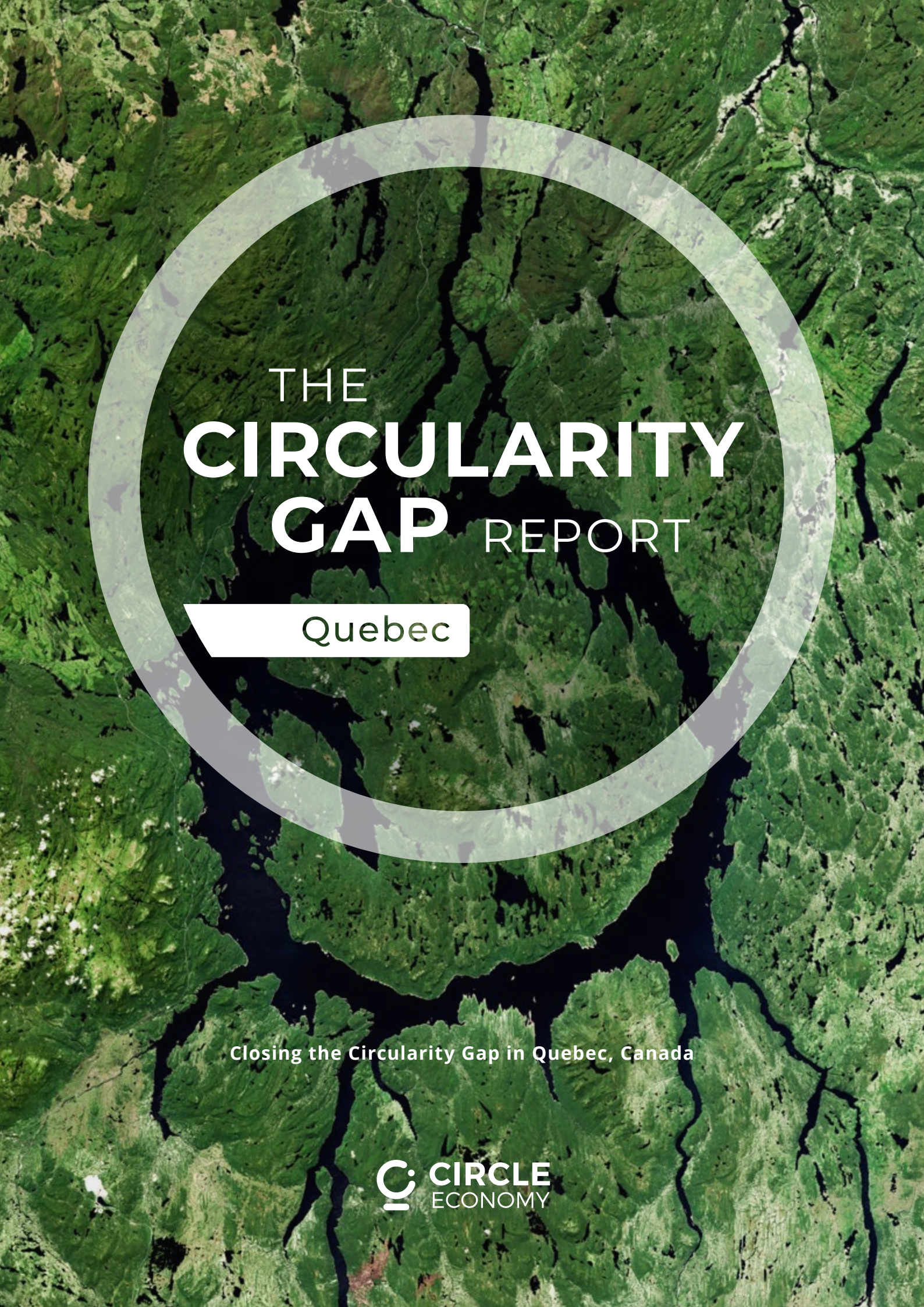

THE CIRCULARITY GAP REPORT

Quebec

Closing the Circularity Gap in Quebec, Canada

CIRCLE ECONOMY

BEHIND THE COVER

The Manicouagan Reservoir was originally a meteorite crater; the fifth largest recorded on Earth, and is 214 million years old. Located in the Côte-Nord region, the crater, nicknamed ‘the eye of Quebec’, is the emblem of the Manicouagan-Uapishka World Biosphere Reserve. Flooded by the construction of the Daniel-Johnson Dam on the Manicouagan River in 1970, the reservoir, with a surface area of 2,000 square kilometres and an average depth of 73 metres, is one of the largest reservoirs in the world in terms of volume and depth.

CIRCLE ECONOMY

Circle Economy works to accelerate the transition to a circular economy. As an impact organisation, we identify opportunities to turn circular economy principles into practical reality. With nature as our mentor, we combine practical insights with scalable responses to humanity’s greatest challenges. Through our multiple programmes, we translate our vision of economic, social and environmental prosperity into reality.

RECYC-QUÉBEC Québec

RECYC-QUÉBEC

La Société québécoise de récupération et de recyclage (RECYC-QUÉBEC) is a leader in responsible waste management in Quebec. Since 1990, the government-corporation has strived in making Quebec a model for innovative and sustainable waste management. Their mission is to promote a circular economy and fight against climate change by encouraging best practices in waste prevention and management.

PACE
Platform for Accelerating the Circular Economy

This report is published as an affiliate project of the Platform for Accelerating the Circular Economy (PACE). PACE is a public-private collaboration mechanism and project accelerator dedicated to bringing about the circular economy at speed and scale. It brings together a coalition of more than 70 leaders and is co-chaired by the heads of Royal Philips and the Global Environment Facility. It was initiated at the World Economic Forum and is currently hosted by the World Resources Institute.

IN SUPPORT *OF THE CIRCULARITY GAP REPORT*

BENOIT CHARETTE
Minister of the Environment and the Fight against Climate Change

The first circularity index of the Quebecois economy is a concrete, effective and balanced measure that demonstrates once again that the economy and environmental protection are compatible. I commend RECYC-QUÉBEC's leadership in this area and invite all sectors of Quebec's economy to work together to rise to the challenges that have been identified. Together, we must develop a long-term vision that will ensure our natural resources are managed in a way that respects the environment, the health and quality of life of the population, while drawing inspiration from best practices worldwide.

BÉATRICE ALAIN
Executive Director, Chantier de l'économie sociale

The strong presence of civil society organisations noted in the report is an important asset for reconciling economic, environmental and social issues at the territorial level and over the long-term. These actors—including the social economy movement—are key to deploying the circular economy to serve both individuals and communities.

ANDRÉ BELLAVANCE
Mayor, Victoriaville
President of the Environment commission, Union des municipalités du Québec

Through their proximity to citizens, businesses and institutions, cities are at the heart of the transition to the circular economy. Many innovative projects are being deployed, particularly in my own city, but there is still an urgent need for action to create a greener, more resilient and sustainable society. Together, let's pool our strengths to bring about these necessary changes.

JACK FROESE
Director, Metro Vancouver Board of Directors, Chair, National Zero Waste Council

The *Circularity Gap Report Quebec* marks a significant contribution to our understanding of both the challenge and opportunity to prevent waste and accelerate Canada's transition to a circular economy. It underscores the need to work together and offers key insights and practical ideas for business, government, and civil society leaders to create a prosperous and resilient future for all Canadians.

HÉLÈNE LAUZON
President & CEO, Quebec Quebec Business Council on the Environment

Post-covid-19 economic recovery represents an unprecedented opportunity to make the transition to a more circular economy. From the extraction of raw materials to the management of residual materials, Quebecois enterprises are showing ingenuity and creativity to develop innovative solutions in this regard. They will be present to ensure a large-scale deployment of the circular economy.

CLAUDE MAHEUX-PICARD
Executive Director, Centre de transfert technologique en écologie industrielle et territoriale (CTTÉI)

Thanks to this report, Quebec now has clear data on which sectors to prioritise in order to accelerate the transition to the circular economy. This will make it easier to measure the tangible impact of our actions. There is a lot of work ahead, but by combining our efforts, a quick increase in our circularity index is possible. It is a societal project that we must all adhere to!

RICHARD MIMEAU
Executive Director, Conseil des entreprises en technologies environnementales du Québec

Private companies in the main sectors of Quebec's green economy are natural allies in the transition to a circular economy. Although this transition has already begun, we will continue to work in collaboration with all the players in the value chain our industry belongs to, in order to promote a favourable environment where resources will be optimised and valued fairly.

GENEVIÈVE MORIN
President & CEO, Fondaction

Making the economy more circular is an essential component of the necessary transformation to a more equitable, inclusive, green and efficient economy. This report reminds us of the urgency to act in this direction and proposes an approach that will facilitate the convergence of all actors as well as the measurement of our collective progress.

DANIEL NORMANDIN
Director, Center for Intersectoral Studies and Research on the Circular Economy (CERIEC) — École de technologie supérieure

The transition to the circular economy is an imperative that affects all the economies of the planet. Since 2014, Quebec has played a pioneering role on the Canadian level. That said, the exercise conducted as part of this report has made it possible to clearly reveal, for the first time, not only the scope of the challenge that is the circularisation of Quebec's economy, but also to reveal opportunities.

EXECUTIVE SUMMARY

Quebec is 3.5% circular, with a Circularity Gap of over 96%. This means that the majority of resources the economy uses to satisfy its needs and wants are not cycled. Quebec has a complex, largely linear economy that is accustomed to high rates of extraction, production, trade and consumption. Around 271 million tonnes of resources and materials funnel into the economy every year, amounting to 32 tonnes per person—higher than the average Canadian. Although a high rate of consumption, a hefty material footprint and a low Circularity Metric are typical for an industrialised economy engaged in trade, it calls for an approach that not only aims to increase circularity. Therefore, in this study, we also highlight strategies to reduce the number of resources needed to fuel the economy in the first place: the material footprint.

The material footprint behind the Quebecois needs and wants. This study provides a first approximation of how resource use is allocated across Quebec's needs and wants, such as Mobility and Housing. We see that the needs' material footprints originate, to a large extent, from outside of the province through its imports—typical for a developed trade region. Quebec fully functions on renewable energy for electricity but still relies heavily on imported fossil fuels for transport. The agricultural sector produces unusually large amounts of waste, but little is currently reused or recycled. Also, the goods and services the government invests in—from providing computers for a public school to contracting a company to build a bridge (public procurement)—are highly resource-intensive. These components of the economy are reflected in how resource use is allocated across the province's needs and wants: Services is the second-highest contributor to the material footprint—on par with Nutrition—while Housing leads the way.

A circular roadmap to close the Circularity Gap in Quebec. To close the Gap, we explore six 'what-if' scenarios that apply core circular strategies to transform the economy. The scenarios are (1) Design circularity into stocks, (2) Prioritise conscious consumables, (3) Strive for circular agriculture, (4) Leverage government procurement, (5) Make manufacturing circular and (6) Make mobility clean. The impact of each scenario is limited, but when combined, Quebec can become 9.8% circular—nearly a threefold increase—and, crucially, cut its material footprint by nearly half (48.2%), to 16.6 tonnes per person.

Quebec's economy is full of potential, but there are limitations in how much we can increase its Circularity Metric. The province's consumption rates drive a huge amount of local virgin resource extraction and waste, as well as extraction and waste abroad as it consumes imported goods. Managing the circularity of imports is difficult. Also, Quebec's continued expansion of infrastructure such as roads and (renewable) energy limits short-term opportunities to become more circular. While sometimes necessary, these resources remain locked away in stock and not available for cycling, thereby weighing down the Circularity Metric. So, even by increasing the Metric from the current 3.5% to 9.8%, the economy will need to undergo massive change. It's also crucial to note that the way we measure circularity is complex and has many components: our scenarios result in massive changes to the economy—including almost halving the amount of resources it uses to fuel the needs of the province—that are not reflected in our Circularity Metric. Our global *Circularity Gap Report 2021*, for example, found that we only have to double the globe's circularity, reaching a Metric of 17%, to limit global warming temperature to well below 2-degrees. So, in moving from 3.5 to 9.8% circular, Quebec in fact will see its economy transform.

The circular economy is a means to an end. Closing the Circularity Gap serves the higher objective of preventing accelerated environmental degradation and social inequality, on both a local and global level. Transformative measures to cut greenhouse gas emissions are inherent in the circular economy. Circular business models and improved resource efficiency are also a means to enhance emission abatement and reduce extraction, thereby improving supply security and price stability when materials are kept in the province. The circular economy is a means to achieving the end goal of a world that is ecologically safe and socially just.[1]

The circular economy can help Quebec make 'building back better' a reality. When realigned, Quebec's economy can meet circular ambitions. It is already nearly entirely sustained by renewable energy, and it has state of the art infrastructure, a skilled labour force, high government spending power and a thriving community of circular grassroots organisations to help drive the transition. The province also boasts immense regenerative capacity, due to its swathes of forest land that continuously sequester carbon and offer the province a competitive advantage. Our analysis and circular roadmap can assist the Quebec government and relevant stakeholders in crafting a bold and full plan for a circular economy; all part of rebuilding a robust, resource-efficient and circular post-Covid-19 economy.

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Photo by Regis Hari Bouchard

1. INTRODUCTION

The materials flowing through the global economy surpass 100 billion tonnes a year—and only 8.6% are cycled, reported our global *Circularity Gap Report 2020*, which launched at the World Economic Forum.[2] Our 2021 edition highlighted that the transition to a circular economy is necessary to close the Emissions Gap and limit the effects of climate breakdown—and how doing so will require almost doubling the global Circularity Metric from 8.6% to 17%.[3] Quebec's Circularity Metric, at 3.5%, sits well below the global average. While Quebec is hailed for its almost entirely renewable energy production and vast swathes of forests, its economy is characterised by high levels of consumption and imports, large volumes of virgin resource extraction and relatively low levels of cycling. The average European has a material footprint of almost 20 tonnes[4] per year, while for the average citizen in Quebec, it's 32 tonnes per year. Our analysis reveals several avenues through which the Quebec economy can shift away from linearity and integrate into this promising and hopeful global systems-shift: the circular economy.

THE RISKS OF THE LINEAR ECONOMY

Much of the globe operates within the linear economy—characterised by 'take-make-waste' processes powered by fossil fuels. The linear economy relies on obtaining large quantities of energy and materials through emission-heavy processes, that are quickly used to satisfy needs and wants—be it Nutrition or Mobility—and then disposed of. This system has allowed some people, in some parts of the world and at certain times, to prosper and economies to grow.

The processes central to how we make and produce goods in this system quickly strip finite materials of their value and lack efficiency. They also directly contribute to climate breakdown, environmental degradation and biodiversity loss, and spur severe social repercussions and massive global inequalities—from food insecurity to poverty to restricted access to healthcare. Irrationally, these inequalities have been able to increase concurrently with rising economic wealth (GDP). Consistent and intensive extraction of finite natural resources has also resulted in volatility across markets and resource scarcity and constraints.

TIME TO UPDATE THE SYSTEM

Certain industries in Quebec have been able to flourish under the linear economy, leading to many of Quebec's successes today: a generally high standard of living, booming trade industries in diversified metal and mineral extraction and a prominent and profitable standing as a net exporter within the country and around the world. Annually, Quebec imports approximately 110 million tonnes of resources from abroad to satisfy the needs of its population, and it extracts so much that its rate of domestic resource extraction per capita tops 24 tonnes—coming in sixth place globally.[5] However, linear industries are dependent on unsustainable processes and consumption rates that outweigh the resource capacity of the earth. And now, globally, urgency is building. Experts predict that climate breakdown—not Covid-19—will be the biggest global health threat of the century and a world operating under a linear system is not resilient to change.[6] Importantly, the scale of the solution needs to match the scale of the emergency. Business-as-usual is no longer an option.

This is where the circular economy comes in. By designing out waste and pollution, keeping products and materials in use, and regenerating natural systems,[7] a circular economy allows us to collectively reimagine and redesign our systems to ensure an ecologically safe and socially just space for us all.[8] As a multistakeholder model, the circular economy's systems-thinking approach boosts capacity and capability to serve universal societal needs in a way that functioning social systems fall within healthy planetary boundaries.[9] This circular framework aligns with a vision of a more resource-aligned, people-centric future.

NO CLEAR CIRCULAR ROADMAP

Quebec's Metric is 3.5%. This means, of the 271.1 million tonnes consumed, 96.5% are not cycled back into the economy and are either locked into stock (such as infrastructure or machinery), dissipated, lost, or are considered circular biomass (see pages 26-27 for more information). The Quebec government has launched the *2030 Plan for a Green Economy* to replace its previous *Climate Change Action Plan* that expired on the 31st of March 2021. It touts multiple policies related to a 'green economy' that include circular elements, such as on minerals, waste management and agrifood. The Plan also lays out the target of reducing the province's greenhouse gas emissions by 37.5% (compared to the 1990 baseline) by 2030.[10] The elements explored by the Plan are also spotlighted in a variety of other policy documents, from the Québec Plan for the Development of Critical and Strategic Minerals[11] to the *Plan d'action 2019–2024 de la Politique québécoise de gestion des matières résiduelles*[12] (Action plan of the Quebec Residual Materials Management Policy) and *Politique Bioalimentaire* (Biofood Policy).[13]

However, both Canada and the province of Quebec lack concrete circular plans or goals; such as the EU's *Circular Economy Action Plan* that sets out 54 actions across waste, landfill, reuse and recycling with end goals set for 2030 and 2035, or the Dutch government's goal of full circularity by 2050. There is ample space for thorough plans to be implemented into Quebec's strategies and policies moving forward—the iteration on the government's sustainable development strategy (2022 to 2027) serving as a good example. Our analysis can provide a benchmark measure of circularity and resource use for the province, which is integral for goal-setting and measuring progress.

COVID-19 AND BUILDING BACK BETTER

Many of the repercussions of Covid-19 on social and economic levels served to hold a magnifying glass to the flaws in our system. As trillions of dollars funnel into economies to facilitate Covid-19 rescue and recovery measures, calls for 'building back better' have been loud. Within this, the circular economy is increasingly hailed as the system that the globe must adopt if we are to be prepared for future crises. In rolling out rescue and recovery measures, many see a valuable opportunity to review business-as-usual practices, models and markets and to build a greener and low-carbon economy, which should be more resilient. Governments are now making decisions on how to set goals and spend capital. The decisions national and subnational governments make today will shape our future climate and the lives of generations to come.

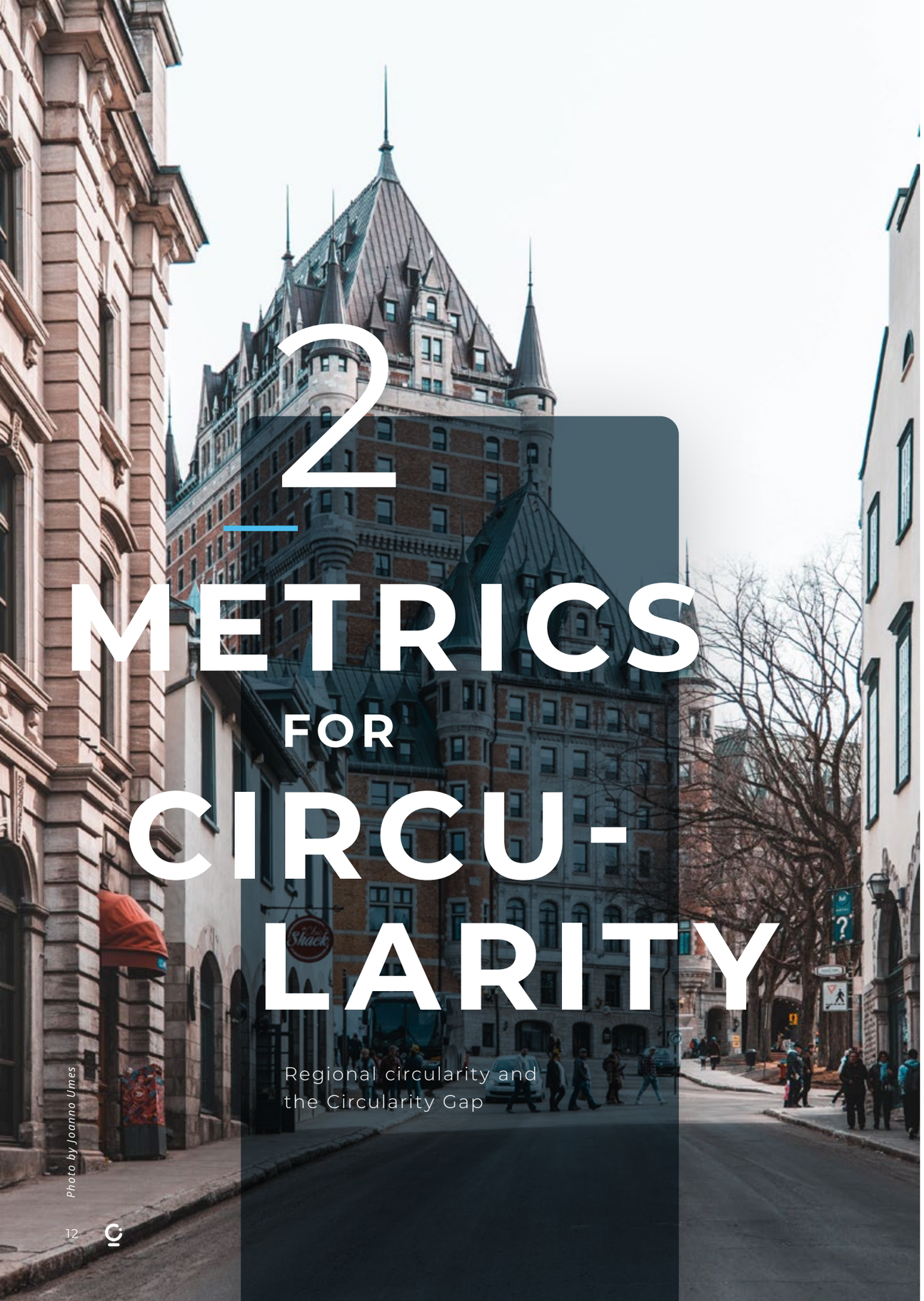
Quebec's *2030 Plan for a Green Economy* aims for the complete electrification of transport, and for buildings and industrial activity to be increasingly powered by the province's renewable energy.

AN ECONOMY FULL OF POTENTIAL

While Quebec's Metric sits approximately 5% below the world average, the make-up of its economy is rife with opportunity for a circular transformation. Our analysis finds that there are many avenues for boosting Quebec's Metric, from diverting wet organic waste (garden, food and sluge) from landfilling and incineration without energy recovery, to integrating circularity into all aspects of public procurement. The province has a strong foundation for future action: close to 100% of its electricity generation comes from renewable sources, which will allow for a smooth transition to electrified transport, while waste recovery volumes outrank those of Europe. It also touts high government spending power and a thriving community of circular grassroots organisations. Nonetheless, Quebec's consumption—leading to high levels of waste within and beyond the province's territorial bounds—leaves room for improvement. In this report we present five scenarios that will almost triple its Circularity Metric and cut its material footprint by half, making the most of the opportunities its economy provides and ingraining circularity every step along the way.

AIMS OF THE *CIRCULARITY GAP REPORT QUEBEC*

1. Provide a snapshot of how circular Quebec is by applying the Circularity Metric.
2. Identify how materials flow throughout the economy and how they may limit or boost the current Circularity Metric and the material footprint.
3. Spotlight possible interventions within significant industries that can aid Quebec's transition to becoming circular and reducing its material footprint.
4. Communicate a call to action based on the above analysis, to inform future goal setting and agendas.



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METRICS FOR CIRCU-LARITY

Regional circularity and the Circularity Gap

Photo by Joanna Umes

Measurements are critical to understanding the world around us. As it becomes more urgent to adapt our economic system to become more circular, we need to provide a tactical approach to measuring the transition—which can seem abstract or complex. In the first edition of the global Circularity Gap Report in 2018, Circle Economy presented the Circularity Metric for the global economy. Since then, the Metric has formed a milestone for global discourse on the circular economy. This current analysis adapts the Metric to suit a provincial profile. This section explains how we assessed Quebec's circularity using our Circularity Metric and introduces supporting metrics that help us understand the significant material flows that contribute to Quebec's large Circularity Gap. These additional insights aim to provide an answer to how the economy can formulate a plan for moving toward circularity: it provides the initial assessment by locating circular opportunities and priorities in the 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

We need resources and materials to fuel our lifestyles. However, the circular economy ensures that with less material input and fewer emissions, we can still deliver the same, or better, output. But this requires we break with the 'take-make-waste' tradition and pivot towards a circular approach under which we refrain from material extraction and optimise the use of existing materials by minimising and eliminating waste. Ultimately, a world where circular strategies are dominant will be more socially just and ecologically safe.

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.[14] In particular, three connected spheres need to be taken into account: how resources are put to work to deliver social outcomes via provisioning systems. Provisioning systems comprise physical systems such as road infrastructure, technologies, and their efficiencies[15] and social systems include government institutions, businesses, communities and markets.[16] Provisioning systems are the essential link between ecological and technical 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 our economy and enable us to thrive, yet with lower environmental impact.

In this study we also consider the importance of reducing consumption. This is because impact prevention through reduction in demand is an important first step to take before exploring other mitigation options. This is reflected also by environmental management hierarchies wherein reductions of production and consumption, narrowing flows, is always the preferred and most effective strategy.

MATERIAL FLOWS AND FOOTPRINTS

In this analysis, we take the metabolism of a province—how resources flow through the economy and are in long-term use—as the starting point for measuring its level of circularity. Figure One, on the next page, provides a schematic depiction of the metabolism of Quebec. It depicts the amounts of materials (divided into four key resource groups, which exclude water and air) **embodied** in 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 result of direct domestic **extraction**. These are minerals (salt for example), metal ores (iron for example), fossil fuels (petroleum, for example) and biomass (food crops, forestry, manure, 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 provincial economy (read

more on page 18). 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. These products then feed into satisfying the societal needs and wants of Quebec, such as Nutrition or Healthcare.

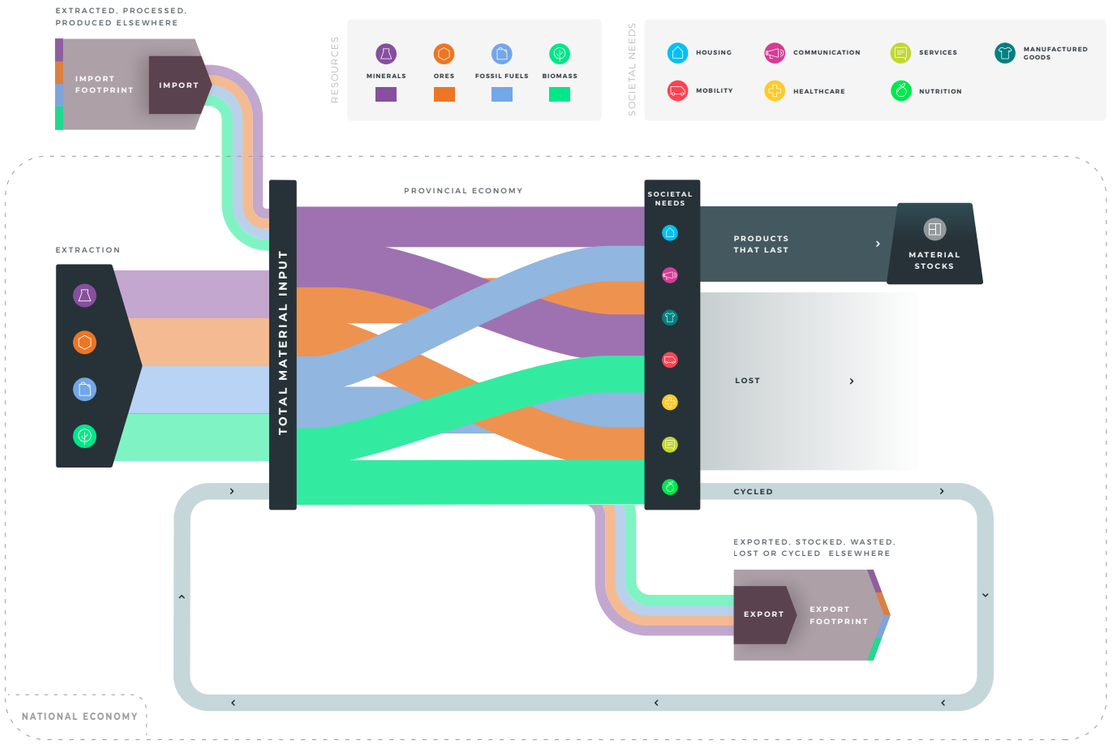


Figure One shows a schematic overview of the material footprint and metabolism of a region. Note: material stock and cycled material flows are not scaled to proportion.

HOW WE CALCULATE OUR CIRCULARITY METRIC

In order to capture a single metric for circularity in an economy, we need to reduce the complexity somewhat. Our starting point for this process is measuring how resources flow through the economy and remain in long-term use. This approach builds on and is inspired by the work of Haas et al. (2015)[17] and continues the approach applied in all other national Circularity Gap Reports.[18] 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).[19 20]

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 quality loss; emissions to air and dispersion to water or land are prevented; and biomass is optimally cascaded.

The four strategies we can use to achieve these objectives are:

- **Narrow flows—use less:** The amount of materials used or greenhouse gases (GHGs) emitted 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 lifetimes, 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, remodelling.
- **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 material use, renewable energy, regenerative agriculture.
- **Cycle flows—use again:** The reuse of materials or products at end-of-life is optimised, facilitating a circular flow of resources. This is enhanced by improved collection and reprocessing of materials and optimal cascading by creating value in each stage of reuse. In practice: Design for recyclability (both technical and biological), design for disassembly, recycling, biomass waste-to-energy.

If we effectively deploy strategies focused on **narrowing, slowing, cycling** and **regenerating** the flow of materials, we will ultimately require fewer materials to provide for similar needs. Because of this, fewer materials will be used by the economy, they will have longer lifespans 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 inputs into a global 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, that we call 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 manage to sustain societal needs and wants with materials that already exist. 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 Quebec can embrace its circular potential.

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. To address the complexities and intricacies of a nation's economy, it is our aim to provide as much information and context on how individual nations can better manage materials to close their Circularity Gap. To understand a country or region's Circularity Gap, we must consider 100% of inputs into the economy: circular inputs, non-circular inputs and inputs that add to reserves and stocks. These categories are based on the work of Haas et al. (2020).[21]

Circular inputs (29.5%)

1. **Socioeconomic cycling (3.5% in Quebec)**
   This refers to the share of secondary materials in the total consumption of an economy: the Circularity Metric. These materials are items that were formerly waste, but now are cycled back into use, and includes recycled materials from both the technical (such as recycled cement and metals) and biological cycles (such as manure and wood). In Quebec, this number is well below the global average of 8.6%, totalling 3.5% of total material input.

2. **Ecological cycling (26% in Quebec)**
   This is the share of renewable primary biomass (wood, food crops, agricultural residues) in the total consumption of an economy. To be considered circular, biomass should be wholly sustainable: it must re-enter the cycle and contribute to new plant growth, allowing the ecosystem biocapacity to remain the same; but this is not often the reality. Therefore, to be considered circular, primary biomass must **at the very least** guarantee full nutrient cycling 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 Quebec provides a significant basin for carbon sequestration, meaning that Canadian LULUCF emissions are certainly negative (-13 million tonnes for Canada), and the biomass consumed within its borders can be considered carbon neutral.

However, 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. As of yet, we have methodological limitations in determining nutrient cycling, and to that end, have not included ecological cycling in our calculation of Quebec's Circularity Metric—even though this would boost the province's circularity rate to an impressive 29.5%. We take a precautionary stance with its exclusion, with the knowledge that its impact on the Metric may not be totally accurate. However, we do see great potential for the future: if the sustainable scale-up of biomass production were to become the norm, circularity could greatly increase. And what's more, ecological cycling does play a crucial role in circularity: many of our scenarios, presented in Chapter Four, promote bio-based materials in sectors as diverse as housing and consumables—yet the impacts of such interventions are not reflected in the Metric, but rather by a shift in ecological cycling. In this manner it can be said that the impact of our proposed circular strategies is greater than the Metric may showcase.

Non-circular inputs (53%)

1. **Non-circular inputs (17% in Quebec)**
   Fossil-based energy carriers, such as gasoline, diesel and natural gas that are burned for energy purposes and emitted into the atmosphere are inherently non-circular: the loop cannot be closed on fossil fuels. In Quebec, the high share of renewable energy lowers this rate, but fossil fuels are still imported and used for energy, heat and mobility.

2. **Non-renewable inputs (36% in Quebec)**
   Non-renewable inputs into the economy that are neither fossil fuels nor ecologically cycled include uncycled materials such as metals, plastics and glass. These are often embodied in consumer products, ranging from furniture and sports goods to aircraft components and machinery for a range of sectors. Although these inputs to the economy can in principle be cycled, 36% of these inputs in Quebec are not and therefore cannot be considered circular.

Added to reserves and stocks (19%)

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, in order to provide Housing and Mobility, as well as renewable energy. This stock build-up is not inherently bad; many countries need to invest to ensure that the local populations have access to basic services, as well as build up infrastructure globally to support renewable energy generation, distribution and storage capacity. These resources do, however, remain locked away and are not available for cycling, and therefore weigh down the Circularity Metric.*

**We believe this share is much larger than what we report here. And this is due to our uncertainties in our life-cycle approach. What this means is that life-cycle based flows of resources (RMEs) and a national system boundary are not easy to reconcile in a coherent mass balance. Because of this, the split between 'added to reserves' and 'non-renewable materials' is difficult to measure accurately. It is likely that a big chunk of non-renewable inputs is actually allocated to stocks (19%), however our current methodology limits our ability to assess this in a more granular manner. We acknowledge this limitation in data quality, however, it doesn't directly influence the Metric.*

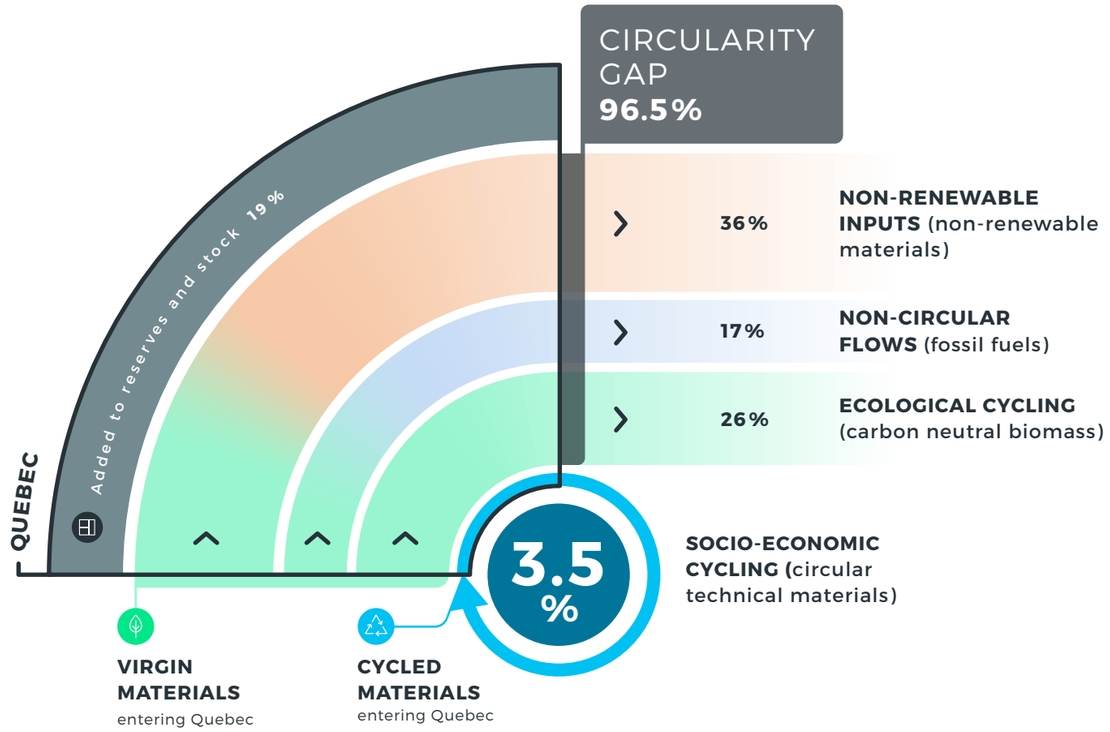


Figure Two shows the full picture of circular and non-circular materials that make up Quebec's Circularity Gap.

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 and regions, however, the dynamics of trade introduce complexities for which we must adapt our Metric, resulting in certain methodological choices.[22]

In assessing a country or region, we can 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.

Secondly, when considering what Quebec citizens consume to satisfy their needs, we must apply a nuanced lens to 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 one tonne when imported, but all the materials used to produce and transport it across global value chains can weigh as much as 3.4 tonnes—its actual material footprint. To represent actual material footprints in imports and exports, we apply so-called raw material equivalents (RMEs) in this study.

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 as 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—the imports of every country have the same average share of secondary materials per resource group.

To understand the amount of secondary materials that are consumed domestically, rather than are exported, we make our second assumption: 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.[23]

PRACTICAL CHALLENGES IN QUANTIFYING CIRCULARITY

- **There is more to circularity than cycling.** A circular economy strives to retain the value and complexity of products for as long as possible, with minimal degradation. The socioeconomic cycling measured in the Circularity Metric is only one component of circularity. The Metric does not *explicitly* consider other strategies (slow, narrow and regenerate) that are core to building a circular economy, such as asset sharing, reuse, lifetime extension or remanufacturing. By reducing the need for new products, they reduce the overall material footprint and waste that is available for cycling. So, what is a benefit for the circular economy, may not always show up as such in the Metric.
- **Lack of consistency in data quality.** Whilst data on material extraction and use are relatively robust, data on the end-of-use stage—landfill, incineration or composting, for example—are weaker. Although Quebec's was above average, challenges nonetheless remain in quantifying national and provincial material flows and stocks. The weakness of the data is in part due to the complexity of waste: it's heterogeneous, geographically spread out, categorised differently across statistical sources and sometimes not measured at all. Difficulties also occur in calculating how waste materials are reused—precluding an accurate analysis of for which goods virgin materials are replaced by cycled waste.
- **Quality loss and material degradation.** The Metric focuses on materials that re-enter the economic system once cycled, but does not consider in what composition, or to what level of quality. In this way, a plastic HDPE bottle may re-enter the economy as a recycled material. Its quality will determine whether it is used for building park benches or other products, for example. This variance would not be documented in the Metric but has strong implications regarding material degradation.
- **Relative compared to absolute numbers.** The Circularity Metric offers a percentage of the total circularity performance by considering the relative, or percentage-based, amount of cycled materials as a share of the total material input. This means that as long as the amount of cycled materials increases relative to the extraction of new materials, we see the statistic improving, even though more virgin resources are being extracted. This would show progress, despite a key objective of the circular economy not being met. To extrapolate the Metric and avoid these uncertainties, it must be accompanied by contextual numbers for the full story.

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

3

SIZING QUEBEC'S GAP

The resource reality of meeting societal needs and wants

Photo by Steven Wright

Quebec is 3.5% circular. This section investigates the province's resource metabolism: how they are used, at what proportions, and to serve which societal needs and wants, such as Nutrition and Manufactured Goods. It also assesses how raw materials are processed and assembled to become the products that address local needs. Visualising what happens at end-of-use sheds light on the accumulation of materials in products, goods and the environment around us. Furthermore, it reveals that Quebec is a highly-consuming province, with resource-intensive activities in the mining, agriculture and forestry sectors. These observations provide a clear starting point, so we can better understand where sectors and supply chains should focus their strategies as they move toward a circular economy.

GLOBAL CIRCULARITY: FROM BAD TO WORSE

Circle Economy's 2020 edition of the global Circularity Gap Report revealed that circularity has wilted—the global rate of circularity shrank from 9.1% to 8.6% in just one year. What's more, 2020 saw more than 100 billion tonnes of materials entering the world's economy for the first time in history, bringing global resource use to new heights. Our 2021 report combined the twin agendas of the circular economy and climate change, ultimately bringing a message of hope: while consumption is spinning out of control and circularity is in reverse, a circular roadmap has the power to close the Emissions Gap by 2032. This would set us on a path to limit warming to well-below 2-degrees—and, crucially, meet the targets set out in the Paris Agreement.

Our analysis also highlighted the key role of countries in the race to leave linear behind: all nations have a role to play and a different road to take. Based on our 2020 report, which introduced three broad country profiles (see the textbox for more information)—Build, Grow, Shift—it's clear that Quebec falls into the Shift profile. It enjoys a high score on the United Nations' Human Development Index, but has a large ecological footprint: if everyone on our planet were to live like the Quebecois, we would require a volume of resources that would take three and a half Earths to provide.[24] Our analysis finds that Quebec's material extraction and domestic consumption both exceed that of the Netherlands (found to be 24.5% circular)[25] and is instead more on par with the extraction and consumption patterns of Norway (found to be 2.4% circular).[26]

The pressure on Shift countries—and Quebec—is to move away from over-consumption of the planet's resources in servicing their relatively affluent and comfortable lifestyles. Their role in terms of global circularity is also prominent—the true impact of Shift countries extends far beyond their national borders, with much of the environmental and social costs incurred elsewhere.

DIFFERENT COUNTRIES, COMMON NEEDS

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

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

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

Shift—Home to a minority of the global population, material consumption in Shift countries is ten times greater than in Build. Their extraction of fossil fuels is relatively high, as is their participation in global trade. So despite high HDI scores that result in comfortable lifestyles, these countries have a way to go in consuming resources in line with what the planet can provide. Country examples: US, Germany, Japan.

SEVEN SOCIETAL NEEDS & WANTS

Here we describe the seven key societal needs and wants and which products and services they include, as well as the volume of materials it takes to fulfil them from Quebec's material footprint of 271.1 million tonnes. Since various products can be allocated differently, here we make our choices explicit. For example, 'radio, television and communication equipment' can be classified either as part of Communication, or as Manufactured Goods. We decided to subsume it under 'Communication'.

HOUSING

The biggest category in terms of resource use is Housing. The construction and maintenance of houses and infrastructure accounts for **88 million tonnes (34%)** of the province's material footprint.

NUTRITION

Agricultural products such as crops and livestock require **42.5 million tonnes (16%)** per year. Food products have short life cycles in our economy, being consumed quickly after production.

MOBILITY

A considerable resource footprint is taken up by the need for mobility; **36.6 million tonnes (14%)**. In particular, two resource types are used: the materials used to build transport technologies and vehicles like cars, trains and airplanes; plus, predominantly, the fossil fuels used to power them.

MANUFACTURED GOODS

Consumables are a diverse and complex group of products—such as refrigerators, clothing, cleaning agents, personal-care products and paints—that generally have short to medium lifetimes in society. Textiles including clothing also consume many different kinds of resources such as cotton, synthetic materials like polyester, dye pigments, and chemicals. They account for **34.7 million tonnes (13%)** worth of resources.

SERVICES

The delivery of services to society ranges from education and public services, to commercial services like banking and insurance. The related material footprint is the third largest, **43 million tonnes (16%)** in total, and typically involves the use of professional equipment, office furniture, computers and other infrastructure.

HEALTHCARE

With an expanding, aging 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 **7.7 million tonnes (3%)** in Quebec.

COMMUNICATION

Communication is becoming an evermore important aspect of today's society, provided by a mix of equipment and technology ranging from personal mobile devices to data centres. Increased connectivity is also an enabler of the circular economy, where digitisation can make physical products obsolete, or enable far better use of existing assets, including consumables, building stock or infrastructure. Resource use in this group is less intense, standing at **9.4 million tonnes (4%)**.

THE MATERIAL FOOTPRINT SATISFYING SOCIETAL NEEDS IN QUEBEC

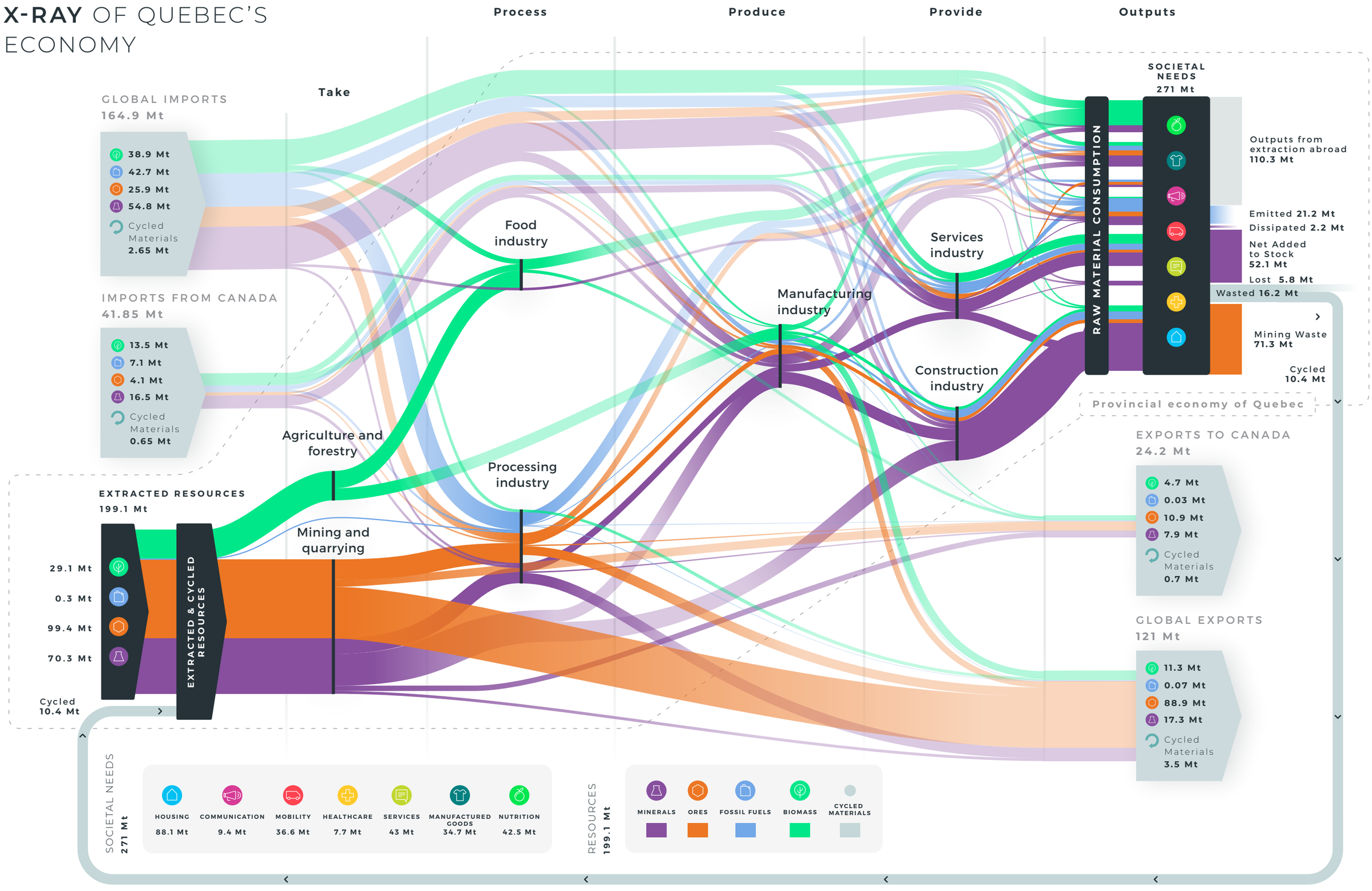
The figure on the next page builds on the schematic material footprint diagram in Figure One on page 14. It dives into the material metabolism of Quebec; linking how four resource groups (minerals, metal ores, fossil fuels and biomass) satisfy the seven key societal needs and wants shown on the previous page. From left to right, the figure shows the domestic extraction of resources (**Take**) which amounts to **199.1 million tonnes**, through the mining of minerals or the production of crops in agriculture 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 into the economy, that include also direct imported products, **66.3 million tonnes** (not shown in the figure) as well as imports of secondary materials, **3.3 million tonnes**.

When considering not just the direct imports, but also the Raw Material Equivalents (RMEs), as previously introduced on page 18, we see that Quebec's RME of imports amount to **203.3 million tonnes** (this would be 206.6 million tonnes if imported secondary materials were accounted for): 41.2 million tonnes from Canada and 162.1 million tonnes from the rest of the world, coming to a total raw material input of **402.4 million tonnes**. The raw 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 busses 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, Quebec exported some **64.3 million tonnes** of final products with an associated RME of **141.2 million tonnes**. According to our estimates, a total of **4.2 million tonnes** of secondary materials were exported in the same year, which leads to a total volume of approximately **271 million tonnes** of materials consumed by Quebecers, of which **9.4 million tonnes** were either secondary materials (amounting to **7.3 million tonnes**), or reused, downcycled waste.

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 **271.1 million tonnes** of material consumption: Quebec's consumption footprint. In Quebec, the total amount of waste generated amounted to **16.2 million tonnes**, of which an estimated **7.6 million tonnes** came from Products that Last and **8.6 million tonnes** from Products that Flow (see more information on page 37). The high contribution of Products that Flow consists of sludges that come from industrial and municipal activities.

Of the total **16.2 million tonnes** of waste being treated, **10.4 million tonnes** (64.2%), are either materially or energetically recovered or directly reused, whereas the other **5.8 million tonnes** are lost indefinitely. Of the latter, **5.3 million tonnes** end up landfilled while the other **0.5 million tonnes** is either incinerated or treated in unspecified ways. Remarkably, about 65% of the eliminated waste[27] is made of wet organic waste. Next to this, aside from materials going to waste, **52.1 million tonnes** are added to reserves and stock (Net Stock Additions) in the form of capital investments such as buildings and infrastructure, machinery and equipment. Another **19.9 million tonnes** are released into the environment as elemental carbon mostly of fossil origin (this corresponds to 90.7 million tonnes of CO_2e). The remaining **1.2 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. Finally, an estimated **110.3 million tonnes** are made of all resources extracted in other countries for the production of Quebec's imports, which end up either embodied in stocks wasted, emitted or dispersed in the production process abroad.

X-RAY OF QUEBEC'S ECONOMY



HIGH CONSUMPTION ACROSS NEEDS AND WANTS

Quebec's Circularity Metric is well below the global average of 8.6% at 3.5%—this is largely due to the relatively high levels of consumption of the residents. Annually, **271.1 million tonnes** of virgin and secondary materials are consumed, which amounts to **32 tonnes per capita**. Quebec's per capita material footprint, based on consumption, also ranks sixth for the countries analysed[28]—one place before the rest of Canada, partly owing to its urbanised nature.

Quebec's high material footprint is linked to its position as a dominant trader to the US and the rest of Canada, exporting billions of Canadian dollars worth of aluminium, aluminium alloys, iron ores and concentrates and renewable electricity. 8% of the province's output relates to interprovincial trade—four times the rest of Canada, making Quebec a net exporter within the country. Imports—primarily aviation equipment, electricity, petroleum, and natural gas[29]—also flow into Quebec's economy, mainly from the US with a significant portion sourced from China. In the last five years, oil supplies in the US and Canada have increased—accounting for a nearly even split in Quebec's imports.[30] The province's large import footprint is a key determinant of the province's high consumption impact and thus of a low Circularity Metric. Large volumes of resources (about **110.3 million tonnes**) are extracted abroad to satisfy Quebec citizens demands: part of these resources become embodied in stocks and part of them are released as waste and emissions in the producing country. The challenge for industrialised and high-income countries and provinces, like Quebec, is to lower this as much as possible, while steering the sustainable management of waste abroad resulting from the demand of their citizens. They can do this by, for instance, favouring imports of secondary over primary materials. This is characteristic of most Shift countries (see page 21), where the low Metric is also the result of raw material consumption topping domestic material consumption: in other words, Quebec is a net importer of resources and thus an exporter of impacts.[31]

Our analysis indicates that an increase in Quebec's already-high rate of recovery from 64% to a utopian 100% would only boost its circularity to 6%—still below the global average. Increased cycling contributes little if consumption (reflected in the material footprint) continues to grow: for Quebec's Circularity Metric to meet the global figure of 8.6%, its material footprint would have to **shrink by 60%**, assuming levels of cycling and thus secondary materials input remain constant. In another hypothetical scenario where material recovery increases to a more reasonable 85%, a material footprint reduction of almost one-half would still be needed to bring Quebec's circularity in line with the global rate.

MINING FOR RAW MATERIALS

Along with Ontario, Quebec sits at the forefront of Canada's mining industry as the province with the most diversified extraction—and ranks sixth globally for investment attraction in the sector.[32] Not only does the province boast a wealth of metals—gold, iron, nickel, titanium, niobium, copper and zinc—it is a world-leading[33] producer of the rarer minerals niobium, titanium dioxide, cobalt and platinum. While one-fifth of Canada's raw material extraction occurs in Quebec, for some metal categories it accounts for more than half the country's total extraction in both weight and value.[34]

The high rate of extraction results in Quebec, with a population of approximately 8.5 million, having a rate of resource extraction that tops **24 tonnes per capita**—coming sixth place globally.[35] For metal ores, the province shoots to second place, only trailing behind Australia with an extraction rate of **12 tonnes per capita**. Extraction rates seem unlikely to slow down: the provincial government's *Strategic Vision for Mining Development in Québec 2016–2021*, for example, aimed to mobilise stakeholders wishing to advance the interests of the industry, and encourages further exploration and development.[36] The *Québec Plan for the Development of Critical and Strategic Minerals 2020-2025* sets the goal of Quebec becoming a leader in the production—and recycling—of critical and strategic minerals, framing such a development as a major contributor to a green economy.[37] [38]

Quebec comes second to another Canadian province—Ontario—for both imports and exports; mineral trade has grown consistently in recent years, with Quebec accounting for 15.7% of the country's total imports and 23.3% of the exports, based on value.[39] Its substantial contribution to the mineral trade industry both domestically and abroad serves the economy's linear take-make-waste model of consumption, as its abundance of metal ores and minerals are funneled into meeting key societal needs.

THRIVING BIOMASS: FORESTS AND FARMLAND

While Quebec's overall volumes of waste and cycling are quite low, especially in comparison to the Netherlands, biomass features heavily in the waste breakdown. Quebec is famed for being a 'land of forests', with more than half its total area home to one of the largest woodland areas in the world.[40] The pulp and paper, forest products and agriculture and food industries are all key players in the province's economy—resulting in an unusual waste composition dominated by biomass (**51%**). While some biomass waste is recycled—just over 1 million tonnes from industry and slightly under half a million tonnes from municipal sources—the lion's share is landfilled (approximately 3.5 million tonnes from all sources).

Our analysis also finds that a significant portion—close to 1.5 million tonnes—is used for energy production; and indeed, the provincial government has poured millions of Canadian dollars into furthering this, funding a forestry-waste-to-biofuel plant in late 2020.[41] While energy recovery can be a useful application for forest or food waste, it is regarded as downcycling and ranks only above disposal on the waste hierarchy;[42] as such, some theorists don't believe waste-to-energy can play a role within the context of a circular economy.[43] There are higher value applications for these materials, such as in construction materials that can store carbon.

Significant opportunities emerge to bolster Quebec's circularity through the diversion of wet organic waste, including organic sludges from landfilling—which represents over one-third of the province's total waste disposal—and energy recovery, almost entirely from biomass, which represents 9%. Read more on our suggestions in Chapter Four.

4

BRID-GING THE GAP

'What if' scenarios for circularity

Photo by Sven Huls

Now that we have presented how the Metric is derived and investigated what it says about the inner workings of the Quebecois economy, it's time to analyse the findings and suggest a circular roadmap. First, we identify some of the most impactful sectors of the economy, which we assess based on either a Mass, Value or Carbon level; as well as their potential to reduce the material footprint. Then, for the sectors with the most potential for circularity, we formulate scenarios that are purposefully constructed to explore and entertain the 'what-if'; free from the constraints of feasibility from a political, social or behavioural (change) standpoint. This approach allows us to explore potential paths forward and better understand which type of sectors and interventions could be most impactful in terms of steering the Circularity Metric and material footprint of Quebec.

SCORING SECTORS ON THE MASS-VALUE-CARBON NEXUS

We have funnelled our focus for the 'what-if' scenarios into six areas which represent key leverage points in the economy. These scenarios are (1) Design circularity into stocks, (2) Prioritise conscious consumables, (3) Strive for circular agriculture, (4) Leverage government procurement, (5) Make manufacturing circular and (6) Make mobility clean. By focusing on a few key areas, 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 Quebec.

Our typical approach to scenario selection relies on a mix of qualitative and quantitative information. First, a group of relevant stakeholders is consulted to gain a qualitative on-the-ground understanding of key sectors of the economy. Secondly, the information garnered from local experts is compared to the results of a quantitative analysis, which inspects the interaction between material consumption (Mass), value creation (Value) and greenhouse gas (GHG) emissions (Carbon), of sectors: the Mass[44]-Value[45]-Carbon[46] (MCV) Nexus. The MVC nexus is a useful tool to pinpoint key levers in the economy where we can make significant change through the introduction of circular strategies.

SUMMARIZING THE MASS-VALUE-CARBON NEXUS

The Nexus clearly shows the dominant Value of services (healthcare, education and recreation, as well as other services) in the Quebecois economy. This supports the focus of scenario four to leverage government procurement toward circular business models and practices across products, services and sectors. Meanwhile, agrifood, manufacturing and construction lead the way in terms of Mass. Indeed, our scenarios (one, three and five) which crossover with these sectors are hugely impactful in reducing the material footprint of the overall economy. In terms of Carbon, agrifood, manufacturing and transport are most impactful; and although we do not measure this impact quantitatively, this also mirrors the impact of our correlating scenarios (three, five and six) on the economy.

To make comparisons between sectors we need comparable, consumption-based data for Mass, Value and Carbon. However, in the case of Quebec, consumption-based GHG emissions for sectors were unavailable at the time of this research—so we instead used production-based emissions data. While this data is still useful to understand the volume of carbon emissions generated across the key sectors, it—unlike consumption-based emissions—does not allow us to re-allocate direct emissions from industries (production-based accounting) based on consumption patterns (consumption-based accounting). Therefore, we cannot directly compare Mass, Value and Carbon against each other in this study.

Due to these data limitations, the selection of the scenarios was based on the expert input of stakeholders and qualitative research. They were then supported by quantitative information on solely material consumption and value generation. In calculating the total impact of the scenarios on the Quebec economy, we can only measure the improvement to the Circularity Metric from a Mass-perspective. However, under each scenario, we report co-benefits of the circular strategies beyond only a reduction in the material footprint.

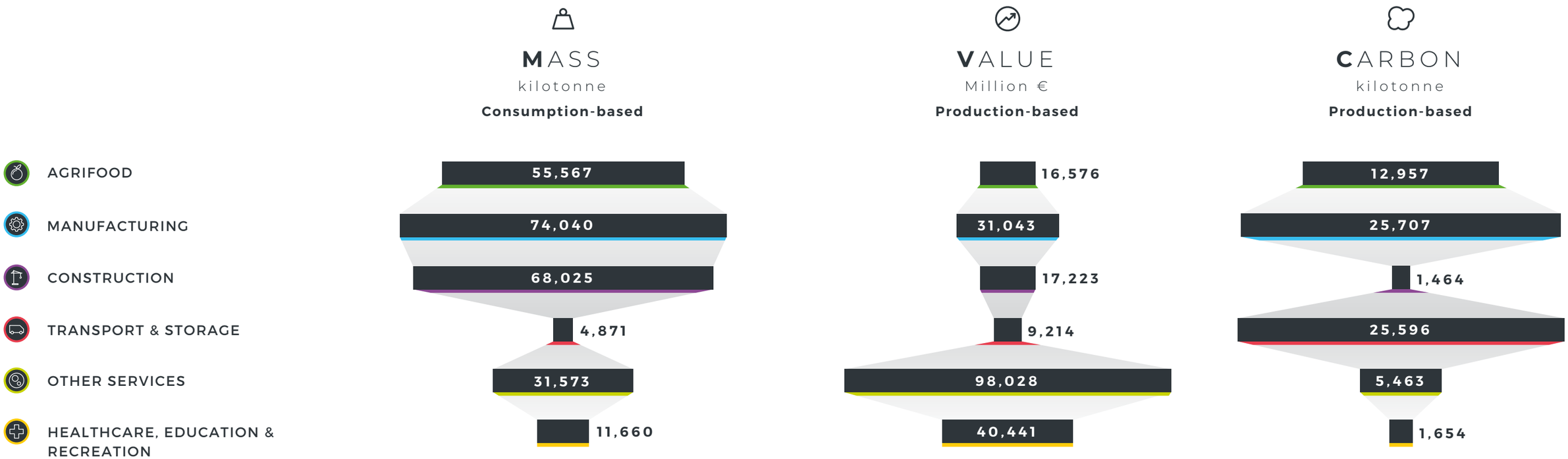


Figure Four shows the impact of specific sectors on the economy in terms of Mass, Value and Carbon. Note that Transport & Storage includes personal mobility.

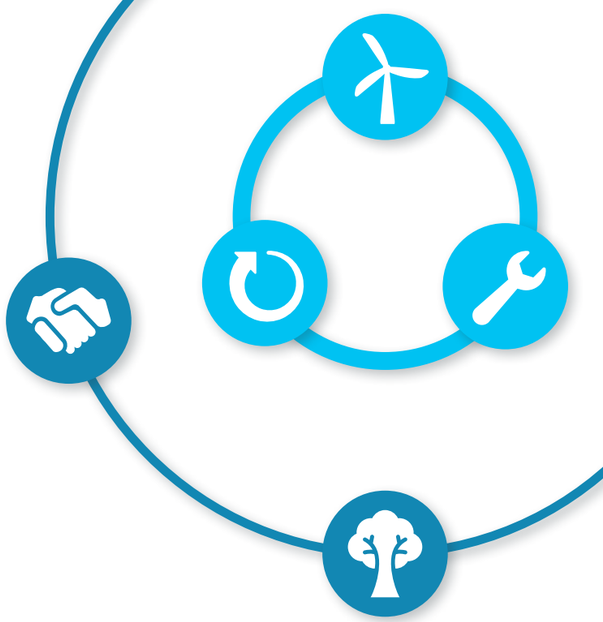
‘WHAT IF’ SCENARIOS

Our six scenarios are deliberately not time-specific, nor have we explored in detail the specific actors or policies necessary for their real-life materialisation. They rather serve as the ambitious exploration of a potential path forward and sketch which type of interventions and levers are most impactful in terms of steering the Circularity Metric, as well as reducing the amount of resources used to fulfill societal needs and wants: the material footprint.

To manipulate different parts of the economy to explore how this impacts the Circularity Metric and material footprint, we apply scenarios that **narrow** the material footprint behind a certain functional need. This can be through material efficiency gains in design and processes, or changes in the delivery of a functional value through a sharing business model or digitalisation. Also, we model scenarios in which additional **cycling** occurs. To strengthen the circularity of biomass and reduce the footprint of non-renewable resources, we model the impact of **regenerating** material flows. This means modelling regenerative sourcing and handling of biomass and replacing fossil fuels with regenerative alternatives. Lastly, we model interventions that slow the consumption of goods and extend their lifetimes, in turn reducing the need for new products and the materials used to produce them.

For the development of the scenarios, we use the Key Elements framework (see next page), to consider the many strategies needed to drive the systemic change required for our sketched scenarios to materialise. The elements feed into the ultimate aims of slowing, narrowing, cycling and regenerating flows (see page 15) to allow us to reach the goals of the circular economy.

THE **KEY ELEMENTS FRAMEWORK**



The circular economy assumes dynamic systems, meaning there is no specific end-point, but it is rather a process of transformation. The eight key elements that give direction to this transformative process, with the aim of slowing the flow of resources, closing the loop and narrowing resource flows, while switching to regenerative resources and clean energy.
The eight key elements describe the full breadth of relevant circular strategies and will be used throughout the report.

Prioritise regenerative resources Renewable, reusable and non-toxic resources in water, material and energy cycles replace non-regenerative resources, with corresponding processes to support regeneration.

Stretch the lifetime Resources and products are maintained, repaired and upgraded to maximise their lifetime and usage intensity.

Use waste as a resource Where waste creation is not avoidable, recover it for recycling, using waste streams as a source of secondary resources.

Design for the future Design systems to facilitate regeneration, restoration, repair, reuse, or disassembly, or utilising waste as a resource.

Rethink the business model Shift incentives and adjust business models to price the entire life-cycle of products and capitalise on cooperation and long-term relationships.

Incorporate digital technology Employ digital technologies to facilitate connecting actors and keeping track of resources.

Team up to create joint value Work together with actors to implement circular economy strategies on the systems level.

Strenghten and advance knowledge Develop research, structure knowledge, encourage innovation networks and disseminate findings with integrity.

RELEVANCE OF CIRCULAR STRATEGIES
ACROSS SCENARIOS

HIGHLY RELEVANT

MODERATELY RELEVANT

LESS RELEVANT

Figure Five depicts the six scenarios we consider to be key change agents in Quebec's circularity and identifies which platforms of our Key elements framework holds the most potential.

P **Prioritise** regenerative resources

S **Stretch** the lifetime

U **Use** waste as a resource

D **Design** for the future

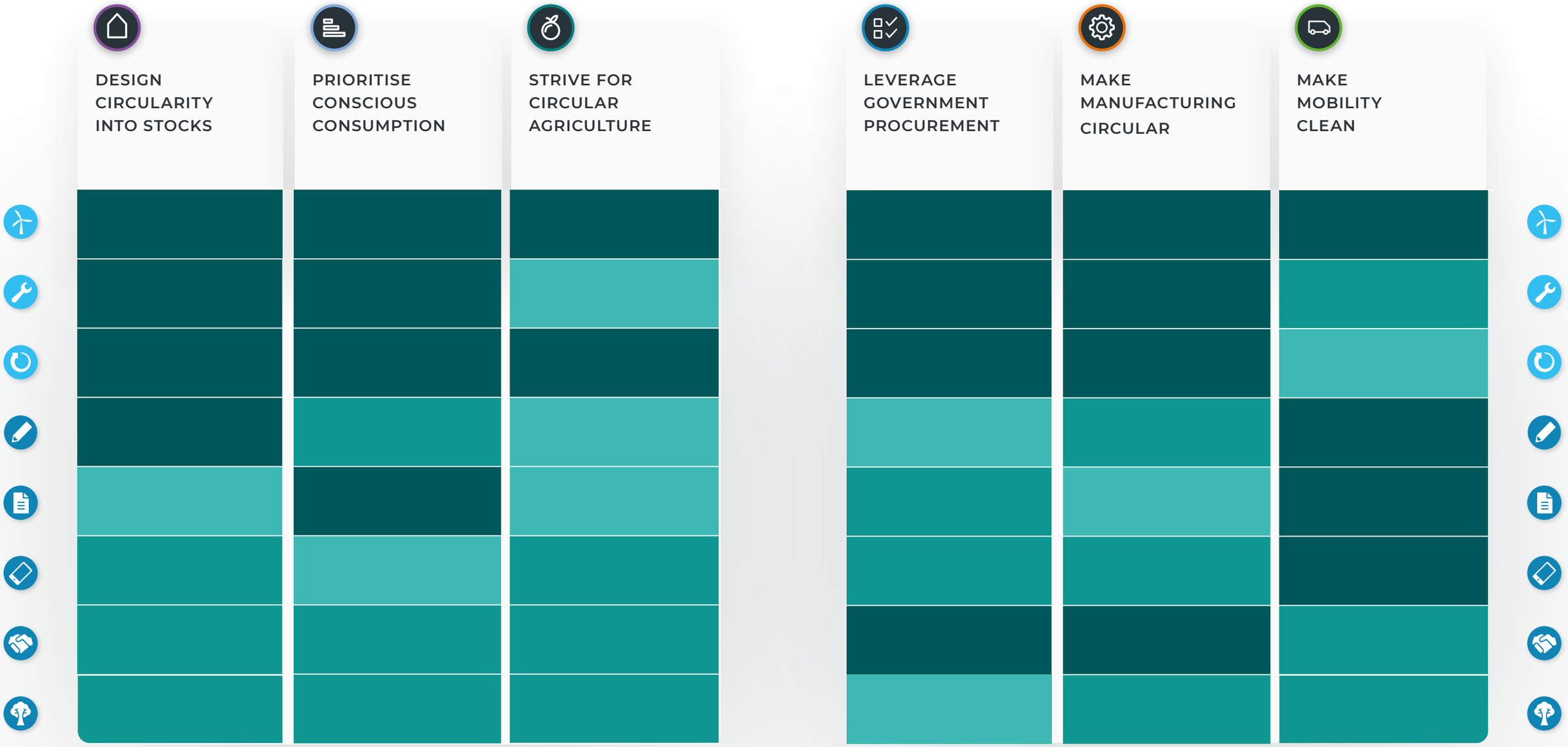
R **Rethink** the business model

I **Incorporate** digital technology

T **Team up** to create joint value

S **Strengthen and advance** knowledge

● Core ● Enabling



1. DESIGN CIRCULARITY INTO STOCKS

Economically, the construction sector (along with real estate management and services) represents close to one-fifth of the province's gross value added,[47] and 18% of GDP (including rental and leasing services)—almost triple the national figure of 7%.[48] Providing housing to its population is the leading societal need in Quebec, standing at 34% of its material footprint—and consequently, this generates large volumes of waste (accounting for about 27% of all waste in the province). Nonmetallic minerals—which are largely mined—are hugely represented in housing and construction, and also wasted: moderate levels go into daily cover (landfill) while some goes to landfill or is incinerated. The Housing sector shows a relatively low volume of carbon emissions, but keep in mind that this is a production-based figure (i.e. showing the direct emissions of activities in the construction sector in Quebec). We know that the carbon footprint of Housing globally, including commercial and industrial buildings, is one of the largest in the world, generating about 13 billion tonnes of GHG emissions per year. Overall this represents the sector's solid potential for impact if this waste were to be avoided or reused.

The circular transition is already visible in Quebec's construction sector: renovation, for example, is a key component of the industry. Over the last few decades, more has been spent on renovation than new housing acquisition[49] and innovation in less resource-intensive construction is in continuous development. Quebec's policy environment also supports action in this area: its *Climate Change Action Plan* showcases the province's effort to make construction green, with Measure 19.4.3 on low-carbon-footprint materials spurring projects comparing the environmental impact of wood and concrete buildings, recycling of wood products, and energy efficiency and material choice in the building sector.[50]

In our 'what-if' circular housing scenario, we outline opportunities for Quebec to boost its circularity while decreasing the construction sector's mammoth material use.

1.1 USE LESS, CYCLE MORE

Circular housing strategies should ultimately reduce the need for new material inputs, through strategies that **narrow** flows and **cycle** materials.

A reduction in living space—reduced overall floorspace of residential housing—for example, would both slash the sector's material footprint with the added benefit of creating additional space in cities. The same strategy can be extended to commercial real estate—and the possibility of doing so is increasing as working from home may remain popular post-pandemic, for those with the means and desire to do so. However, the impact of Covid-19 has also seen a rise in Quebecers purchasing second homes in the countryside, spurred by lower housing costs—so as of yet, floorspace per capita is increasing.[51]

This intervention also sees raw material extraction grind to a halt, as increased cycling leads to **using waste as a resource**. All waste materials from construction and demolition will be cycled into new projects—and the number of new projects should fall as increased renovation and maintenance serve to **preserve and extend what's already made**. Huge opportunities exist in this realm: in Canada, 3.4 million tonnes of construction materials are sent to landfill on a yearly basis, comprising approximately 1.8 million tonnes of embodied CO_2e. If the construction sector were to prioritise disassembly over demolition—reusing up to 85% of materials—emissions could be axed by as much as 1.3 million tonnes CO_2e per year and waste volumes cut by 2.5 million tonnes.[52]

In modelling the potential impact of these interventions, we make a number of 'what if' assumptions. In reflecting the reduction of floor space, the increased use of construction and demolition waste and a corresponding rise of renovation and maintenance activities, we model what would happen if virgin resource use for residential and non-residential stock expansion could be reduced by 100%; meaning that all new construction can be sustained solely by cycled materials from demolition.

1.2 CHAMPION NATURAL AND LIGHTWEIGHT MATERIALS

Wherever possible, material- and emissions-intensive materials, like cement, should be swapped out for **regenerative** alternatives, like timber—especially as this material is in plentiful supply due to the regenerative capacity of Quebec's vast forests. Timber does feature in buildings across the province: Quebec has also risen to the fore as a world leader in mass timber construction, specialising in the manufacturing of glulam beam and cross-laminated timber.[53] Using timber in construction can massively drive down carbon emissions and allow buildings to become carbon sinks.[54]

Material substitution with laminated timber and engineered wood products will also help to **narrow** flows, by reducing the direct weight and material footprint of buildings; frugal design that takes context and functionality into account—and avoids overdesigning—will be crucial in reducing construction's impact.

Inspired by the work of Moran et al. (2020),[55] we model the potential impact of replacing 15% of steel, cement, aluminium and other fabricated metals with lower-impact materials like timber. We also integrated the estimates of reviews by Donati et al. (2020)[56] and Hertwich et al. (2019),[57] which suggests that lightweight design could reduce the weight of load bearing elements in buildings by a further 40%.

1.3 USE LESS RESIDENTIAL ENERGY

Our final intervention entails a mix of strategies that address residential energy use. Passive house design could **narrow** flows by decreasing energy consumption, owing to improved insulation (made from materials which are ideally secondary and reusable) and building materials. Secondly, local renewable energy production could serve to **prioritise regenerative resources** that would decrease housing's emissions intensity. Hot water savings, lower room temperatures, smart metering, green roofs, combined systems of passive solar heat with heat pumps and the use of energy efficient appliances would all further contribute to slashing housing's impact: more output, with fewer materials and emissions.

Our modelling went on to create a collective 'what-if' scenario including inputs from a range of studies including, among others, Ivanova et al. (2020),[58] Vita et al. (2019)[59] and Moran et al. (2020).[60] These explore the effects of various interventions that can be applied to different industry inputs and outputs, ultimately driving down energy consumption.

Impact on Quebec's circularity: With the proposed circular interventions for housing, Quebec could cut its material footprint by a massive 11% and increase its Circularity Metric by 25.7%, from 3.5% to 4.4%. Beyond materials, the proposed interventions also bear immense potential for reducing greenhouse gas (GHG) emissions arising from a reduction in the use of materials and space as well as energy generation. Most prominently, this reduction stems from emissions directly related to land-use change, as well as lesser use of emissions-intensive materials such as cement and steel and reduced combustion of fossil energy carriers. Our *Circularity Gap Report 2021*[61] found that similar interventions on a global level in Shift countries could cut emissions by 4.2 billion tonnes, which clearly portrays the massive emissions-reduction potential for Quebec; a typical Shift economy. Other co-benefits include increased availability of space for community use or renaturation—bringing both environmental and social benefits.

2. PRIORITISE CONSCIOUS CONSUMABLES

The 'consumables' sector encompasses a range of goods, from Products that Flow—consumer goods that filter quickly through the economy such as food items or single-use plastics—to more durable Products that Last—ranging from electronics to textiles to technical equipment. Quebec fits the Shift country profile (see page 21) and consumption levels are generally high—and linked to large volumes of waste generated offshore as a consequence of imported products: 203.3 million tonnes of Raw Material Equivalents. However, within the province, goods that reach end-of-life and are discarded, both at an industrial and municipal level, pose a problem for Quebec's circularity—with waste totaling 8.6 million tonnes for Products that Flow and 7.6 million tonnes for Products that Last.

Recycling is crucial in this domain, yet Quebec's sorting facilities have suffered their share of issues, such as the overflowing of Montreal's facilities in 2018 following China's ban on imported waste.[62] Experts, such as the Coalition of Ecological Waste Management's Executive Director Karel Ménard, have called for Quebec to 'rethink its curbside collection'[63] and make significant shifts in modes of production and consumption—and Quebec's provincial government is doing just this, with plans to modernise its deposit-return and curbside collection systems with an extended producer responsibility approach.[64]

To this end, Quebec—and Canada as a whole—are taking some steps to combat the overuse of one of our economy's fastest-moving goods: single-use plastics. A range of Quebec businesses have made moves to

phase out plastic straws and disposable produce bags in stores across the province, and as of 2020 have banned the provision of single-use plastic bags in Montreal.[65] Yet the need for coherent, province-wide policy, applied beyond plastic goods and informed by circular strategies is clear.

In our 'what-if' conscious consumable scenario, we outline opportunities for Quebec to boost its circularity by increasing the share of bio-based and regenerative materials, boosting recycling and encouraging shifts in consumer behaviour.

2.1 SHIFT TO BIO-BASED CONSUMABLES

Our first intervention targets plastic items, going beyond the legislation already planned in Canada, as well as textiles. Flows can be **narrowed** by banning single-use items, instead replacing them with more sustainable, preferably bio-based materials, which **regenerates** flows. If renewable energy sources are used throughout the production processes of bio-based alternatives, they are more circular from a Life Cycle Analysis (LCA) perspective. This intervention involves reducing the number of plastic items consumed—from bottles to bags to cutlery—and rethinking the materials we use to make our clothes. Taking an approach to textiles that favours cellulosic and sustainably harvested bio-based fibres instead of fur, leather, and synthetic (petroleum-based) materials that carry a high material and carbon footprint further **prioritises regenerative resources** and bolsters circularity by taking resource-intensive materials out of the mix.

Our scenario models the impact on a variety of associated industries, following the work of Wood et al. (2018).[66] Our model assumes plastic use is curbed by a further 10% and a nearly complete (80%) switch to bio-based chemicals in household products.

2.2 REWIRE CURRENT MODES OF CONSUMPTION

Our second intervention involves shifting the choices of consumers and mainstreaming circularity. Efforts should be made to **design for the future** and **preserve and extend what's already made**, by making and purchasing items meant to last and keeping them in use for longer. The life cycles of consumer goods can be extended through strategies that **rethink the business model**: minimum warranties and resale business models should be bolstered in tandem with strengthening the market for second-hand goods, as well as repair and remanufacturing activities. Consumption of fast fashion should drop significantly; consumers must instead seek to extend the lifetime of their purchases—and thus **slow** flows—through resale, repair and second-hand shopping. Infrastructure should be improved to allow for better textile **cycling** at end-of-life.

Our model explored a range of interventions—including a reduction in the material footprint of garments, furniture, electronics and other consumer goods stemming from the consistent uptake of repair, high quality design for durability and sharing models. The specific assumptions vary between products and industry groups; but reductions in material footprint range from 10% (for technical equipment) to 30% (in the case of textiles and fashion). These assumptions are explored in further detail in the methodology document on our website.

2.3 RAMP UP RECYCLING

Under our final intervention, recycling of industrial and municipal waste—post-consumer paper and glass, plastics, textiles, mixed metals, and electric and electronic waste—is ramped up to 100%. All of the materials mentioned that are currently landfilled or incinerated should rather be **cycled**. In order for this to be achieved, however, further insight into the current obstacles facing the recycling sector, such as insufficient infrastructure, overwhelming quantities of waste and bans on waste imports elsewhere, is needed.

This scenario was modelled assuming increased use of recycled fabrics in fashion and recycled fibers in paper.

Impact on Quebec's circularity: With the proposed circular interventions for consumables, Quebec could slash its material footprint by 4.4% and increase its Circularity Metric by 20%, from 3.5% to 4.2%. A shift towards more conscious consumer goods and amendments in consumption behaviour not only reduce the material footprint and increase circularity: the uptake of bio-based materials, elimination of single-use plastics and strengthening of material cycling are essential in addressing the plastic pollution that is affecting our oceans and ecosystems on land. Similarly, the discharge of chemical pollutants and exorbitant water consumption arising from the production of plastics or textiles can be curbed by strong reductions in production—generated by a more circular approach to consumption and increased cycling.

FROM CONSTRUCTION TO CONSUMABLES: A NORTH AMERICAN LEADER IN DESIGN

Quebec has risen to the forefront of the North American timber construction industry, specialising in glulam and CLT manufacturing. Quebecois companies such as Nordic Structures and Art Massif are attracting attention for **prioritising regenerative resources** in new architectural technologies. The latter is developing a project using glulam beam for an innovative new academic building—crediting Quebec's favourable legislation for timber construction for their success and leadership in the field.[67] And timber isn't the only focus: organisations like Québec BVI, Quebox and the Unité mixte de recherche en sciences urbaines (Joint urban sciences research unit) network have all worked to develop, pilot and promote sustainable development in Quebec's built environment.[68] Such innovation is visible in a number of buildings that make use of local, recycled materials: the library of Boisé, for example, and the Montreal planetarium, both of which have achieved the prestigious LEED platinum certification for outstanding environmental design.

Some Quebec initiatives are also taking charge of the way society engages with goods, challenging models of ownership by providing innovative alternatives. La Remise, launched in 2015 in Montreal and managed entirely by volunteers, is the province's first tool sharing 'library'. The organisation provides its 2,000 members with access to a range of tools: from carpentry and construction, to bicycle and vehicle mechanics, to those for kitchens and gardens. Members also have the chance to partake in workshops and technical training sessions carried out by specialists for anything from furniture making or sewing to electronic repairs, all activities intended to reduce the consumption of new goods and **preserve and extend what's already made**. The initiative has enjoyed success in the last years—especially among young adults that lack the space to store their own tools—and has inspired similar undertakings across the province.[69]

Photo par Alice Triquet

3. STRIVE FOR CIRCULAR AGRICULTURE

Quebec's agricultural sector runs strong, with a deep history that has informed its landscape, rural culture and economic development. Livestock raising is the main focus, yet it also produces almost three-quarters of the world's maple syrup and exports more than 69% of its agrifood products to the US.[70] Despite these figures, agricultural land makes up only 2% of Quebec's total area; this figure is modest in comparison to France (58% farmland) and the US (45% farmland). But in facilitating this large share of the economy, measures to increase production have allowed industrial agriculture—which utilises monocultures and chemical inputs such as fertilisers—and its consequential environmental degradation to become commonplace. The province also has high food waste rates from farm (agricultural production processes) to fork (the consumer's plates).

An important aspect of reducing the ecological footprint of the industry is in steering dietary habits. Local diets rely heavily on imports of processed foods, fruits, vegetables and grains[71] so that a range of non-seasonal produce can be enjoyed year-round. Studies have also noted that three-quarters of the province's population fall short of recommended fruit and vegetable intake and overshoot recommended sodium and saturated fat intake. This implies high consumption of foods that are inefficient in terms of converting calories to energy and can lead to overconsumption. Groups of lower socioeconomic status were also found to be at the highest risk of a low-quality diet.[72]

In late 2020, the Ministry of Agriculture unveiled a new sustainable agriculture plan, with targets to reduce toxic pesticide and fertiliser use, bolster soil health, optimise water management and revive biodiversity.[73] Innovations and policies aimed at reducing food losses and waste have also become increasingly prevalent: the Quebec Agrifood Innovation Centre, for example, has pioneered research on optimising meat packaging to prevent losses and extend shelf life,[74] while the Supermarket Recovery Program will see retailers across the province donating surplus produce to food banks.[75] The province has also repealed regulations that had banned the sale of fruits and vegetables not meeting strict aesthetic standards.[76]

Nonetheless, the concept of circular agriculture doesn't crop up in the province's current plans. In this scenario of circular agriculture, a rebalancing of livestock farming and crop cultivation, paired with behavioural shifts on the consumption side, can greatly impact the resource-intensity of the sector.

3.1 MAKE AGRICULTURAL PRODUCTION CIRCULAR

Circular agriculture strategies ultimately serve to **narrow** flows and **use waste as a resource**: agricultural and food waste can be used as livestock fodder, replacing the need for feed crops. Crop-based feed can take up land and often cause environmental damage—for example, in the form of land-use changes such as deforestation—in the countries who commonly export it internationally. In this system, crop trimmings and waste become food for animals, which then nourish the crops in turn with manure. In this way, **regenerative resources are prioritised**, as the need for harmful synthetic fertilisers is drastically reduced. This allows for a more diverse agricultural economy, greater resilience and diversity of products, and improved ecosystem services.

This intervention would necessitate a reduction in livestock numbers: with the current split between livestock and crop cultivation, the complete replacement of traditional feed with waste would not be possible.[77] So, in our modelling we hypothesise, what if we managed to replace all fodder crops with food waste and agricultural waste?

3.2 SHIFT TOWARD PLANT-BASED DIETS

The success of the intervention above depends on a decrease in livestock production, which entails a drop in animal protein consumption. In reducing animal protein consumption, flows would be **narrowed**. A decrease in livestock numbers would result in an improved balance between crop cultivation and livestock farming, and would encourage other environmental benefits: lower emissions, reduced freshwater use, improved land management and biodiversity. This intervention may be supported by Quebecois consumers, who are becoming increasingly sensitive to the composition and nutritional value of the food they eat, as well as food quality and safety.[78]

3.3 CONSUME LESS

Flows can also be **narrowed** through an overall reduction in consumption. This can be achieved at multiple levels: the elimination of supply chain waste, eating beyond caloric needs at the consumption stage and food waste in food service at the use stage. This ensures an equal, sufficient distribution of calories and necessary nutrients—like protein—across the population. In turn, the strain on natural resources, and therefore material footprint, will drop—along with land use and emissions. RECYC-QUÉBEC is part of a wider Canadian campaign, J'aime manger, pas gaspiller (Love Food, Hate Waste) which provides a variety of tips—from meal planning to keeping produce fresh for longer—that aims to address some of these issues of consumption and waste.[79]

In addition to the assumption of a plant-based diet, we also consider that caloric intake is capped at the average level, and acknowledge footprint reductions stemming from the lower footprint of organic (zero artificial fertilisers), local (50% reduction in transport of food) and seasonal (30% reduction in fuels and electricity) foods.

3.4 VALORISE ORGANIC WASTE

Organic waste is the largest unrecovered waste stream in the province: about two-thirds of the 5.8 million tonnes of eliminated waste consists of organic waste, including wet waste, municipal and industrial sludges and agricultural waste. Here lies a huge opportunity to **use waste as a resource** and **cycle** agricultural waste. While conversion of organic waste into animal feed is the most desirable scenario—as it retains most of the materials' original value—this cannot always be the case: sludges, municipal organic waste and some other agricultural wastes must have other applications, and ecologically safe disposal and nutrient and energy recovery must be ensured. This strategy assumes the reuse of organic waste through a variety of applications: crop waste, for example, can be transformed into eco-briquettes—compressed blocks of biomass that can be used for fuel in households—and sludge can be applied back to farmland. Energy recovery from waste can also be achieved through anaerobic digestion. **Impact on Quebec's circularity**: With the proposed circular interventions for nutrition, Quebec could slash its material footprint by a huge 12.3% and increase its Circularity Metric by 14.2%, from 3.5% to 4%. While this scenario brings impressive reductions in material footprint, even more significant environmental impacts could stem from a reduction in land use—freeing up land to become much-needed reserves for biodiversity. This land would also provide crucial ecosystem services, from carbon sequestration to water purification. These positive impacts, stemming from a shift in the foods Quebec consumes and produces, can be achieved both locally and abroad for regions that export to the province.

4. LEVERAGE GOVERNMENT PROCUREMENT

Although circular procurement is an emerging topic, the value of such an approach is not to be overlooked. In the Canadian context, public sector procurement is valued at approximately CA$200 billion per year in Canada—with 80% occurring at the local level,[80] representing a strong opportunity for the Quebec, as well as cities. Government spending across goods and services—from public administration to defence, education and healthcare—is a major material hotspot of Quebec's economy. Public procurement accounts for 10% of its material footprint—27 million tonnes. Therefore, guiding the circular transition by procuring circular models and services across a wide range of products, services and sectors has significant potential to pull the circular transition in Quebec forward.

It can be a progressive move for the government to work collaboratively with local industry players to transition to more circular models by procuring goods and services that contribute to a closed energy and materials chain. And here lies an opportunity for Quebec, which has a thriving base of motivated, grassroots organisations promoting the circular economy.

The Quebec government has taken measures to ingrain sustainable practices in public procurement: *The Sustainable Development Act*, for example, provides a legislative framework for government departments and agencies comprising 16 principles on responsible production and consumption.[81]

Further efforts to put the act into practice include the *Government Sustainable Development Strategy 2008–2013* and *Sustainable Development Strategy 2015–2020*, which give direction to organisations party to the Act. *Produire et consommer de façon responsable* (Produce and consume responsibly), one such direction, generates departmental and agency action to develop

green procurement policies, plans and practices;[82] while the *Politique administrative pour un gouvernement écoresponsable* (Administrative policy for an eco-responsible government) lays out specific requirements for various product categories, and areas of action including goods and services, information technology, buildings intended for public use and transportation for government employees.[83]

Even though this scenario of circular public procurement is applied across product ranges and, therefore, does not add new industry or sector transitions to the list, it represents a key means of driving demand for circular solutions and is therefore imperative to accelerating their adoption.

4.1 MAKE PUBLIC PROCUREMENT CIRCULAR

This scenario involves greening public procurement: flows can be **narrowed** by increasing the resource efficiency of public administration, government procurement and public health care. **Designing for the future, extending and preserving what's already made** and **using waste as a resource** also come to the fore as crucial strategies: governments should set high standards for purchasing goods with extended lifetimes, thus **slowing** flows, and with the highest content of recycled materials possible. The municipal offices in the city of Venlo, the Netherlands, embodies these principles: the building, designed according to the cradle-to-cradle philosophy, has been developed as a huge raw materials bank—all materials will be available for direct reuse at the end of the building's functional lifetime.[84]

Impact on Quebec's circularity: With the proposed circular interventions for public procurement, Quebec could slash its material footprint by a substantial 7.9% and increase its Circularity Metric by 14.2%, from 3.5% to 4%. In addition to the direct impact of public procurement initiatives on material flows, they also send a powerful signal to industries, demonstrating substantial demand for circular solutions—which, once created, may spill over into private sector consumption. From a transition management perspective, driving demand through public procurement will incentivise suppliers to innovate and come to the fore with new, circular solutions, which can then be scaled and made available more broadly.

QUEBEC GOING GREEN: COMPOST COLLECTION AND RECYCLED ROADS

The cycling of organic waste represents a huge opportunity for Quebec—and the provincial government is planning to invest CA$1.2 billion over the next ten years. All Quebecers will have the opportunity to compost green waste by 2025, in a bid to achieve the ultimate goal of 70% of all organic waste composted by 2030.[85]

The Quebec government is also prioritising eco-design in its procurement strategy: the City of Montreal, for example, has partnered with a number of organisations to support research on the reuse of recycled glass in road construction.[86] This innovation would both valorise waste—as a large portion of the province's glass from the curbside recycling system ends up in landfill—and increase the roads' longevity by preventing cracks brought on by the province's severe winter temperatures.[87] Local innovation such as this, combined with stronger government commitments to source more sustainable and circular materials for public projects, represent a key avenue for Quebec to come a step closer to closing its Circularity Gap.

5. MAKE MANUFACTURING CIRCULAR

While Quebec's role in manufacturing surfaces in other scenarios, it also warrants separate analysis as the province has a dominant role as a manufacturing powerhouse of the Canadian economy. Approximately one-quarter of Canada's manufacturing output can be attributed to Quebec, which leads the way in food production, pulp and paper products, transportation equipment, primary metals, chemical and pharmaceutical products and refined petroleum and coal products.[88] Aerospace equipment—much of which is manufactured in Montreal—is the province's crowning glory, accounting for the largest share of Canada's output in the sector.[89] The city employs 6.5% of its workforce in aviation manufacturing alone,[90] while the Capitale-Nationale administrative region boasts a sizable manufacturing sales value of nearly CA$8.5 billion from pulp and paper, processed food, metal and wood, chemicals and electronics production.[91]

The sector took a hit in 2020, however, as the first wave of the Covid-19 pandemic saw operational shutdowns that docked the sales of Quebec manufacturers by CA$4 billion. As of January 2021, the fear of a second shutdown is prominent: the sector employs close to half a million people and accounts for 14% of Quebec's GDP.[92] The stringent health and safety strategies being implemented in factories, however, pave the way for a different kind of change: the greening of the industry through circular interventions focused on increasing efficiency, minimising yield losses and optimising material use—thus slashing virgin material extraction and waste creation. Such practices have economic, as well as environmental, benefits and carry the power to position Quebec for success in the years to come.

5.1 MAKE MANUFACTURING RESOURCE-EFFICIENT

The manufacturing industry can put a number of strategies into practice to jumpstart its circular transition: flows can be **narrowed** with process improvements and material substitutions across sectors. A reduction of scrap material—generated from standard procedure—would also improve efficiency and reduce the need for virgin inputs, further **narrowing** flows. Such strategies can be applied across key material groups, specifically on Quebec's large production volumes in non-ferrous metal, copper, aluminium, chemicals and wood production. **Prioritising regenerative resources** and committing to sustainably sourced biomass also play a crucial role here. Where waste volumes cannot be reduced, industrial symbiosis—the use of waste from one business as feedstock for another—represents another avenue for the different industry clusters in Quebec to improve resource efficiency by **using waste as a resource**. As one of the leading manufacturing hubs in Canada, Quebec can leverage these strategies to reduce material consumption domestically and aid its export partners in lowering the footprint of export products.

Our modelling explores the effect of process improvements on reducing yield loss. We consider material savings amounting to 25% across steel, aluminium, copper, cement, wood and chemical manufacturing. We assume that these yield losses apply to all the sectors. We base this on the knowledge that yield loss reductions specifically concerns the production of semi-manufactured goods across industries.

We also assume that scrap created during the processing of materials is cycled rather than discarded. This could stem from the extension of good practices to all industries in Quebec or the creation of new markets for secondary materials.

Impact on Quebec's circularity: With the proposed circular interventions for manufacturing, Quebec could slash its material footprint by 9.1% and increase its Circularity Metric by 8.5%, from 3.5% to 3.8%. As a leading consumer of energy and heat, changes made by the manufacturing industry have the potential to slash GHG emissions: every bit of material use avoided ultimately reduces the emissions embedded in a final product. Our Circularity Gap Report 2021 found that 70% of GHG emissions are generated through material handling and use; and overhauling emissions- and resource-intensive manufacturing processes will have a transformational impact on global emissions.[93] Clear economic benefits for industry also emerge from lesser use of precious metals and decreased waste.

6. MAKE MOBILITY CLEAN

Quebec has committed to becoming a 'North American leader in sustainable mobility by 2030'; including a ban of internal combustion engine (ICE) vehicles as of 2035. This is an important goal, as the majority of fossil fuels imported into the province (36.7 million tonnes) are used for transport fuel and the sector emits 43% of emissions. Mobility is also a resource-intensive societal need and accounts for 14% of the province's material footprint. Private vehicle usage is high[94] and use of public transport is quite low. In the 15 years leading up to 2016, public transit use by commuters in Montreal rose by only 1.4%, levelling off at 23.5%, while those choosing to cycle to work comprised just 2.1% of all commuters.[95] Carpooling is also low in Quebec, with only 10.6% of commuters sharing a ride to work, based on 2016 census data.[96]

In following this trend, Quebec boasts the assets, ideal conditions and existing infrastructure to transition to cleaner mobility. For example, 12,000 kilometres of bicycle paths, with more than 5,000 kilometres on the Route Verte,[97] a network of multi-use trails linking more than 320 municipalities,[98] which could increasingly be used for commuting. Furthermore, Quebec is a strong producer of mobility solutions, and the manufacturing of trucks, busses, electric vehicle components, artificial intelligence and automated driving technology all play a prominent role in Quebec's economy.[99] Although resource-hungry manufacturing drives up the Circularity Metric, it also shows the potential to drive change with leading technology and knowledge. The province also is a global leader in the aerospace industry, with Montreal ranking as one of the world's three aeronautics hubs and the province making up half of Canada's aerospace production.[100]

Policy-wise, the Ministry of Transport has developed a *Sustainable Mobility Policy* looking towards 2030—addressing all modes of transportation and interventions on the road network level across ten targets.[101] Active modes of transport—like walking and cycling—are encouraged and prioritised in the Policy's *2018–2023 Active Transportation Action Plan*,[102] while the *2015–2020 Transportation Electrification Action Plan* has invested over CA$600 million in increasing the province's electric vehicle fleet to 100,000 and reducing GHG emissions from transport by 150,000 tonnes.[103] The new Plan for a Green Economy, launched by the Ministry of Environment, prioritises electrification—mainly in the transport sector—with plans to devote CA$3.6 billion to electrifying light trains, city and school busses, taxis and eventually cars and trucks.[104] In this what-if clean and shared mobility scenario, five interventions outline the opportunities for Quebec to amplify circularity and slash material use—and meet emissions reduction targets.

6.1 CAR SHARE & SHIFT TO PUBLIC TRANSPORT

Circular mobility strategies concerned with **narrowing** resource flows by optimising the use and performance of existing vehicles include car and ride sharing, public transit efficiency and increased ridership on public transit. Car sharing can be supported by **incorporating digital technology** such as online sharing platforms, which would reduce Quebec's material footprint: fleet size would decrease as Quebecers begin to grab a car only when needed, rather than investing in a private vehicle that sits unused for large amounts of time.[105] In this way, currently underutilised cars are optimised, vastly reducing the need for such a large fleet. With increased public transport, bus, metro, tram, cable car and ferry systems would be strengthened and promoted, and regional and long-distance train and bus connections would be improved to discourage carbon- and material-intensive private car or air travel.

This intervention was modelled as a mix of car sharing, car-pooling, ride-sharing, trip chaining and park and ride systems, collectively curbing the use of private mobility by 90%. It is, however, assumed that this will result in a 50% increase in spending on public transport and 20% increase in repair services for the motor vehicles sector as increased maintenance would be needed. Our modelling acknowledges that in rural areas, reductions in car ownership would be lower—estimated at 50%.

6.2 TRAVEL LESS

Flows can also be **narrowed** by reducing the kilometres travelled: as Covid-19 has impacted the way we live and work, more employers are recognising the value—or at least acceptability—of working from home or telecommuting. Virtualised interaction, which reduces physical commuting, could reduce the need for frequent vehicle use, and have additional positive impacts on emissions and traffic congestion.[106] Workplaces also have an excellent incentive to allow for more remote working, as the typical employer can save up to CA$13,700 per year for each employee that works remotely just half the time.[107] As vaccination schemes roll out and we begin to shape our 'new normal', governments could continue to promote telecommuting for situations where it is safe and socially beneficial.

Following a study by Vita et al (2019),[108] our model assumes that inputs to mobility on land would decrease by 50%, coupled with an increase in household consumption of electricity and fuel by 20%.

6.3 DESIGN FOR THE FUTURE OF CIRCULAR MOBILITY

This intervention both **narrows** and **slows** flows, making use of strategies such as lightweighting and design for repairability to reduce mobility's mammoth impact. In **designing for the future**, vehicles can be designed and manufactured with lightweight materials as well as a frugal approach to the equipment included within. While cultural factors feed into a preference for larger vehicles, governments could tax highly emitting, heavyweight vehicles as one avenue of implementation—especially as there is little need for them in urban centres. By **designing for the future** and **preserving and extending what's already made**, the material footprint of mobility can also be significantly impacted. Design for repair, predictive, intelligent maintenance, the increased availability of spare and replacement parts, and a shift of innovation focus from hardware to software can all serve to extend vehicle lifetimes, reduce unnecessary waste, and lower material use. Such measures can be encouraged fiscally, for example through tax breaks for repairs; companies with large vehicle fleets can also be encouraged to enact strategies that improve proactive maintenance.

Our model explores the potential impact of material savings from design reaching 50% in automotive vehicles and an average of 17% in trains, ferries and aviation. Crucially, such reductions in weight also spur additional savings in fuel—based on Wood et al. (2018)[109] and Hertwich et al. (2019),[110] this is assumed to be 6% for every 10% weight reduction.

6.4 CYCLE BETTER AND EXTRACT FEWER RAW MATERIALS

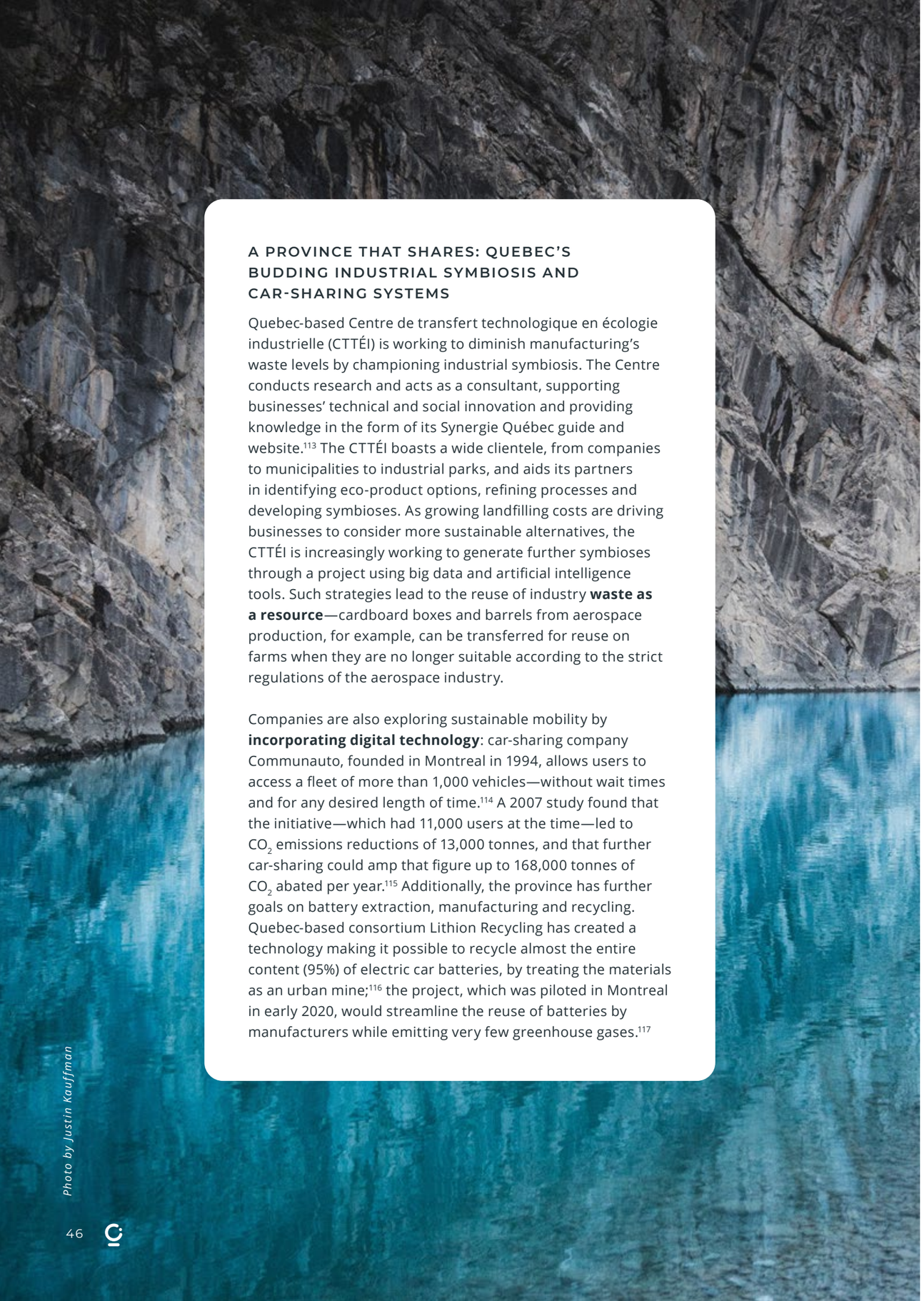
The mobility sector's high material footprint is linked to its use of precious metals—which are less available to mine following years of systematic depletion and geopolitical scarcity. As vehicle electrification increases to match sustainability goals, even more precious materials are extracted and fed into the economy, making the recycling of such materials a crucial strategy. This intervention considers different cycling options for automotive batteries in a cascading manner: useful battery life should be **preserved and extended** and materials **cycled** or made available for direct reuse. Vehicle manufacturers can also **use waste as a resource** and increase the share of recycled materials used in production, recycling all tires, mixed metals and plastics.

6.5 MAKE MOBILITY EMISSIONS-FREE

Prioritising regenerative resources can encourage emissions-free mobility. Phasing out fossil fuel-based engines in transport vehicles, especially trains, passenger cars and trucks has huge potential for impact—especially considering Quebec's unique position as a renewable energy leader in Canada. With hydropower meeting almost all of the province's energy needs, the transition to an all-electric vehicle fleet would slash emissions (43% of which stem from mobility) and decrease fossil fuel imports.

Quebec's plans for electrification include the sales ban of new, fossil-powered cars beginning in 2035.[111] Yet critics note that the ban will not extend to commercial vehicles or second-hand cars and that the 2035 implementation date is far too distant. Increasing the province's electric vehicle fleet through other measures—such as public procurement, encouraging or influencing consumer choices and the improvement of charging infrastructure—will also be important to incorporate to reduce emissions and increase circularity.

Impact on Quebec's circularity: With clean and shared mobility, Quebec could slash its material footprint by 6.6% and increase its Circularity Metric by 5.7%, from 3.5% to 3.7%. As a major source of GHG emissions, a circular mobility sector could also bring about significant reductions in this area—having the co-benefit of improved air quality in urban areas, contributing to the health of Quebec's residents. On a global level, less travel, electrification and resource-efficient design were among the interventions that contributed to a GHG emission reduction of 2.6 billion tonnes in Shift countries alone.[112] What's more: shared mobility approaches and strengthened public transport offerings ensure that mobility services are accessible more widely, benefiting those that may not be able to afford a private vehicle.



A PROVINCE THAT SHARES: QUEBEC'S BUDDING INDUSTRIAL SYMBIOSIS AND CAR-SHARING SYSTEMS

Quebec-based Centre de transfert technologique en écologie industrielle (CTTÉI) is working to diminish manufacturing's waste levels by championing industrial symbiosis. The Centre conducts research and acts as a consultant, supporting businesses' technical and social innovation and providing knowledge in the form of its Synergie Québec guide and website.[113] The CTTÉI boasts a wide clientele, from companies to municipalities to industrial parks, and aids its partners in identifying eco-product options, refining processes and developing symbioses. As growing landfilling costs are driving businesses to consider more sustainable alternatives, the CTTÉI is increasingly working to generate further symbioses through a project using big data and artificial intelligence tools. Such strategies lead to the reuse of industry **waste as a resource**—cardboard boxes and barrels from aerospace production, for example, can be transferred for reuse on farms when they are no longer suitable according to the strict regulations of the aerospace industry.

Companies are also exploring sustainable mobility by **incorporating digital technology**: car-sharing company Communauto, founded in Montreal in 1994, allows users to access a fleet of more than 1,000 vehicles—without wait times and for any desired length of time.[114] A 2007 study found that the initiative—which had 11,000 users at the time—led to CO_2 emissions reductions of 13,000 tonnes, and that further car-sharing could amp that figure up to 168,000 tonnes of CO_2 abated per year.[115] Additionally, the province has further goals on battery extraction, manufacturing and recycling. Quebec-based consortium Lithion Recycling has created a technology making it possible to recycle almost the entire content (95%) of electric car batteries, by treating the materials as an urban mine;[116] the project, which was piloted in Montreal in early 2020, would streamline the reuse of batteries by manufacturers while emitting very few greenhouse gases.[117]

Photo by Justin Kaufman

7. 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 more substantial impact, recognising also that starting at a Metric of 3.5% leaves a long road to circularity ahead.

In our broad 'what-if' image for the economy, if we harness the cross-intervention synergies, Quebec reaches a Circularity Metric of **9.8%** and the material footprint of consumption is lowered by a remarkable **48.2%** to merely **140.4 million tonnes**. In this combined scenario, we also assume a recycling rate for wet organic waste of 100% for an overall cycling rate (including energy recycling and downcycling) of a little less than 78%.

In terms of the Circularity Metric, the increase may not seem as transformative as the extent of our scenarios suggest. However, it is important that the primary objective of a circular economy lies in the reduction of the material footprint and enabling a higher share of it can come from secondary materials. A second imperative point is the role of ecological cycling (highlighted in Chapter Two, page 16). Many of the interventions listed, especially in the context of agriculture, also entail a more sustainable production of biomass and maintenance of the producing ecosystems, thus strengthening the potential in ecological cycling, which concerns a significant part (26%) of the province's current metabolism.

Importantly, even a seemingly small increase in circularity can bring numerous co-benefits, especially in the realm of climate change: our *Circularity Gap Report 2021* found that we only have to double the globe's circularity, reaching a Metric of 17%, to close the Emissions Gap and limit warming to well below 2-degrees. Quebec's Metric—which could nearly triple—thus carries a lot of potential.

When combining the interventions, it is crucial to be aware of potential overlaps. In particular, the scenarios on repair and recycling, as well as fossil resource consumption, are applied across sectors, 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**.

WHY ISN'T THE METRIC HIGHER?

Our Metric measures socioeconomic cycling—excluding circular ecological cycling. This was a precautionary decision based on insufficient data (see page 16). Increasing the Metric is also limited by (often necessary) stock additions—which 'lock in' resources and reduce a portion of the total materials available for cycling—and the unlikelihood of Quebec reducing non-circular inputs (fossil fuels) from its current 17% to 0%. We also cannot fully model the impact circular strategies may have on the complex footprint of Quebec's imports, as their production data stems from many countries (see page 26).

Our primary modelling technique, input-output analysis (IOA), also poses a methodological limitation. This method needs precise data or robust assumptions—where we must account for the desired impact of our interventions, whether it is increasing secondary material use or reducing consumption. While these assumptions can be made for interventions that **narrow** flows, doing so for **cycle** interventions is difficult. For the latter, we need more complex data to generate a coherent interface between the economic and physical dimensions, often concerning an external 'third order' of information such as recycling or emissions rates and targets. Our model may encounter issues in interpreting the literature it is informed by, or in research or data issues. Therefore, we avoided modelling decisions that could lead to inaccuracies or false inflation of the Metric.

SCENARIOS, INTERVENTIONS & STRATEGIES

	INTERVENTIONS	STRATEGIES	IMPACT AND MATERIAL FOOTPRINT
1. DESIGN CIRCULARITY INTO STOCKCS	**1.1 Use less, cycle more**	• Reduce floor space for residential and commercial buildings • Reduce raw material extraction • Cycle construction and demolition waste • Increase renovation and maintenance	Circularity rises from 3.5% to **4.4%**. Reduction of material footprint by **11%**, decrease to **241.2** million tonnes. Co-benefits: Reduction in GHG emissions, increased availability of space for community use or renaturation.
	1.2 Champion natural and lightweight materials	• Swap out emissions-intensive cement for regenerative timber • Avoid overdesigning and prioritise functionality	
	1.3 Decrease residential energy use	• Promote passive house design • Prioritise local renewable energy • Implement energy efficient technologies	
2. PRIORITISE CONSCIOUS CONSUMABLES	**2.1 Shift to bio-based consumables**	• Prioritise the choice of consumables from a life-cycle perspective • Favour synthetic textiles over animal-based ones	Circularity rises from 3.5% to **4.2%**. Reduction of material footprint by **4.4%**, decrease to **259.2** million tonnes. Co-benefits: Reduced plastic pollution, less discharge of chemical pollutants, lower water consumption.
	2.2 Rewire current modes of consumption	• Purchase items meant to last • Bolster minimum warranties and resale business models • Slash consumption of fast fashion • Improve textiles cycling	
	2.3 Ramp up recycling	• Increase recycling of industrial paper and plastic waste	
3. STRIVE FOR CIRCULAR AGRICULTURE	**3.1 Make agricultural production circular**	• Use agricultural waste for livestock fodder, and use livestock manure as fertiliser	Circularity rises from 3.5% to **4%**. Reduction of material footprint by **12.3%**, decrease to **237.6** million tonnes. Co-benefits: Reduced land use resulting in the creation of nature reserves, increased biodiversity, carbon sequestration and water purification.
	3.2 Shift towards plant-based diets	• Increase consumption of plant-based protein	
	3.3 Consume less	• Eliminate waste throughout the supply chain • Reduce eating beyond caloric needs at the consumption stage	
	3.4 Valorise organic waste	• Reuse organic waste such as sludge • Energy recovery from waste	

	INTERVENTIONS	STRATEGIES	IMPACT AND MATERIAL FOOTPRINT
4. LEVERAGE GOVERNMENT PROCUREMENT	**4.1 Make public procurement circular**	• Governments must purchase good with extended lifetimes and high recycled content • Increase the resource efficiency of procurement and public health care	Circularity jumps from 3.5% to **4%**. Reduction of material footprint by **7.9%**, decrease to **249.6** million tonnes. Co-benefits: Galvanised private
5. MAKE MANU-FACTURING CIRCULAR	**5.1 Make manufacturing resource-efficient**	• Implement process improvements and material substitutions across sectors • Reduce scrap metal • Commit to sustainably sourced biomass	Circularity rises from 3.5% to **3.8%**. Reduction of material footprint by 9.1%, decrease to **246.4** million tonnes. Co-benefits: Strong reductions in GHG emissions, economic benefits for the manufacturing industry.
6. MAKE MOBILITY CLEAN	**6.1 Car share and shift to public transport**	• Support car sharing to reduce vehicle fleet • Increase public transport use through improved train and bus connections	Circularity rises from 3.5% to **3.7%** Reduction of material footprint by 6.6%, decrease to **253.1** million tonnes. Co-benefits: Reduced GHG emissions, improved air quality, greater access to mobility through improved sharing and public transport systems.
	6.2 Travel less	• Continue telecommuting post-pandemic • Virtualise interaction	
	6.3 Design for the future of circular mobility	• Promote lightweight vehicle design • Design for repair and follow predictive maintenance	
	6.4 Cycle better and extract fewer raw materials	• Focus on extending vehicle lives • Cycle automotive batteries • Increase the use of cycled materials in vehicle production	
	6.5 Make mobility emissions-free	• Phase out fossil-based engines and electrify transport	
7. COMBINED	**THE POWER OF COMBINED INTERVENTIONS**		Circularity rises from 3.5% to **9.8%**. Reduction of material footprint by 48.2%, decrease to **140.4** million tonnes.

The table above shows the scenarios, interventions and strategies for the six sectors. It explores the impact on the Circularity Metric and the material footprint of Quebec.

5. THE WAY FORWARD

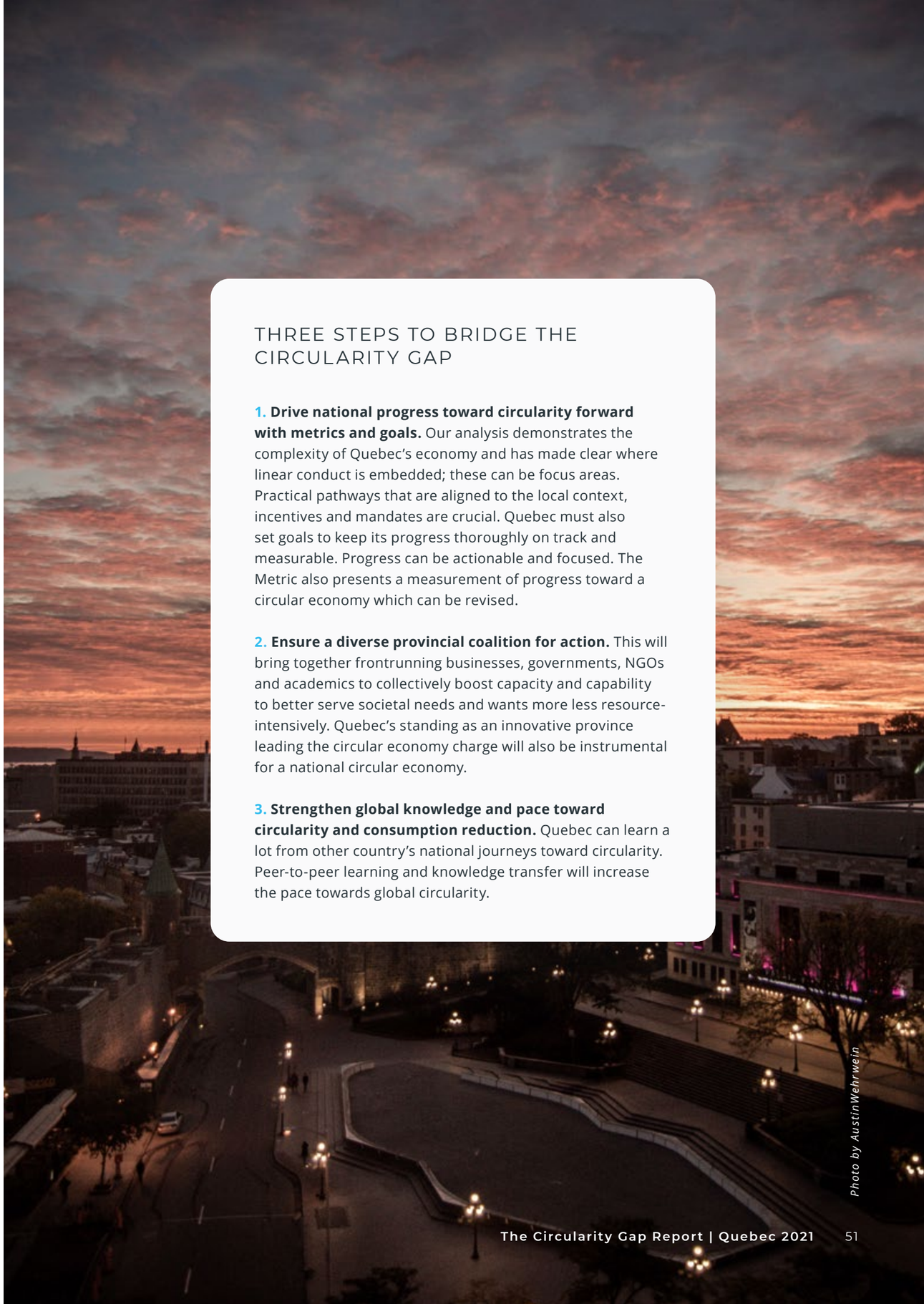
Quebec can transform its economy to use half as many resources to fulfil its societal needs and wants while becoming nearly three times more circular. This study provides a first approximation of how resource use is allocated across Quebec's needs and wants. Through the scenarios presented, Quebec can overhaul its economy; moving toward more circular and resource-efficient processes. Although the massive changes entail only a small increase in circularity (from 3.5% to 9.8%), it's important to note the transformational potential of even a minor increase in circularity. Our global *Circularity Gap Report 2021*, for example, found that we only have to double the globe's circularity, reaching a Metric of 17%, to limit global temperature rise to well below 2-degrees. The scenarios also deliver an outstanding reduction to the material footprint of 48.2%.

A circular economy can shape a province that is safe, just and resilient to future crises. There are a range of co-benefits that the circular economy can bring to Quebec's economy and society. With circular infrastructure and agriculture, the province will see increased availability of public space for the community and the chance to explore renaturation and restoration of nature reserves to boost biodiversity, carbon sequestration and water purification. In prioritising conscious consumables, the plague of plastic pollution will stall, as will chemicals that discharge into our soil. As the government leverages its power to procure circular goods and services, private sector innovation can prosper; encouraging new circular solutions that leverage the best Canada has to offer. Moving to circular housing, infrastructure and manufacturing will also deliver huge greenhouse gas emissions savings; a must to prevent the worst impacts of climate breakdown. Our *Circularity Gap Report 2021*[118] found that circular interventions across all Shift countries alone could cut emissions by nearly ten billion tonnes, which clearly portrays the massive emissions-reduction potential for Quebec; a typical Shift economy.

An opportunity to really build back better. Although the pandemic has caused pain and disruption, it has also paved the way for change. The potential of these changes warrants exploration and scale-up with the capital funds that have become available.

Achieving the goal of a green recovery will require multi-level engagement from government, business and civil society. Only a group effort from multiple stakeholders will get us on a positive trajectory once again. The decisions national and subnational governments make today will shape our future climate and the lives of generations to come.

All countries are critical change agents, and Quebec can increase global circularity too. We are all operating in a world that is only 8.6% circular, and the legacy of the linear economy is embedded deep in Quebec's society. As a province that boasts all the typical characteristics of a Shift economy—high consumption, extraction and waste levels matched by prosperous living conditions—there is responsibility on Quebec to use its government spending power, innovation and drive to increase circularity not only at home, but also abroad. As part of a global economy, Quebec can play a special role as a key exporter of globally-valuable commodities such as energy, forestry, mining product, and manufactured goods. Ensuring these natural resources and assets are strictly managed in a sustainable and circular way is extremely important from a global perspective. It's time for Quebec to leverage the excellent opportunity to become more circular, resource-efficient and resilient.



THREE STEPS TO BRIDGE THE CIRCULARITY GAP

1. **Drive national progress toward circularity forward with metrics and goals.** Our analysis demonstrates the complexity of Quebec's economy and has made clear where linear conduct is embedded; these can be focus areas. Practical pathways that are aligned to the local context, incentives and mandates are crucial. Quebec 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 diverse provincial coalition for action.** This will bring together frontrunning businesses, governments, NGOs and academics to collectively boost capacity and capability to better serve societal needs and wants more less resource-intensively. Quebec's standing as an innovative province leading the circular economy charge will also be instrumental for a national circular economy.

3. **Strengthen global knowledge and pace toward circularity and consumption reduction.** Quebec 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.

Photo by AustinWehrwein

REFERENCES

1. Raworth, K. (2017). Doughnut economics: *Seven ways to think like a 21st-century economist*. Chelsea Green Publishing.
2. Circle Economy. (2020). The *Circularity Gap Report 2020* (pp. 1-64, Rep.). Amsterdam: Circle Economy. Retrieved from: CGRi Website
3. Circle Economy. (2021). The *Circularity Gap Report 2021* (pp. 1-71, Rep.). Amsterdam: Circle Economy. Retrieved from: CGRi Website
4. Data collected from Exiobase 3.7: Stadler K, Wood, R., Bulavskaya, T., Sodersten, C.J., Simas, M., Schmidt, S., Usubiaga, A., Acosta-Fernandez, J., Kuenen, J., Bruckner, M., Giljum, S., Lutter, S., Merciai, S., Schmidt, J.H., Theurl, M.C., Plutzar, C., Kastner, T., Eisenmenger, M., Erb, K., de Koning, A., & Tukker, A. (2018) EXIOBASE 3: Developing a time series of detailed environmentally extended multi-regional input-output tables. Journal of Industrial Ecology 22(3), 502-515. doi:10.1111/jiec.12715
5. Exiobase 3.7 regions: 43+5 rest of the world regions: Stadler et al. (2018) EXIOBASE 3: Developing a time series of detailed environmentally extended multi-regional input-output tables. Journal of Industrial Ecology. doi:10.1111/jiec.12715
6. Goering, L. (2018, November 29). Climate change 'biggest global health threat' of century, doctors warn. Reuters. Retrieved from: Reuters Website
7. Ellen MacArthur Foundation (EMF). (n.d.). What is the circular economy? Retrieved from: EMF Website
8. Raworth, K. (2017). Doughnut economics: *Seven ways to think like a 21st-century economist*.
9. Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M. Biggs, R., Carpenter, S. R., de Vries, W., de Wit, C., Folke, C., Gerten, D., Heinkle, J., Mace, G. M., Persson, L. M., Ramanthan, V, Reyers, B., & Sörlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. Science, 347(6223), 736-748. doi:10.1126/science.1259855
10. Gouvernement du Québec. (2020). Plan pour une économie verte 2030: Politique-cadre d'électrification et de lutte contre les changements climatiques. Québec City, Canada: Gouvernement du Québec. Retrieved from: Gouvernement du Québec Website
11. Ministère de l'Énergie et des Ressources Naturelles (MERN). (2020). *Québec Plan for the Development of Critical and Strategic Minerals 2020–2025* (pp. 1-62, Rep.). Québec City, Canada: Gouvernement du Québec. Retrieved from: Quebec Government Website
12. RECYC-QUÉBEC. (2020). *Plan d'action 2019–2024 de la politique québécoise de gestion des matières résiduelles* (pp. 1-21, Rep.). RECYC-QUÉBEC. Québec City: Canada. Retrieved from: RECYC-QUÉBEC Website
13. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPAQ). (2018). *Politique bioalimentaire* (pp. 1-108, Rep.). Québec City, Canada: Gouvernement du Québec. Retrieved from: MAPAQ Website
14. O'Neill, D., Fanning, A., Lamb, W., & Steinberger, J. (2018). A good life for all within planetary boundaries. *Nature Sustainability,* 1(2), 88-95. doi:10.1038/s41893-018-0021-4
15. Cullen, J., Allwood, J., & Borgstein, E. (2011). Reducing energy demand: *What are the practical limits? Environmental Science Technology,* 45, 1711-1718. doi:doi.org/10.1021/es102641n
16. Jo, T. (2011). Social provisioning process and socio-economic modeling. The American Journal of Economics and Sociology 70(5), 1094-1116. doi:10.1111/j.1536-7150.2011.00808.x
17. Haas, W., Krausmann, F., Wiedenhofer, D. & Heinz, M. (2015). How circular is the global economy? An assessment of material flows, waste production, and recycling in the European Union and the world in 2005. Journal of Industrial Ecology 19(5), 765-777. doi:10.1111/jiec.12244
18. Circle Economy. (2019). *The circularity gap report: Austria* (pp. 1-36, Rep.). Amsterdam: Circle Economy. Retrieved from: Circle Economy Website
19. Bocken, N., de Pauw, I., Bakker, C. & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering 33*(5), 308-320. doi:10.1080/21681015.2016.1172124
20. Circular Strategies. (n.d.). Supporting innovation for a circular economy. Retrieved from: Circular Strategies Website
21. Haas, W., Krausmann, F., Wiedenhofer, D., Lauk, C., & Mayer, A. (2020). Spaceship earth's odyssey to a circular economy—a century long perspective. *Resources, Conservation and Recycling 163*, 105076. doi:10.1016/j.resconrec.2020.105076
22. Centraal Bureau voor de Statistiek (CBS). (2020, June 3). *Notitie circulair materiaalgebruik in Nederland* [Press release]. Retrieved from CBS Website
23. This assumption is applied at the level of single resource group (biomass, metals, minerals and fossil fuels), that is: if the share of secondary biomass, say recycled paper, in the total input of biomass is 1%, then the share of consumed recycled paper in the total consumption of biomass will also be 1%.
24. The Global Footprint Network. (2019). Ecological footprint explorer. Retrieved from: Data Footprint Network Website
25. Circle Economy. (2020). *The circularity gap report: Netherlands* (pp. 1-56, Rep.). Amsterdam, Netherlands: Circle Economy. Retrieved from: CGRi Website
26. Circle Economy. (n.d.). The power of countries to close the circularity gap: Why CGR countries? Retrieved from CGRi Website
27. Any mismatch in the figures is due to rounding.
28. Exiobase 3.7 regions: 43+5 rest of the world regions: Stadler et al. (2018) EXIOBASE 3: Developing a time series of detailed environmentally extended multi-regional input-output tables. *Journal of Industrial Ecology.* doi:10.1111/jiec.12715
29. The Observatory of Economic Complexity (OEC). (2021). Quebec. Retrieved from: OEC Website
30. Whitmore, J. & Pineau, P. (2021). *État de l'énergie au Québec: Édition 2021* (pp. 1-65, Rep.). Montreal, Canada: Chaire de gestion du secteur de l'énergie, HEC Montréal. Retrieved from: Energie Website
31. Wiedmann, T. O., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J., & Kanemoto, K. (2015). The material footprint of nations. *Proceedings of the national academy of sciences, 112*(20), 6271-6276. doi:10.1073/pnas.1220362110
32. The Canadian Minerals and Metals Plan. (n.d.). Mining in Canada. Retrieved from: The Canadian Minerals and Metals Plan Website
33. Investissement Québec International. (n.d.). Mining: A wide variety of metals and minerals within easy reach. Retrieved from: Investissement Québec Website
34. MERN. (2016). *Tableau internet mines*. Quebec City: MERN. Retrieved from: MERN Website
35. Exiobase 3.7 regions: 43+5 rest of the world regions: Stadler et al. (2018) EXIOBASE 3: Developing a time series of detailed environmentally extended multi-regional input-output tables. Journal of Industrial Ecology. doi:10.1111/jiec.12715
36. MERN. (2018). *Investing in Québec's mining sector* (pp. 1-50, Rep.). Quebec City: MERN. Retrieved from: MERN Website
37. Government of Quebec. (2021). Development of critical and strategic minerals in Québec. Retrieved from: Government of Quebec Website
38. Strategic minerals contribute to Quebec achieving its goals for a more sustainable economy, as they are used in the manufacturing of green technologies—such as solar panels.
39. Natural Resources Canada (NRCan). (2018). Mineral trade. Retrieved from: NRCan Website
40. Ministère des Forêts, de la Faune et des Parcs (MFFP). (n.d.). Québec: A land of forests. Retrieved from: MFFP Website
41. Neste. (2020, December 3). Quebec government invests $5.9M in wood-waste-to-biofuel project. *Canadian Biomass*. Retrieved from: Canadian Biomass Magazine Website
42. European Commission. (2008). Directive 2008/98/EC on waste (Waste Framework Directive). Retrieved from European Commission Website
43. Bocken et al. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*. doi:10.1080/21681015.2016.1172124
44. SNAC Exiobase 3.7 for Quebec (own elaboration), consumption-based accounting, reference year 2017.
45. SNAC Exiobase 3.7 for Quebec (own elaboration), production-based accounting, reference year 2015.
46. Institut de la statistique du Québec. (2021). Greenhouse gas (GHG) emissions account by sector, Québec, 2009 to 2018, production-based accounting. Retrieved from: Statistique Quebec
47. Own analysis.
48. Institut de la statistique du Québec. (2020). Produit intérieur brut aux prix de base par industrie, Québec, 1997–2019. Retrieved from: Statistique Québec
49. Government of Canada. (2020, December 8). Québec sectoral profile 2018–2020: Construction. Retrieved from: Government of Canada Website
50. FP Innovations. (2020, November 24). The future of carbon footprint of sustainable construction in Quebec [Web log post]. Retrieved from: FP Innovations Website
51. Input gathered during the roundtable between Circle Economy and the RECYC-QUÉBEC coalition.
52. National Zero Waste Council (NZWC). (2021). *Waste prevention: The environmental and economic benefits for Canada* (pp. 1-92, Rep.). Vancouver, Canada: National Zero Waste Council. Retrieved from: NZWC Website
53. ArchDaily. (2020, October 19). Quebec, Canada: The heart of mass timber construction. Retrieved from: ArchDaily website
54. Potsdam Institute for Climate Impact Research. (2020, January 27). Buildings can become a global CO_2 sink if made out of wood instead of cement and steel. Retrieved from: PIK website
55. Moran, D., Wood, R., Hertwich, E., Mattson, K., Rodriguez, J. F., Schanes, K., & Barrett, J. (2020). Quantifying the potential for consumer-oriented policy to reduce European and foreign carbon emissions. *Climate Policy,* 20(sup1), S28-S38. doi:10.1080/14693062.2018.1551186
56. Donati, F., Aguilar-Hernandez, G. A., Sigüenza-Sánchez, C. P., de Koning, A., Rodrigues, J. F., & Tukker, A. (2020). Modeling the circular economy in environmentally

extended input-output tables: Methods, software and case study. *Resources, Conservation and Recycling, 152*, 104508. doi:10.1016/j.resconrec.2019.104508

57. Hertwich, E., Ali, S., Ciacci, L., Fishman, T., Heeren, N., Masanet, E., Asghari, F., Olivetti, E., Pauliuk, S., Tu, Q., & Wolfram, P. (2019). Material efficiency strategies to reducing greenhouse gas emissions associated with buildings, vehicles, and electronics—a review. *Environmental Research Letters*, 14(4), 043004. doi:10.1088/1748-9326/ab0fe3
58. Ivanova, D., Barrett, J., Wiedenhofer, D., Macura, B., Callaghan, M., & Creutzig, F. (2020). Quantifying the potential for climate change mitigation of consumption options. *Environmental Research Letters, 15*(9), 093001. doi: 10.1088/1748-9326/ab8589
59. Vita, G., Lundström, J. R., Hertwich, E. G., Quist, J., Ivanova, D., Stadler, K., & Wood, R. (2019). The environmental impact of green consumption and sufficiency lifestyles scenarios in Europe: connecting local sustainability visions to global consequences. *Ecological Economics, 164*, 106322. doi:10.1016/j.ecolecon.2019.05.002
60. Moran, D., Wood, R., Hertwich, E., Mattson, K., Rodriguez, J. F., Schanes, K., & Barrett, J. (2020). Quantifying the potential for consumer-oriented policy to reduce European and foreign carbon emissions. Climate Policy, 20(sup1), S28-S38. doi:10.1080/14693062.2018.1551186
61. Circle Economy. (2021). The *Circularity Gap Report 2021.* Retrieved from: CGRi Website
62. CBC News. (2018, May 17). Montreal bails out local recycling plant hit hard by Chinese ban. *CBC News*. Retrieved from: CBC News Website
63. Brunette, A. (2018, June 16). This is what a recycling crisis in Quebec looks like. *CBC News*. Retrieved from: CBC News Website
64. Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC). (2021). Modernization of Québec's deposit-return and curbside collection systems (pp. 1-3, Draft bill). Gouvernement du Québec. Retrieved from: MELCC Website
65. Elliot, T. (2019, July 31). These are all the major companies in Quebec that are banning single-use plastics [Web log post]. Retrieved from: MTL Blog
66. Wood, R., Moran, D., Stadler, K., Ivanova, D., Steen-Olsen, K., Tisserant, A., & Hertwich, E. (2018). Prioritizing consumption-based carbon policy based on the evaluation of mitigation potential using input-output methods. *Journal of Industrial Ecology, 22*(3), 540-552. doi:10.1111/jiec.12702
67. ArchDaily. (2020). Quebec, Canada: The heart of mass timber construction. Retrieved from: ArchDaily Website
68. Québec City Tourism. (n.d.). Green and smart construction. Retrieved from: Québec Cite Website
69. Conseil du patronat du Quebec, the Quebec Business Council on the Environment, & Éco Entreprises Québec. (2018). *Circular economy in Quebec: economic opportunities and impacts* (pp. 1-77, Rep.). Montreal, Canada: Conseil du patronat du Quebec. Retrieved from: CPQ Website
70. L'Union des producteurs agricoles (UPA). (n.d.). Agriculture by the numbers. Retrieved from: UPA Website
71. OEC. (n.d.) Quebec. Retrieved from: OEC website
72. Brassard, D., Laramée, C., Corneau, L., Bégin, C., Bélanger, M., Bouchard, L., Couillard, C., Desroches, S., Houle, J., Langlois, M., Provencher, V., Rabasa-Lhoret, R., Vhol, M., Robitaille, J., Lemieux, S., Lamarche, B. (2018). Poor adherence to dietary guidelines among French-speaking adults in the province of Quebec, Canada: The PREDISE study. *Canadian Journal of Cardiology, 34*(12), 1665-1673. doi:10.1016/j.cjca.2018.09.006
73. Gouvernement du Québec. (2020). *Agir, pour une agriculture durable: Plan 2020–2030* (pp. 1-38, Rep.). Québec City: Gouvernement du Québec. Retrieved from: CDN Contenu Québec Website
74. Environment and Climate Change Canada. (2019). Taking stock: *Reducing food loss and waste in Canada* (pp. 1-40, Rep.). Ottawa: Environment and Climate Change Canada. Retrieved from: Government of Canada Website
75. O'Hare, J. (2017, March 14). Over 600 supermarkets in Quebec are giving extra food to food banks. Global Citizen. Retrieved from: Global Citizen Website
76. Environment and Climate Change Canada. (2019). Taking stock: *Reducing food loss and waste in Canada*. Retrieved from: Government of Canada Website
77. Note: Our model does not take a reduction in herd size into account, but instead models the complete replacement of feedstock inputs with organic waste streams. This is not, however, significantly reflected in the numbers.
78. Commission sur l'avenir de l'agriculture et de l'agroalimentaire québécois (CAAAQ). (2007). *Agriculture and agrifood: Choosing the future* (pp. 1-50, Rep.). Québec City: CAAAQ. Retrieved from: CAAAQ Website
79. Love Food, Hate Waste Canada. (n.d.). Retrieved from: Love Food, Hate Waste Website
80. Recycling Council of Ontario. (2019). Circular procurement summit: Advancing the circular economy through public sector purchasing. Retrieved from: RCO Website
81. MELCC. (n.d.). *The Sustainable Development Act*. Retrieved from: Government of Quebec Website
82. Espace québécois de concertation sur les practiques d'approvisionnement responsable (ECPAR). (2018). Public contracts. Retrieved from: ECPAR Website
83. Government of Québec. (2009). *Politique administrative pour un gouvernement écoresponsable* (pp. 1-5, Policy). Québec City: Gouvernement de Québec. Retrieved from: MELCC Website
84. Archello. (n.d.). Municipal office Venlo. Retrieved from: Archello Website
85. Sargeant, T. (2020, July 3). Quebec government to spend $1.2B to manage organic waste, environment minister says. *Global News*. Retrieved from: Global News Website
86. Kassm, K. (2019). Tero: Designing products for more sustainable habits. Retrieved from: Innovation MTL Website
87. Leavitt, S. (2016, January 4). Recycled glass mixed with asphalt may be solution to pothole woes. *CBC News*. Retrieved from: CBC News Website
88. Manufacturing. (n.d.). *In Britannica*. Retrieved from: Britannica Website
89. George Brown College. (2021, February 23). Where are Canada's manufacturing hotspots? Retrieved from: George Brown College Website
90. George Brown College. (2021). Where are Canada's manufacturing hotspots? Retrieved from: George Brown College Website
91. Mendez-Leblond, S. (2020). Bulletin manufacturier: Les destinations des biens fabriqués au Québec (pp. 1-10, Bulletin no. 17). Québec City: Institut de la Statistique du Québec. Retrieved from: Statistique Québec
92. Serebrin, J. (2021, January 5). Quebec manufacturing and construction sectors warn against new Covid-19 lockdowns. CTV News. Retrieved from: CTV News
93. Circle Economy. (2021). The *Circularity Gap Report 2021.* Retrieved from: CGRi Website
94. Statistics Canada. (n.d.). Vehicle registrations, by type of vehicle: Quebec 2015–2019. doi:10.25318/2310006701-eng
95. Communauté métropolitaine de Montréal (CMM). (2018). *Déplacements domicile—travail dans le grand Montréal: Faible progression du transport durable depuis 2001* (pp. 1-8, Issue brief). Montréal: CMM. Retrieved from: CMM Website
96. Statistics Canada. (2017). Census in brief: Commuters using sustainable transportation in census metropolitan areas. Retrieved from: Statistics Canada Website
97. Direction générale de la Politique de mobilité durable et de l'électrification. (2018). *Transporting Québec towards modernity: Sustainable mobility policy—2030* (pp. 1-21, Rep.). Québec City: Gouvernement du Québec, ministère des Transports. Retrieved from: Ministère des Transports Website
98. La Route Verte. (n.d.). Allez-y, c'est vert! Retrieved from: La Route Verte Website
99. Global Affairs Canada. (2018). *Invest in Canada: Canada's competitive advantages. Automotive sector.* (pp. 1-6, Rep.). Ottawa: Global Affairs Canada. Retrieved from: International—Government of Canada Website
100. Investissement Québec International. (n.d.). Industries—Aerospace. Retrieved from: Investissement Québec Website
101. Tremblay, M. (2019). Sustainable Mobility Policy—2030: Transporting Québec towards modernity. In 26th World Road Congress. Abu Dhabi, United Arab Emirates: World Road Association. Retrieved from: Transportation Research Board
102. Direction générale de la Politique de mobilité durable et de l'électrification. (2018). *Transporting Québec towards modernity: Sustainable mobility policy—2030.* Retrieved from: Ministère des Transports Website
103. Ministère des Transports. (n.d.). Électrification des transports. Retrieved from: Ministère des Transports Website
104. MELCC. (2020). Le gouvernement du Québec lance le Plan pour une économie vert 2030 (Press release). Retrieved from: MELCC Website
105. Morris, D. (2016, March 13). Today's cars are parked 95% of the time. *Fortune*. Retrieved from: Fortune Website
106. Carrico, A., & Riemer, M. (2011). Motivating energy conservation in the workplace: An evaluation of the use of group-level feedback and peer education. *Journal of Environmental Psychology*, 31(1), 1-13. doi:10.1016/j.jenvp.2010.11.004
107. Global Workplace Analytics. (2020). Work-at-home after Covid-19—our forecast. Retrieved from: Global Workplace Analytics
108. Vita, G., Lundström, J. R., Hertwich, E. G., Quist, J., Ivanova, D., Stadler, K., & Wood, R. (2019). The environmental impact of green consumption and sufficiency lifestyles scenarios in Europe: connecting local sustainability visions to global consequences. *Ecological Economics, 164*, 106322. doi:10.1016/j.ecolecon.2019.05.002
109. Wood, R., Moran, D., Stadler, K., Ivanova, D., Steen-Olsen, K., Tisserant, A., & Hertwich, E. (2018). Prioritizing consumption-based carbon policy based on the evaluation of mitigation potential using input-output methods. *Journal of Industrial Ecology, 22*(3), 540-552. doi:10.1111/jiec.12702

110. Hertwich, E., Ali, S., Ciacci, L., Fishman, T., Heeren, N., Masanet, E., Asghari, F., Olivetti, E., Pauliuk, S., Tu, Q., & Wolfram, P. (2019). Material efficiency strategies to reducing greenhouse gas emissions associated with buildings, vehicles, and electronics—a review. *Environmental Research Letters, 14*(4), 043004. doi:10.1088/1748-9326/ab0fe3

111. Lampert, A. (2020, November 16). Quebec to ban sale of new gasoline-powered cars from 2035. *Reuters*. Retrieved from: Reuters Website

112. Circle Economy. (2021). The *Circularity Gap Report 2021.* Retrieved from: CGRi Website

113. Institut de la Statistique du Québec. (2020.). Produit intérieur brut aux prix de base par industrie, Québec, 1997-2019. Retrieved from: Statistique Québec Website

114. CAA Quebec. (n.d.). Communauto: Save up to $40 on subscription plans. Retrieved from: CAA Quebec Website

115. Viviani, M., Caron, E., & Létourneau, A. (2007, February 19). *First study on car-sharing in Québec: CO_2 emissions reduced by 168 000 tons per year thanks to car-sharing* [Press release]. Retrieved from: Communauto Web Archive

116. Rompre, S. (2019, May 31). Most of electric cars' batteries will be recycled, Quebec consortium promises. *CTV News*. Retrieved from: CTV News Website

117. Lithion. (n.d.). Finally, a powerful and sustainable solution for lithium-ion battery recycling. Retrieved from: Lithion Website

118. Circle Economy. (2021). The *Circularity Gap Report 2021.* Retrieved from: CGRi Website

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