Turning Point

The Expert Panel on the Circular Economy in Canada

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The Council of Canadian Academies
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The project that is the subject of this report was undertaken with the approval of the Board of Directors of the Council of Canadian Academies (CCA). Board members are drawn from the Royal Society of Canada (RSC), the Canadian Academy of Engineering (CAE), and the Canadian Academy of Health Sciences (CAHS), as well as from the general public. The members of the Expert Panel responsible for the report were selected by CCA for their special competencies and with regard for appropriate balance.

This report was prepared in response to a request from Environment and Climate Change Canada. Any opinions, findings, or conclusions expressed in this publication are those of the authors, the Expert Panel on the Circular Economy in Canada, and do not necessarily represent the views of their organizations of affiliation or employment, or the sponsoring organization, Environment and Climate Change Canada.

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The Expert Panel on the Circular Economy in Canada would like to acknowledge the Inuit, Métis, and First Nations Peoples who have been stewards of their lands. For generations, Indigenous Peoples have lived in reciprocal relationships with the land, applying practices to harvest natural resources in sustainable ways and preserve the natural cycles such as of water and nutrients.

The Council of Canadian Academies (CCA) acknowledges that our Ottawa offices are located in the unceded, unsurrendered ancestral home of the Anishinaabe Algonquin Nation, which has historically nurtured the land, water, and air of this territory and continues to do so today. Though our offices are in one place, our work to support evidence-informed decision-making has broad potential benefits and can hopefully contribute to collective action to address long-standing inequities and injustices impacting Indigenous people. We are committed to drawing on a range of knowledges and experiences to inform policies that will build a stronger, more equitable, and more just society.

The Council of Canadian Academies

The Council of Canadian Academies (CCA) is a not-for-profit organization that supports independent, science-based, authoritative expert assessments to inform public policy development in Canada. Led by a Board of Directors and advised by a Scientific Advisory Committee, the CCA's work encompasses a broad definition of science, incorporating the natural, social, and health sciences as well as engineering and the humanities. CCA assessments are conducted by independent, multidisciplinary panels of experts from across Canada and abroad. Assessments strive to identify emerging issues, gaps in knowledge, Canadian strengths, and international trends and practices. Upon completion, assessments provide government decision-makers, researchers, and stakeholders with high-quality information required to develop informed and innovative public policy.

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Founded in 1882, the RSC comprises the Academies of Arts, Humanities and Sciences, as well as Canada's first national system of multidisciplinary recognition for the emerging generation of Canadian intellectual leadership: The College of New Scholars, Artists and Scientists. Its mission is to recognize scholarly, research, and artistic excellence, to advise governments and organizations, and to promote a culture of knowledge and innovation in Canada and with other national academies around the world.

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The Expert Panel on the Circular Economy in Canada

Under the guidance of its Scientific Advisory Committee, Board of Directors, and founding Academies, the CCA assembled the Expert Panel on the Circular Economy in Canada to undertake this project. Each expert was selected for their expertise, experience, and demonstrated leadership in fields relevant to this project.

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Message from the Chair of the Expert Panel

The linear economic model of "take, make, use, waste" is no longer viable. Although it has generated an enormous amount of wealth, it has also contributed to excessive extraction of natural resources and accumulation of waste. The linear production system is pushing the planet past its ecological limits and regenerative abilities. As well, it is exacerbating social injustices through the inequitable impact of pollution and distribution of wealth.

This report presents a positive alternative for Canada to move forward in addressing these environmental, social, and economic challenges. The circular economy has the ability not only to ease the ecological crisis, but also to create jobs and mitigate social injustices, while allowing Canada to remain economically competitive. The circular economy is increasingly viewed as a desirable future for all economies, and Canada is well positioned to make the transition by coupling a national strategy with regional ventures.

Interest in the circular economy is exploding, and its body of work is growing rapidly. Not only did these fast-paced developments make it challenging for the CCA team to keep abreast of the work being undertaken, they also make this report important and timely.

The changing landscape of insights into the circular economy also stimulated much discussion among Panel members. Throughout our discussions, there were three themes that we often repeated.

The circular economy is an imperative. Only 6.1% of materials entering the Canadian economy come from recycled sources. This statistic warrants a pause. It means that Canada requires the extraction or import of new material to meet almost 94% of its manufacturing needs, with most material accumulating as either passive infrastructure or as waste. For Canada to maintain its strong economy and global competitiveness, meet its commitments to reducing carbon emissions and maintaining biodiversity, and keep its people prosperous and healthy, it is critical that Canada's economy to become more circular.

The circular economy calls for systems change. Given the obvious benefits of the circular economy, we may ask why Canada's economy is not more circular. This is because transitioning from a linear economy to a circular one requires most economic and social systems to change. Governments will need to embrace innovative policy measures and to coordinate the collection, pricing, and reuse of waste across all levels and jurisdictions. Businesses will need to adopt new

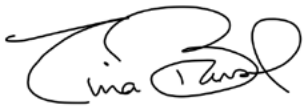
business models and rework their supply chains. People will need to consume, use, reuse, and access services in new ways. As well, the circular economy will inevitably create winners and losers, and such shifts are especially difficult in an economy that is grounded in natural resource extraction. However, these systems *can* be changed—not through the action of any single actor, but by everyone coming together and playing a part.

The circular economy is urgent. As this report was going to print, the United Nations' International Panel on Climate Change (IPCC) released its Sixth Assessment Report, which was called "code red for humanity" by the UN Secretary-General. The climate is changing at a faster rate than previously reported, and northern countries, such as Canada, will experience particularly severe impacts. Climate change is attributable to industrial production and the use and discharge of fossil fuels. It is not only imperative that Canada's economy become more circular, but that it do so quickly.

It has truly been an honour and privilege to chair this Panel, which consisted of an outstanding group of professionals, representing the business, non-profit, and academic sectors. Because our work started and ended during the COVID-19 pandemic, we conducted all our meetings virtually. What could have been tiring work was always energized by the deep engagement and thought-provoking contributions by each one of the Panel members.

Speaking on behalf of the Panel, I would like to thank the CCA team for their hard work on this report. They worked towards expedited timelines, coordinating the views of a large and diverse panel and synthesizing the evidence and insights on a complex topic. I am also grateful to Environment and Climate Change Canada for sponsoring this report.

I sincerely hope that this report provides a platform to motivate a more circular economy that works with the natural environment for a prosperous society.



Tima Bansal, FRSC
Chair, The Expert Panel on the Circular Economy in Canada

Message from the President and CEO

Some of the most pressing policy challenges facing society today have to do with the state of the planet. Climate change, biodiversity loss, pollution, and stress on water and other resources may be environmental issues as we typically think of them, but their impacts are not isolated to just the environment. They affect every aspect of business and life.

The benefits in addressing these challenges are also far reaching and there are still plenty of opportunities to do so. These opportunities have been catalogued in numerous studies and reports over the last decade, including CCA's own recent reports *Canada's Top Climate Change Risks* (2019) and *Greater Than the Sum of Its Parts: Toward Integrated Natural Resource Management in Canada* (2019) for instance.

There is growing awareness and engagement among various government departments and other stakeholders that solutions to these issues will require collaborative approaches and that siloed methods are no longer viable. The circular economy is a paradigm example of this multi-pronged approach. It necessitates participation from all sectors, including governments, businesses, and civil society.

Potential benefits of transitioning away from a standard linear economic model to a circular one include job creation, a reduction in pollution and emissions, and broadly increasing public well-being.

Turning Point, provides an overview of the circular economy and its current state in Canada, including some of the tools and approaches for measuring it in practice.

This report was made possible thanks to the important work and dedication of the Expert Panel, chaired by Tima Bansal, FRSC. The CCA's Board of Directors, Scientific Advisory Committee, and the three founding Academies — the Royal Society of Canada, the Canadian Academy of Engineering, and the Canadian Academy of Health Sciences — provided key guidance and oversight during the assessment process. I extend my thanks to everyone involved for their input and support.

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Peer Review

This report was reviewed in draft form by individuals selected by the CCA for their diverse perspectives and areas of expertise. The reviewers assessed the objectivity and quality of the report. Their confidential submissions were considered in full by the Panel, and many of their suggestions were incorporated into the report. They were not asked to endorse the conclusions, nor did they see the final draft of the report before its release. Responsibility for the final content of this report rests entirely with the authoring Expert Panel and the CCA.

The CCA wishes to thank the following people for their review of this report:

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The peer review process was monitored on behalf of the CCA's Board of Directors and Scientific Advisory Committee by **Karen Bakker,** Professor and Canada Research Chair in Political Ecology, University of British Columbia (Vancouver, BC); and **Eliot A. Phillipson, O.C., FCAHS,** Sir John and Lady Eaton Professor of Medicine Emeritus, University of Toronto (Toronto, ON); Former President and CEO, Canada Foundation for Innovation (Ottawa, ON). The role of the peer review monitor is to ensure that the Panel gives full and fair consideration to the submissions of the peer reviewers. The Board of the CCA authorizes public release of an Expert Panel report only after the peer review monitor confirms that the CCA's peer review requirements have been satisfied. The CCA thanks Dr. Bakker and Dr. Phillipson for their diligent contributions as peer review monitors.

Executive Summary

The Circular Economy (CE) is a concept that has increased in prominence in recent years as an alternative to the dominant linear economic model of "take-make-use-waste," in which raw materials are extracted to produce goods that are used and then discarded as waste. As demand for raw materials has continued to rise due to increased population, increased levels of consumption, and technological advances, humanity has begun to exceed the boundaries of what the planet can sustain. Non-renewable resources are quickly being depleted, and renewable resources are being extracted faster than their rate of replacement. Only a small portion of materials is cycled back into the economy, while the vast majority is landfilled, incinerated, or released into the environment. This not only creates environmental impacts — such as land degradation, pollution, and biodiversity loss — but it also wastes economically valuable materials and contributes to social inequalities, including the disproportionate exposure of marginalized communities to pollution.

The CE aims to conserve material resources through a variety of strategies that seek to maximize the material and economic value obtained from extracted and harvested resources. Circular strategies include design for durability, repair, and reuse; product-as-a-service (PaaS) business models; and material recovery and recycling. The CE reflects the cycles observed in nature, wherein carbon, water, and nutrients cycle through ecosystems. By reducing the extraction, harvest, and consumption of raw materials and reducing waste, the CE provides an opportunity for Canada to become more economically successful, environmentally sustainable, and socially equitable. However, if Canada takes no action to increase circularity, there are significant opportunity costs for its environment, economy, and quality of life. With no increase in circularity, Canada's waste and emissions will significantly increase, and Canadian firms will risk falling behind in global market share, competitiveness, and innovation as Canada's trading partners advance the CE.

The Charge to the Panel

Environment and Climate Change Canada (the Sponsor) asked the Council of Canadian Academies (CCA) to conduct an evidence-based assessment to answer the following question:

What are the potential opportunities and challenges for a circular economy in Canada?

To address the charge, the CCA assembled a multidisciplinary Panel of 16 experts from across Canada and abroad. The Panel included academic experts and practitioners from industry, governments, and non-governmental organizations (NGOs).

Defining and Measuring Progress Towards the CE

The CE is best seen as an aspirational direction in which to move that ultimately involves transformative, system-wide change.

As the Panel undertook the charge, members observed that the CE is subject to many definitions reflecting the diverse sectors and disciplines involved in it and the evolution of the CE concept over time. As such, the CE is difficult to define and should be considered not as an end-goal but as a journey where concrete steps and key targets are clearly identified. Transitioning to a CE represents a shift away from the traditional, predominantly linear model. To guide deliberations, the Panel defines the CE as:

> a systemic approach to production and consumption for living within planetary boundaries that conserves material resources, reduces energy and water use, and generates less waste and pollution.

In developing this definition, the Panel highlighted key considerations to enable the transition towards a CE. A CE can be achieved by maintaining the utility of manufactured objects over long periods of time; extending the service life of infrastructure, buildings, equipment, and goods; transforming valuable waste into inputs; and striving for circular agriculture. These shifts call for significant changes in practices to make governments, businesses, and civil society proactive in ensuring that economic activities advance sustainability and equity.

CE strategies and practices are implemented through loops of various scales at one or more points in the value chain, as summarized in Figure 1. CE loops are applied at the extraction and harvesting stages by increasing product and by-product recovery; markets are created for by-products and secondary materials through the circular procurement of materials. The implementation of circular design to inform manufacturing is key to increasing product life, durability, and recycling, and enabling further product sharing and reuse. The manufacturing stage also includes process optimization to maximize energy, water, and materials efficiency. Responsible and circular procurement of products and services is an important lever for governments in advancing a CE. At the distribution and product use stages, labelling, the use of sharing platforms,

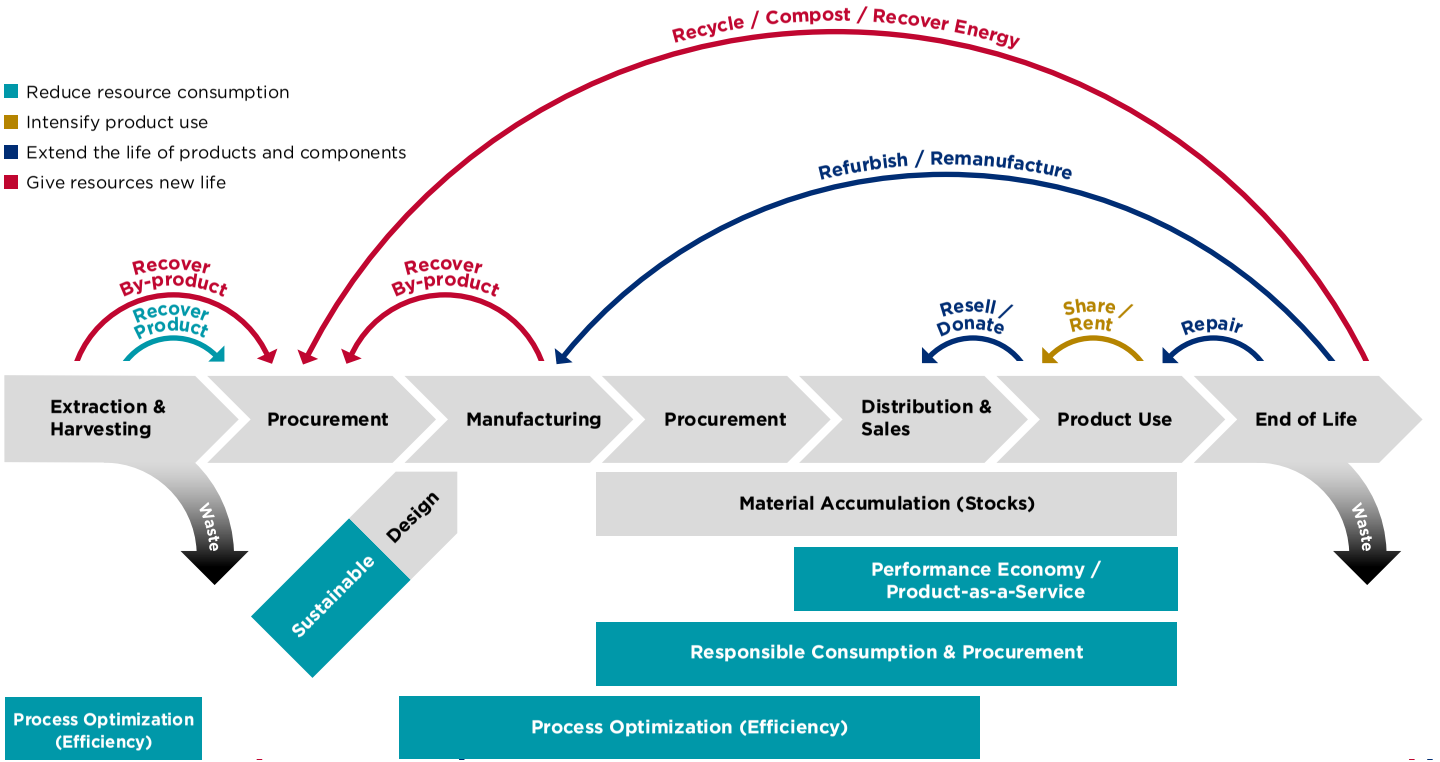


Figure 1 CE Strategies Create Loops in the Value Chain

CE strategies are represented as coloured loops or boxes, with colour indicating the related objectives identified by Institut de l'environnement, du développement durable et de l'économie circulaire. Recovering products can be considered part of the process optimization strategy, and recovering by-products, recycling, composting, or recovering energy can be implemented as part of industrial ecology. Sustainable design includes elements such as reducing material, increasing durability, and increasing ability to remanufacture. Loops include technical flows (e.g., high-value recycling) and biological flows (e.g., composting), which have distinct mechanisms (for more information see Braungart *et al.*, 2007), but which, for simplicity, are presented without distinction in this figure. The Panel notes that not all materials can be completely cycled, and not all material needs can be met by cycled materials alone.

and PaaS models can be implemented to increase product utilization and give consumers options for responsible consumption. At the end of life, products are processed to extract secondary materials for recycling, composting, or energy recovery; and secondary parts for reuse, remanufacture, refurbishment, or repair.

To assess Canada's progress towards the CE, more and better data are needed to measure the baseline circularity of the economy and track the effectiveness of policies and programs.

The measurement of circularity is essential to assessing the impact of CE practices and strategies. Measures of the CE include the circularity gap and circularity rate, both of which are not well estimated in Canada due to limited data. Canada does not currently track material flows in a comprehensive fashion (as the European Union does). These data are important for measuring the circularity of the Canadian economy, for setting priorities based on the estimates of the effects of various measures on circularity, for estimating the implications of changes such as a move to net-zero emissions for the circularity of the Canadian economy, and for comparing Canada's transition towards a CE with progress in other countries.

In addition to material flow data, the Panel noted that the following information would be particularly useful for measuring and advancing a CE in the Canadian context:

- data on the relationship between circularity and international trade, and on the trade of circular products and materials, particularly across the Canada-U.S. border;
- data on recycling capacity, materials landfilled, and tipping fees;
- data on the prevalence (availability and/or uptake) of circular business practices, such as PaaS models;
- improved circularity metrics that also capture the social impacts of the CE, such as health;
- standardized metrics for CE activities and product qualities, such as durability or ease of disassembly for repair;
- international definitions and classifications for secondary or end-of-life materials;
- research on circular business models and transforming linear models into circular ones;
- research on practices that Canadians associate with sustainability or circularity;
- research on the impacts of circular economic models on biodiversity;

- research and metrics on the impacts of different CE policies; and
- research on the relationships among economic growth, circular business models, and environmental impacts.

The implications of adopting a CE for material inputs in Canada are measured by modelling four scenarios.

The Panel developed a model to estimate the impact of circular approaches on the flow of materials in the Canadian economy. Four scenarios were created to illustrate what the Canadian economy would look like in 2040 if: (i) Canada were to continue to operate with no change in circular adoption, (ii) Canada were to adopt the current EU27 approach to circularity, (iii) Canada were to adopt France's highly circular measures, and (iv) Canada were to adopt the EU27 measures while aiming at net-zero greenhouse gas (GHG) emissions by 2050. Figure 2 compares the circularity rates, the amount of processed material, and the circularity gaps for each scenario.

Based on material flows data, the circularity rate of Canada in 2020 is 6.1%. If this rate were maintained for the next 20 years, both total material inputs and waste are projected to increase by 40%. Adopting circular practices comparable to those of the EU27 (Scenario 2) or France (Scenario 3) will increase Canada's circularity rate from 6.1% to 14.4% or 21.3%, respectively, by 2040. Under these scenarios, about half of the current material inputs will be needed, decreasing the circularity gap from 2.2 gigatonnes to 1.0 or 0.9 gigatonnes, respectively. Transitioning to net-zero GHG emissions in Canada by 2050 while adopting EU27 circularity practices (Scenario 4) will increase the circularity rate to 20.3% but will have only moderate impacts on reducing material inputs and the circularity gap due to increased extraction and processing of new materials required to produce enough renewable energy to maintain the same energy demand.

In addition, the EU27 + net-zero scenario provides insight into the cascading and competing effects of policies on material requirements. For example, the reduction in GHG emissions from fossil fuels could imply an increase in other processed materials, such as metals. In this case, mitigation measures may represent an opportunity for the mining sector in Canada, and circular approaches could help meet targets for responsible mining practices while also helping to establish and secure the critical mineral supplies necessary for the green energy transition. In this respect, the CE could be seen as a key contributor to the climate change agenda, not only reducing emissions relating to materials extraction and processing but also accounting for the material requirements of zero-carbon at the outset by embedding circular principles early on.

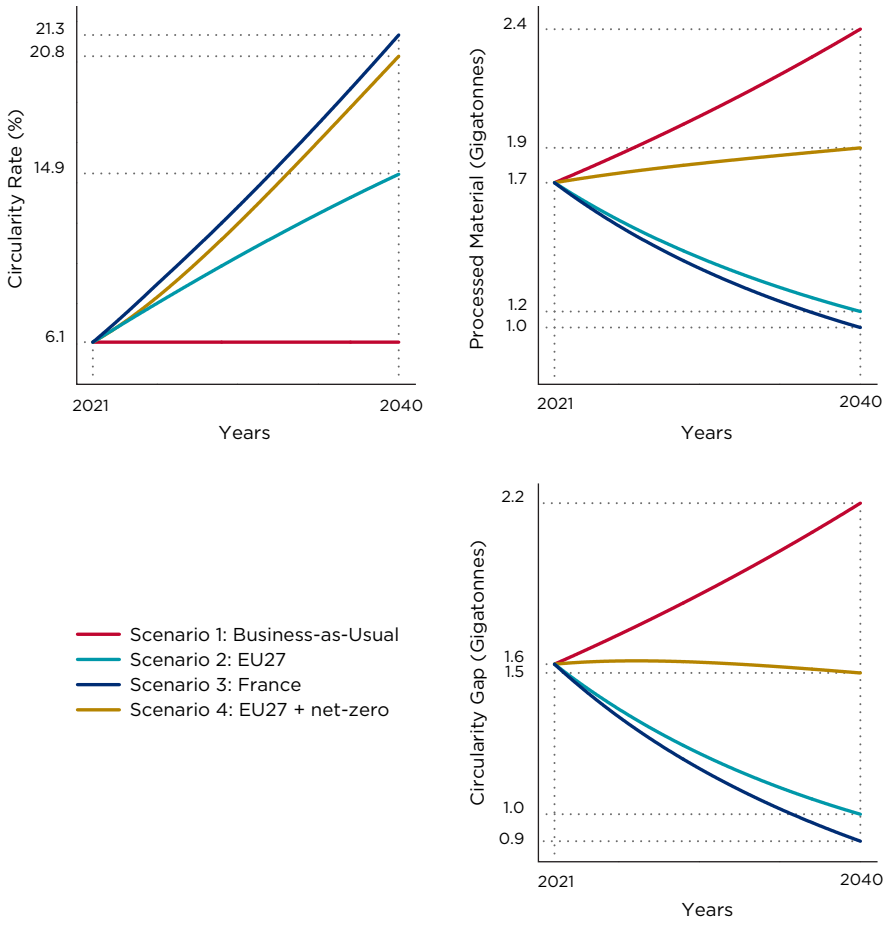


Figure 2 Implications of CE Policies in Canada: Four Scenarios

Scenario 1 (Business-as-Usual) is based on the continuation of the current pattern of materials use, projected out 20 years; Scenario 2 (EU27) simulates the impact of Canada transitioning over 20 years to the average performance of the EU27 in 2017; Scenario 3 (France) simulates the impact of Canada transitioning to the performance of France in 2017 over 20 years; and Scenario 4 (EU27 + net-zero) is the same as Scenario 2 but with the addition of a net-zero target for GHG emissions in 2050.

Factors Relevant to a CE in Canada

Canada's economic, environmental, social, geographical, and jurisdictional features require a distinct approach to the CE and have impeded Canada's progress so far.

The distinct features of the Canadian context have created challenges that have slowed Canada's transition towards the CE relative to peer countries. Unlike most countries pursuing a CE, Canada has a significant natural resource sector and will require specific strategies to help this sector through a circular transition. CE strategies must consider Canada's large size and low population density, the concentration of much of its population along the Canada–U.S. border, and differences between urban and non-urban areas. Canada's economy is also characterized by the prevalence of small- and medium-sized enterprises (SMEs), which provide opportunities for local CE strategies that could help to mitigate the geographical challenges. The CE also presents significant opportunities for Canadian firms that engage in value-retention activities like repair, refurbishment, and remanufacturing. On a broader scale, a close and integrated trade relationship with the United States and the exporting of a significant portion of plastic and e-waste will also affect the adoption of circular supply chains in Canada. Although there is strong support for environmental protection among the Canadian public, including support for some circular measures, cultural and geographic factors in Canada have contributed to the creation of an economy with very high consumption rates of materials, energy, and water. This high level of consumption degrades ecosystems and contributes to strain on planetary boundaries. Canada's federal jurisdictional structure means that each level of government has different roles and responsibilities with respect to implementing a CE, requiring cooperation across levels of government for a transition. Collaboration with Indigenous governments and communities is also an important component of a successful and inclusive CE transition, as Indigenous knowledge and practices incorporate concepts of circularity and responsible stewardship. An approach made in and for Canada will be necessary to advance the CE.

The Current State of the CE in Canada

Canadian industry has sectoral strengths and existing initiatives that can be built on to advance the CE.

Sectoral strengths and opportunities represent seeds of circularity in Canada in various industries, including plastics, natural resources, construction, food and agriculture, electronics, and textiles. Many Canadian CE initiatives currently deal with plastics, largely promoting plastics recycling. Nearly half of plastic waste in Canada comes from packaging, a key area for waste reduction. Mining, forestry, and

fossil fuel industries are also exploring circular strategies in resource extraction and processing, such as reducing waste and recovering valuable by-products, the implementation of which would generate more value from Canada's natural resources sector. Construction represents a core sector for advancing the CE in Canada due to its economic importance, high material requirements, and large amounts of waste. Even small changes regarding the reuse of buildings or building materials could have a significant impact. Preventable food waste in Canada has an economic value of at least $49 billion, and several Canadian companies are taking advantage of opportunities to reduce and recycle food and agricultural waste. In the electronics sector, key initiatives for increasing circularity include product–service systems, product life extension, and design for disassembly. Several initiatives within the textile sector in Canada are geared towards increasing textile recycling; additional initiatives could target the underutilization of clothing. Industrial symbiosis projects and the development of eco-industrial parks in Canada have advanced the CE in a variety of sectors. Industry-specific training programs could also be introduced in multiple sectors to help prepare the Canadian workforce for a transition to a CE.

Steps towards a CE have been initiated at multiple levels of government, and NGOs, universities, and colleges are supporting a transition.

Various Canadian jurisdictions have implemented initiatives or strategies that contribute to a CE, though these are somewhat limited, and only Quebec has advanced a comprehensive approach. Federal initiatives towards the CE include the Canada-wide Strategy on Zero Plastic Waste and exploring circular procurement opportunities. Current provincial and territorial initiatives largely focus on waste management, plastics, and extended producer responsibility (EPR), though several provinces have instituted sustainability strategies that include additional CE concepts. Many municipalities in Canada have become involved in the CE through zero-waste strategies, new circular procurement standards, or other initiatives. Collaborations among local governments, NGOs, and provincial and territorial agencies, such as the Canadian Circular Cities and Regions Initiative (CCRI), support knowledge sharing and capacity building. More broadly, many NGOs in Canada are supporting cross-sectoral collaboration towards a CE. Several Canadian universities and colleges have developed significant expertise in CE research, are collaborating to facilitate the transition towards a CE, and also offer some CE courses or programs. This patchwork of government and civil society initiatives has been useful in the early stages of the CE, but coordination of efforts would be needed to create systemic change.

Challenges to implementing a CE in Canada

Businesses find it challenging to adopt circular strategies due to linear supply chains, economic disincentives, and a lack of practical information.

Economic disincentives, as well as shareholder pressure to minimize risks, have inhibited circular leadership in business. Landfilling and virgin materials are both low cost in Canada, which creates economic disincentives for waste reduction and the use of secondary materials. The cost of investment is high for some circular business models, such as refurbishment, which is difficult for businesses to justify when the long-term return on circular investments is unclear. Investment costs are especially challenging for SMEs, which have limited access to capital. To be most effective, the CE requires not only coordination within a business but coordination across the supply chain. Businesses thus find implementing circular strategies within linear supply chains to be challenging. Trust can be difficult to establish between businesses, which impedes the sharing of information relevant to establishing circular practices. Innovation and commercialization of innovative solutions are also necessary to advance the CE but piloting circular business models is challenging. In the absence of practical information regarding how to adopt these models, businesses often adopt linear models such as planned obsolescence, which are competitive under existing linear systems.

Aligning policies and regulations to support a CE is challenging, especially given Canada's jurisdictional complexity.

The development of policies such as sustainable procurement and effective EPR in Canada has been hampered by a fragmented policy approach, information gaps, and difficulty balancing the needs of different stakeholders. Lobbying is known to slow the development of sustainability policy and could be a significant factor for CE policy development given Canada's long history of natural resource-focused economic policy. Data gaps and limited circularity metrics impede the development of effective circular policy and assessment of the impacts of interventions. Canadian data collection regarding waste diversion is inconsistent between jurisdictions. Moreover, the effects of a shift towards CE on global trade are unclear. Trade barriers, such as a lack of international standards for circular materials, will need to be overcome to advance the CE on a global scale. One key challenge will be to ensure that regulations permit trade in valuable secondary materials without allowing waste to be exported to developing countries that do not have the capacity to process it safely. To address many of these barriers, collaboration and policy harmonization are needed across governments in Canada, but this coordination is difficult given Canada's jurisdictional complexity.

A cultural shift is necessary to promote circular behaviour among consumers, but accessibility also impedes the adoption of circular practices.

Canada has a strong culture of consumerism, which promotes overconsumption, contributes to attitudes that reduce demand for refurbished products or recycled material, and impedes individual adoption of circular practices such as reuse and sharing. Demographics and socio-economic status affect the cultural acceptability of circular practices. Moreover, material factors such as affordability, contractual obligations, or urban structure impact the accessibility of circular practices. Material conditions also affect the accessibility of the CE for some communities: distance and climate limit the types of material loops that can be effectively established, and these challenges are heightened for rural and remote communities due to infrastructure gaps and low population densities. Indigenous communities may also need new mechanisms to access capital for circular investments. On the national level, the CE may create unintended negative social impacts, for example, through job market shifts, which will have to be accounted for when planning the circular transition. Negative social and environmental effects could also occur globally, for example, if the advancement of the CE in Canada results in the outsourcing of pollution to developing countries. A rebound effect, where increased efficiency leads to increased consumption, could also offset the benefits of the CE.

Opportunities for a CE in Canada

Circular business models and strategies provide economic benefits such as new revenue streams, reduced supply chain risks, and improved brand reputation.

Circular business models create new revenue streams through the provision of new services or by obtaining value from by-products and offer competitive advantages to businesses by reducing requirements for material and energy inputs. Circular business models such as PaaS create long-term relationships with customers, improving loyalty and stabilizing revenue flows. The use of secondary materials in place of raw materials helps to mitigate supply chain risks. Collaborative strategies such as industrial symbiosis create opportunities for businesses to use another firm's waste products as production inputs. Collaborative networks also provide a competitive advantage for participants by improving information sharing and incentivizing optimal asset management across a supply chain. Finally, circular practices help businesses meet the expectations of stakeholders who increasingly expect businesses to engage in environmentally and socially responsible practices. Shifts to circular systems by Canada's trading partners are likely to intensify the competitive advantages of circular models and practices.

A CE would help Canada to achieve existing policy goals, such as the net-zero transition, and would create economic, environmental, and social benefits.

Material and energy efficiency and sustainable production and consumption provide economic, environmental, and social benefits for high-income, natural resource-exporting countries such as Canada. The CE may offer a chance for Canada to become an international leader in sustainable natural resource management. Even with a global transition towards a CE, increasing demand for raw materials means that Canada's natural resource exports will still be required. In particular, the material requirements of increasing renewable energy infrastructure motivate planning a transition towards a CE alongside Canada's climate change agenda to secure minerals important for renewable energy production (Figure 2). Materials efficiency policies and improved waste management strategies could also contribute to meeting carbon emissions targets by reducing the energy used to extract and process materials and avoiding methane emissions from organic waste. This would help Canada fulfill its commitments under the Paris Agreement and the Pan-Canadian Framework on Climate Change and Clean Growth, which were both adopted in 2016. A transition towards a CE would also help Canada meet the United Nations Sustainable Development Goals and would contribute to a resilient economic recovery from COVID-19.

Societal benefits such as increased equity and well-being could be achieved through a just transition towards a CE, and net effects on employment are likely to be positive or neutral.

While a transition towards a CE does not guarantee a more equitable society, it provides an opportunity to achieve societal benefits such as poverty reduction, meaningful employment, and human well-being. A *just transition* approach, including collaborative and inclusive planning processes, helps ensure that the benefits (and risks) of the CE are equally distributed through society, both within Canada and internationally. While the CE is expected to cause significant labour market shifts, studies suggest that the effect on employment in Canada will be a net positive or neutral, with job losses resulting from the transition offset by job gains in other sectors. Job growth in Canada is expected to occur primarily in renewable resources, waste, and clean technology sectors, with particular opportunities in the reprocessing of secondary metals.

Levers for Change Towards a CE

While governments use many levers to advance the CE, policy coordination across government levels and departments is essential for the success of CE initiatives.

Circular procurement is a powerful lever for governments, as it creates demand for circular products and services and creates market signals. Other economic instruments, such as tax policy, disposal fees, and federal transfer payments, can encourage circular activities and discourage linear practices. Governments could also make public investments in circular infrastructure and support and attract private CE financing through regulations or other interventions. Regulations for sustainable design improve product circularity while also benefiting businesses. Provincial and territorial EPR programs have generally not resulted in greater circularity in material flows, or the reduction of waste; however, improved incentives for circular design should result in less waste and more recycling. Canada's federal, provincial/territorial, and municipal governments have various roles to play, such as making trade agreements, offering education and skills training, and engaging local stakeholders, respectively. Structures that enable collaboration across and within governments will be important in harmonizing circular policies and regulatory schemes. A key role for national governments is the development of a CE strategy or roadmap; roadmaps can also be implemented at subnational levels, as well as for specific sectors or materials. Roadmaps provide an opportunity to involve diverse stakeholders in industry and civil society and to adapt CE strategies to the Canadian context.

Businesses can advance the CE through circular strategies, investments, standards and certifications, and company-wide and inter-firm commitments.

Company-wide commitments to the CE provide strong signals to policymakers, company staff, suppliers, and other companies, unlocking business opportunities while advancing the CE. Inter-firm partnerships such as industrial symbiosis also accelerate the circular transition. Adopting new technologies such as the internet of things, artificial intelligence, and 3D printing help businesses to implement circular practices by improving design or supporting reverse logistics. For the financial services sector, private investment is important to support companies and industries transitioning towards a CE and allows investors to address environmental, social, and governance issues. Businesses and industry associations can use circular standards and certifications — or play a role in the development of such standards — to provide assurance of quality and compliance with CE principles. Such standards are useful in supporting circular procurement. Industry also plays a role in developing training for CE skills.

Civil society will need to be engaged to advance the transition; individual behavioural change has a limited ability to drive the CE.

Public support will be necessary for a circular transition, and cultural norms around consumption will need to shift. However, the culture of overconsumption involves a broad social context, and a systems-level view will be necessary to identify the social conditions that structure options for individuals and incentivize overconsumption. Overall, consumer interest and individual behaviour are insufficient to drive the CE. At the same time, education, public awareness, and skills training will be needed to support the transition towards a CE and promote the uptake of CE practices and products among both consumers and producers. Incorporating the CE into educational curricula and offering training and retraining for workers will prepare the workforce for the CE labour market. NGOs help drive circularity in Canada by contributing research, facilitating partnerships and collaboration between stakeholders, providing guidance and best practices, sharing information, engaging in advocacy, and facilitating the development of roadmaps.

Final Reflections

As the mounting social and environmental costs and economic risks of the linear economy become increasingly apparent, the CE is recognized as an important contributor to move towards a more sustainable economy. Because the CE is specifically aimed at creating economic value by improving environmental outcomes, in the view of the Panel, it represents a model that rejects a false dichotomy between the environment and the economy. A transition towards a CE will help Canada to meet existing policy goals and support Canada's climate agenda while also enabling economic productivity through more informed and efficient ways of design, production, and consumption. Current systems and incentives are based on linear economic approaches; thus, a transition towards a CE will require transformative, systems-level change. At the same time, this transformation will be advanced in part by taking advantage of "small wins" that accumulate into more significant changes. Indeed, Canada currently has many circular initiatives that can be built on to advance the CE. Leveraging these existing initiatives requires a collaborative cross-sectoral approach involving multiple levels and departments of government, along with different industries and stakeholders in civil society. Such an approach would need to be supported by continuous innovation and strengthened data collection. While it is not possible to achieve a completely circular economy, the journey towards one is an opportunity to create sustainable links among the economy, society, and the environment that will benefit human well-being.

Glossary

Backfilling	"A recovery operation where suitable waste is used for reclamation purposes in excavated areas or for engineering purposes in landscaping and where the waste is a substitute for non-waste materials" (Eurostat, 2015).
Biodiversity	"The diversity of wildlife that safeguards the preconditions for life on Earth. Biodiversity can be examined through factors such as species diversity, intraspecific genetic variation and ecosystems formed by various species" (Sitra, 2021).
Biofuel	"A fuel made of biomass (organic matter). For example, dried wood chips that can be burned or refined biofuel such as bioethanol or biodiesel" (OECD, 2013a).
Biomass	"Organic, non-fossil material of biological origin (plants and animals) used as a raw material for production of biofuels" (Eurostat, 2015).
Carbon Neutral	"A product, company, municipality, or state that only emits as much carbon dioxide as it can offset. The carbon footprint of a carbon-neutral product during its entire life cycle is zero" (Sitra, 2021).
Carbon Sequestration	"A biochemical process by which atmospheric carbon is absorbed by living organisms, including trees, soil micro-organisms, and crops, and involving the storage of carbon in soils, with the potential to reduce atmospheric carbon dioxide levels" (OECD, 2013b).
Circular Business Models	"Business models designed in ways that are aligned with one or more of the circular economy principles" (EMF, n.d.-a).
Circular Economy (CE)	A systemic approach to production and consumption for living within planetary boundaries that conserves material resources, reduces energy and water use, and generates less waste and pollution (as defined by the Panel).
Circularity Gap	The difference between total processed material and the contribution of non-virgin materials from recycling and backfilling (Victor & Chapariha, 2021).
Circularity Rate	"[A measurement] of the contribution of recycled materials towards the overall use of materials. The circularity rate is the share of material resources used in the [economy] which came from recycled products and recovered materials, thus saving primary raw materials from being extracted. A higher circularity rate means that more secondary materials replace primary raw materials, thus reducing the environmental impacts of extracting primary material" (Eurostat, 2020).
Clean Technology	"Any technology that uses less material or energy, generates less waste, and causes less negative environmental impact than the industry standard" (ECO Canada, 2020).

Eco- or Sustainable Design	"Eco-design accounts for the environmental impact of a product from its design phase, notably by optimizing its use of resources and durability, including modularization and remanufacturing, component reuse and reduction in raw materials use" (CPQ, 2018).
Eco-Industrial Park	"A business community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues, including for instance energy, water, and materials" (Halonen & Seppänen, 2019).
Energy Recovery	"A waste treatment process that generates energy in the form of electricity, heat or fuel" (SPI, 2020b).
E-Waste	"A term used to cover items of all types of electrical and electronic equipment … and its parts that have been discarded by the owner as waste without the intention of re-use" (UNU/StEP Initiative 2014, 2014).
Fossil Fuels (fossil energy materials)	"A generic term for non-renewable energy sources such as coal, coal products, natural gas, derived gas, crude oil, petroleum products and non-renewable wastes" (Eurostat, 2015).
Greenhouse Gas	"Atmospheric gases that let solar radiation reach the earth's surface but absorbs the heat radiating from it. Greenhouse gases include water vapour, carbon dioxide, methane, tropospheric ozone, dinitrogen oxide and F-gases, or fluorinated greenhouse gases" (Sitra, 2021).
Incineration	"A method of waste disposal that involves the combustion of waste. It may refer to incineration on land or at sea. Incineration with energy recovery refers to incineration processes where the energy created in the combustion process is harnessed for re-use, for example for power generation. Incineration without energy recovery means the heat generated by combustion is dissipated in the environment" (Eurostat, 2015).
Industrial Ecology	"The study of the flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use, and transformation of resources" (White, 1994).
Industrial Symbiosis	"Industrial symbiosis engages traditionally separate entities in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products" (Chertow, 2000).
Linear Economy	"An economy in which finite resources are extracted to make products that are used — generally not to their full potential — and then thrown away ('take-make-waste')" (EMF, n.d.-c).
Linear Lock-In	"The engrained structures that have anchored themselves around our linear-based growth models" (EMF, 2014).
Material Accumulation (net additions to stocks)	"Measures the 'physical growth of the economy'…Materials are added to the economy's stock each year (gross additions), and old materials are removed from stock as buildings are demolished, and durable goods disposed of (removals)" (Eurostat, 2009).

Metal Ores	"Metal ores (also called gross ores) are all the materials which are removed from the mine for the purpose of extracting the desired metal(s). Materials which are removed from the mine for the sole purpose to get access to the reserve, but are then left at the site, are not included" (Eurostat, 2015).
Planetary Boundary	"A safe operating space for humanity based on the intrinsic biophysical processes that regulate the stability of the Earth system" (Steffen *et al.*, 2015).
Process Optimization	"An operations strategy that aims to continuously and iteratively eliminate waste through improved production processes. It involves making only what is necessary in order to minimize excess inventory and streamlining production to reduce time spent on production and improve flow processes" (SPI, 2020b).
Product-as-a-Service (PaaS)	"A business model where the ownership of the product remains with the manufacturer, incentivising, for example, longer product life, easier refurbishment, and better recycling, meaning it is more likely to lend itself to the principles of a circular economy" (EMF, n.d.-a).
Recycling	"Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations" (Victor & Chapariha, 2021).
Remanufacture	"Re-engineer products and components to as-new condition with the same, or improved, level of performance as a newly manufactured one" (EMF, n.d.-c).
Renewable Energy Sources	Energy (electricity, heat, and fuel) created from "non-biomass-based renewable sources" (solar, wind, hydro, geothermal) or biomass-based energy ("must be a by-product of a process that primarily aims to recirculate nutrients") (EMF, n.d.-a).
Reuse	"Reuse of waste means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived" (Eurostat, 2015).
Sharing Economy	"A new kind of economic thinking, in which the opportunity to use goods and services is regarded as more important than owning them" (Sitra, 2021).
Small Wins	"Concrete, completed, in-depth changes [that] can accumulate into transformative change through various non-linear propelling mechanisms" (Termeer & Metze, 2019).

Abbreviations

BAU	business-as-usual
CCME	Canadian Council for Ministers of the Environment
CE	Circular Economy
CTTÉI	Centre de transfert technologique en écologie industrielle
ECCC	Environment and Climate Change Canada
EDDEC	Institut de l'environnement, du développement durable et de l'économie circulaire
EMF	Ellen MacArthur Foundation
EPR	extended producer responsibility
ESG	environmental, social, and governance
GHG	greenhouse gas
ISO	International Organization for Standardization
NRCan	Natural Resources Canada
NZWC	National Zero Waste Council
OECD	Organisation for Economic Co-operation and Development
PaaS	product-as-a-service
SDG	Sustainable Development Goals
SME	small- and medium-sized enterprise
SPI	Smart Prosperity Institute

Contents

1 Introduction 1
1.1 Charge to the Panel 4
1.2 The Panel's Approach and Methodology 4
1.3 Approach to Evidence 5
1.4 Structure of the Report 7

2 Defining and Measuring the CE 8
2.1 Defining the CE 10
2.2 Strategies Supporting the Implementation of a CE 12
2.3 Measuring Circularity 19
2.4 Modelling Material Flows to Estimate the Potential Impact of the CE in Canada 25

3 Factors Relevant to a CE in Canada 38
3.1 Geographic and Jurisdictional Context 39
3.2 Economic Context 41
3.3 Environmental Context 46
3.4 Social Context 49

4 The Current State of the CE in Canada 52
4.1 Sectoral Initiatives and the CE 53
4.2 Jurisdictional Strengths 66
4.3 Partnerships and NGOs 73
4.4 Research Strengths 75
4.5 Skills Strengths 76

5 Challenges to a CE in Canada 78
5.1 Geographic Barriers 80
5.2 Economic Barriers 83
5.3 Business Barriers 86
5.4 Data Barriers 92
5.5 Policy and Regulatory Barriers 95
5.6 Social and Behavioural Barriers 103

6 Opportunities for a CE in Canada 112
6.1 Economic Opportunities for Businesses 114
6.2 Labour Market Opportunities 117
6.3 Opportunities for Economic Growth 120
6.4 Opportunities for a More Socio-Economically Equitable Society 121
6.5 Opportunities for Canada's Natural Resources Sector . . . 123
6.6 Opportunities to Meet Existing Policy Goals 126
6.7 Opportunities Relating to Energy 129
6.8 COVID-19 Recovery and Increasing Resilience 131

7 Levers for Change Towards a CE 134
7.1 Economic Instruments and Policies 136
7.2 Innovation 146
7.3 Public Awareness, Education, and Skills Training 154
7.4 Trade and International Relations 157
7.5 EPR Programs 159

8 Advancing the Transition Towards a CE in Canada . . . 162
8.1 CE Roadmaps and Strategies 163
8.2 The Role of Different Actors 167
8.3 Governance of a CE 172
8.4 Implementation Approaches 174

9 Conclusion and Panel Reflections 177
9.1 Answering the Charge 178
9.2 Panel Final Reflections 189

Appendix 193

References 201

1

Introduction

1.1 Charge to the Panel
1.2 The Panel's Approach and Methodology
1.3 Approach to Evidence
1.4 Structure of the Report

With human activities straining multiple planetary boundaries, global economic systems are in need of change. For more than 150 years, the dominant linear economic model has been based on a "take-make-use-waste" approach in which raw materials are extracted to produce goods that are used and then discarded as waste. Although the median standard of living has increased in developed countries for many years (Nolan, 2020), evidence suggests that we have now reached the limits of linear models.

Demand for materials has increased because of a growing global population, increased per capita consumption, and the adoption of more advanced technologies. Over 100 billion tonnes of materials are currently being used or consumed yearly worldwide (CGRI, 2020). This is associated with a growing ecological footprint. The extraction and processing of resources for use and consumption account for over 90% of environmental impacts on biodiversity loss and water stress and half of greenhouse gas (GHG) emissions (IRP, 2019). Half of the planetary boundary limits first proposed by earth and environmental scientists in 2009 have been exceeded, in particular for the rate of biodiversity loss (Rockström *et al*., 2009; Steffen *et al*., 2015). Given these issues, the idea of a circular economy (CE) has become highly visible as an alternative to the linear economy. This report explores what a CE is, how it works, and how it could benefit Canada. It also examines the social, cultural, economic and policy opportunities and challenges Canada will face in planning a CE transition.

Goods are often made from materials that are renewable but extracted beyond the rate of their replacement or from materials that are non-renewable and increasingly depleted. The CE aims to reduce the extraction of new materials and limit the waste that is generated by the production and consumption of goods. This is done through a variety of strategies that seek to maximize the value obtained from extracted materials. The life of products is extended through durable design and repair so that these materials remain in use for longer. The value obtained from a good is maximized by models such as renting, sharing, and Product-as-a-Service (PaaS) practices that allow multiple customers to gain the benefits of products without individually owning them. Resources are used more efficiently, and by-products and end-of-life materials are seen as valuable resources that are cycled back into the economy rather than discarded. In this way, the CE shares similar characteristics to the cycles observed in natural ecosystems for nutrients, carbon, and water.

In Canada, where recycling programs have been in place for the last 30 years, only 9% of plastics are recycled, with the rest being dumped in landfills (86%), incinerated (4%), or released into the environment as litter (1%, or 29,000 tonnes)

(Deloitte, 2019a). Globally, only 9% of all raw materials extracted annually are cycled back into the economy. While another 31% of these materials remain in use, 61% currently become unrecoverable, ending up as pollution from extraction operations, as waste, and as emissions contributing to climate change and other environmental problems (CGRI, 2020). Environmental degradation contributes to social inequities; in Canada, air and water pollution disproportionately affect Indigenous, racialized, and low-income populations (Mascarenhas, 2007; Giang & Castellani, 2020).

By conserving resources and reducing waste, the CE proposes to address economic, environmental, and social issues related to material consumption and use. As such, it provides a unique opportunity for Canada to become more economically successful, environmentally sustainable, and socially equitable by acting quickly and ambitiously. Potential benefits from the CE include obtaining greater value from materials, developing novel business models, creating new jobs in materials recovery and renewable energy, developing a more resilient supply chain, reducing costs locally and regionally, reducing pollution and emissions, mitigating social injustice, and broadly increasing public well-being. Moreover, innovation will play an important role in the advancement of a CE and will create opportunities for Canadian businesses. The CE approach to the consumption of materials, water, and energy can help the Government of Canada make progress towards international commitments to the Sustainable Development Goals (SDGs) and climate targets, including the 2016 Paris Agreement.

Achieving these results requires public and private action, and some steps have already been taken towards a CE in Canada and internationally. Some governments and businesses have made efforts to reuse and recover materials and develop innovative business models and product design. International interest in the CE has grown in the past three decades in jurisdictions such as China and the European Union (EU), often driven by limitations on domestic sources of natural resources. Differences in the availability of materials, as well as geography and social and political contexts, require Canada to develop its own approach to circularity. The CE is part of a set of existing tools and approaches that will contribute to bringing human activity back within planetary boundaries. Advancing the CE is not without challenges, downsides, or limitations, but it also represents an opportunity for Canada to demonstrate international leadership in sustainable natural resource management and journey towards a smarter way of consuming.

1.1 Charge to the Panel

To better understand the opportunities and challenges of implementing CE approaches in Canada, Environment and Climate Change Canada (ECCC, the Sponsor) has asked the Council of Canadian Academies (CCA) to answer the following question and sub-questions:

What are the potential opportunities and challenges for a circular economy (CE) in Canada?

- What are the key components and approaches of a CE?
- What are the potential economic, environmental, and social impacts of a CE in Canada?
- Drawing from relevant international examples and Canadian data, what are the early opportunities (economic, environmental, and social) for advancing a CE in Canada? What are the challenges (e.g., governance, technological, economic, trade, cultural) to realizing these opportunities?
- What are the implications of advancing or not advancing a CE in Canada?

To address the charge, the CCA assembled a multidisciplinary Panel of 16 experts from across Canada and abroad. Panel members brought expertise related to business, economics, social sciences, natural resources, governance, and engineering. The Panel included academic experts and practitioners from industry, governments, and non-governmental organizations (NGOs).

1.2 The Panel's Approach and Methodology

One of the Panel's first tasks was to determine the various research fields, terminology, and practices that relate to the CE. The Panel noted that the CE is not a field or discipline by itself, but instead is defined by the many sectors in which it is applied. As such, although the core concepts of a CE are broadly applicable, there is not a single definition of the CE.

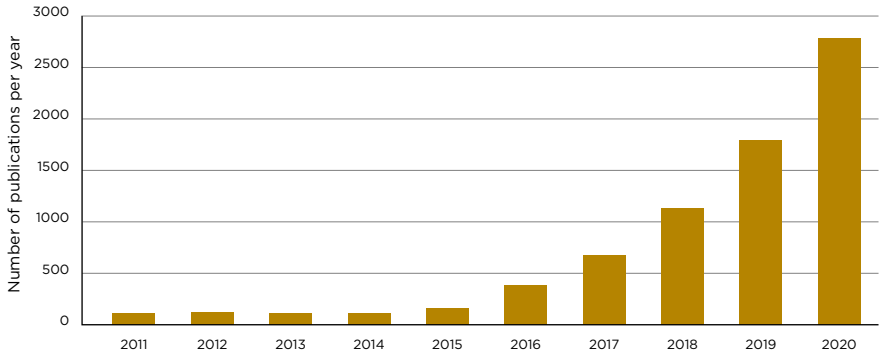
This assessment examines current and potential strategies within industries and government policies around the CE, both in Canada and internationally. The focus of the assessment is the economic, environmental, and social impacts of CE approaches, as well as the opportunities and challenges for government and industry in Canada around advancing a CE. The Panel examined leading indicators, metrics, and methodologies for measuring the degree of circularity in an economy and developed a simulation model to estimate the impact of various circularity measures, such as more recycling and more durable products, on material flows. This tool is applied in the report to generate specific simulations of the impacts and effectiveness of circularity measures for reducing requirements for new materials and the generation of waste. Although a CE is expected to contribute to GHG reduction, assessing the quantitative impact of a CE on climate change was not a focus of this report. Similarly, while quantitative cost–benefit analyses or risk assessments of CE approaches and strategies are outside the scope of the assessment, the challenges and opportunities of various CE strategies are qualitatively described.

1.3 Approach to Evidence

This assessment draws on evidence from a wide range of sources in a variety of sectors, including academia, government, and industry, as well as NGOs. Publicly available evidence considered in this assessment includes peer-reviewed literature, reports from government and industry, statistics from various national and international agencies, grey literature, and more.

1.3.1 Literature Review

The peer-reviewed literature covering the domains of the CE is recent and vast, as the CE can be applied as part of many disciplines. As of the end of 2020, the Web of Science Core Collection contained 7,882 English publications on the CE. Most of these were associated with environmental sciences/studies, environmental engineering, and green technologies, but publications on management, economics, and business were also included. The number of publications using the term *circular economy* has increased significantly over the last decade, particularly after 2016 (Figure 1.1). This timing may correspond with the increased interest of several countries in the CE, which led to the first World Circular Economy Forum in 2017. Within Canada, the number of publications on the CE is very limited, with a total of 149 results, mostly related to waste reduction. Notably, French-language publications are not included in this survey, such that some publications from Quebec were likely excluded from the initial review, though some French-language publications were identified by the Panel during the assessment process.



Data Source: Web of Science (2021)

Figure 1.1 Number of Publications per Year Using the Term Circular Economy, 2011-2020

This chart shows the increase in the number of references to the term circular economy in published literature. Fewer than 100 publications per year were found prior to 2009, and no publications were found prior to 1989.

While the term circular economy has only recently gained wide visibility, the concept incorporates a variety of related ideas, such as *industrial ecology, biomimicry*, and *cradle-to-cradle* (Friant *et al.*, 2020). The terminology for these related ideas may have been used more frequently than CE in the past, and in some cases, these terms are still used in a way that overlaps with the CE literature. In addition, many studies refer to circular practices without using the term circular economy. A series of related terms were identified for inclusion in the literature review.[1] This literature was complemented by a review of grey literature from various sources. The Panel notes that both the grey and peer-reviewed literature regarding the CE are quickly evolving due to increased interest in and experimentation with CE practices. This fast evolution complicates the assessment of current evidence on the CE, as many publications may quickly become out of date, and selecting publications that remain relevant today is challenging.

1.3.2 Data and Modelling

This report highlights several important gaps in assessing the potential of a CE in Canada. Although data exist for specific commodities (e.g., plastics) or on some circular approaches (e.g., recycling), insufficient data currently exist to broadly and adequately describe the quantities of materials entering and leaving the

1 The following terms were identified: industrial ecology, life-cycle thinking/management, cradle-to-cradle, regenerative design, blue economy, performance economy, functional economy, biomimicry, bioeconomy, green manufacturing, and extended producer responsibility (EPR) (as a practice connected to the CE).

economy. As a result, some of the metrics and tools used in other countries to assess the effectiveness of CE approaches cannot be applied in Canada.

Statistics Canada does collect and publish economic resource accounts about some natural resources in Canada (GC, 2021b); however, gaps remain. For example, although natural resource extraction and import/export data are available, comprehensive material stock and flow accounts are not published in Canada comparable to what is available in Europe through Eurostat.

The charge asks that early opportunities be identified for advancing a CE in Canada, using international examples and Canadian data. To address this, the Panel created a database for Canada to describe material flows and developed a model to simulate policies intended to promote circularity. The results were visualized using Sankey diagrams for a series of scenarios ranging from low to high circularity. A summary of the model is available in the Appendix, and further details are included in Victor & Chapariha (2021).

1.4 Structure of the Report

The remainder of the report is organized as follows:

- Chapter 2 presents the Panel's definition of the CE, provides an overview of circular practices and business models, and describes the tools and approaches for measuring circularity in practice. The chapter also presents the outcome of selected modelling scenarios on the flow of materials in the Canadian economy.
- Chapter 3 provides the Canadian geographic, jurisdictional, economic, environmental, and social contexts with respect to the CE and introduces some unique opportunities and challenges for Canada.
- Chapter 4 describes the state of CE in Canada. The chapter focuses on the early successes in implementing circular approaches in Canada across various sectors of the economy, as well as in different levels of government.
- Chapter 5 provides an in-depth discussion of the challenges of implementing a CE in Canada, categorized by the geographic, economic, business, data, policy, and social dimensions of those challenges.
- Chapter 6 explores some of the key economic, environmental, and social opportunities and benefits of transitioning to a CE in Canada.
- Chapter 7 describes some of the policy levers that help to advance the transition to a CE in Canada.
- Chapter 8 outlines important considerations for implementing a CE strategy in Canada, as well as the respective roles of government, business, and civil society in advancing the transition.
- Chapter 9 concludes the report by answering the charge and providing final reflections from the Panel.

2

Defining and Measuring the CE

2.1 Defining the CE

2.2 Strategies Supporting the Implementation of a CE

2.3 Measuring Circularity

2.4 Modelling Material Flows to Estimate the Potential Impact of the CE in Canada

Chapter Findings

- The CE has various definitions which reflect the needs of various sectors. The CE can be seen as a journey for society to re-invent its economy by the creation of loops in the value chain providing value through access to goods rather than ownership and improved efficiency.
- Canada has high potential for CE implementation, with estimates showing that North America has the third-largest circularity gap globally.
- Meaningful comparisons with other countries and assessing CE outcomes domestically are made difficult by a lack of comprehensive data on material flows in Canada.
- Based on available material flow data, the circularity rate of Canada in 2020 was 6.1%. If this were maintained for the next 20 years, both total material inputs and waste would increase by 40%.
- Adopting circular practices comparable to that of the EU27 or France would increase Canada's circularity rate from 6.1% to 14.4% or 21.3%, respectively, by 2040. Under these scenarios, about half of the current material inputs will be needed, and the circularity gap will decrease from 2.2 gigatonnes to 1.0 or 0.9 gigatonnes, respectively.
- Transitioning to net-zero GHG emissions in Canada by 2050 while adopting circular practices comparable to the EU27 would increase the circularity rate to 20.3%, but would have moderate impacts on material inputs and the circularity gap due to the increased extraction and processing of new materials required to produce enough renewable energy to maintain the same energy demand.

The concept of a CE has been studied and developed mostly in Europe and Asia (McDowall *et al.*, 2017), and it can still be considered an underdeveloped approach in North America given the limited number of publications on it. In Canada, the CE has become of recent interest to local and provincial/territorial governments, with the province of Quebec currently adopting the most comprehensive CE approaches. It is also a concept that has been informed by multiple disciplines, each with corresponding differences in definitions and focal points. As indicated in Chapter 1, although the concept of a CE is still relatively new in Canada, many other terms related to the CE have been used in the past. Despite the diverse definitions of the CE, key common features can be identified. The purpose of this chapter is to establish an understanding of the CE, including the Panel's definition, with central concepts and measurement aspects. It also presents a model which sets out both the potential and the limits of the CE in Canada.

Most current models used to assess circularity have focused on the impacts that the CE may have on the economy, with fewer models focusing on the material flows, despite the major objective of the CE to retain and cycle materials at their highest value. The Panel notes the importance of considering both material flow and economic outcomes when defining and measuring CE (Section 2.3).

2.1 Defining the CE

For the purposes of this assessment, the Panel has created the following working definition as the basis for framing the CE throughout the report:

> A CE is a systemic approach to production and consumption for living within planetary boundaries that conserves material resources, reduces energy and water use, and generates less waste and pollution.

In developing this definition, the Panel highlighted key considerations to enable the transition towards a CE:

> A CE can be achieved by maintaining the utility of manufactured objects over long periods of time; extending the service life of infrastructure, buildings, equipment, and goods; transforming valuable waste into inputs; and striving for circular agriculture. These shifts call for significant changes in practices across governments, businesses, and civil society to ensure economic activities advance sustainability and equity more proactively.

The Panel acknowledges the large number of definitions of the CE in the literature. A review by Kirchherr *et al.* (2017) identified 114 definitions of the CE and found that most of these (95) were distinct, with the Ellen MacArthur Foundation (EMF) definition cited most frequently. The Government of Canada has not adopted an official definition of the CE. However, made-in-Canada definitions have been developed by national organizations such as The Natural Step Canada's Circular Economy Lab (SPI, 2018). At the provincial level, only Quebec has adopted an official definition of the CE, which was developed largely by the Pôle québécois de concertation sur l'économie circulaire (Québec circulaire, n.d.). As indicated by Velenturf and Purnell (2021), the CE "has been defined in almost as many ways as there are circular economy researchers and practitioners." This illustrates the ongoing evolution of the CE over time

and highlights the importance of considering the CE as a journey rather than a destination.

In the Panel's definition, *systemic* refers to the fundamental and long-term change required along the value chain to move away from the linear model (take-make-use-waste) to a circular model that aims to provide environmental, economic, and societal benefits (EMF, 2017a). The planetary boundaries referred to in the definition are expressed in terms of environmental impacts, such as climate change and biodiversity loss (Rockström *et al*., 2009). The CE seeks to minimize environmental impacts associated with resource extraction and use by optimizing the extraction of resources and the production and use of goods, and ultimately by reducing resource requirements. The Panel notes that although a reduction in material extraction is central to the CE, not all materials will be equally affected, as some materials may be more suitable for manufacturing circular products and thus will experience strong demand in a CE.

Three underlying features (Figure 2.1) form the basis of the CE: "design out waste and pollution, keep products and materials in use, and regenerate natural systems" (EMF, 2017a). As a system change approach, the CE involves all scales of the economy, from individual consumers to businesses at both the local and global scales (EMF, 2017a).

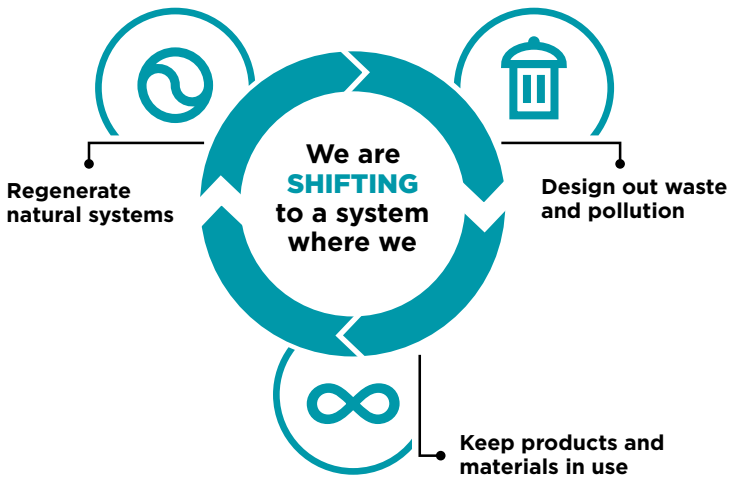


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Figure 2.1 The Three Primary Principles Associated with a Transition to a CE

The integration of all three principles is key to achieving a CE: the regeneration of natural systems, a design to eliminate waste and pollution and approaches to keep products and materials in use.

The importance of the CE transition in advancing sustainable production and consumption has been acknowledged by the United Nations (UN) in a resolution titled *Innovative Pathways to Achieve Sustainable Consumption and Production*, which invited member states to move towards a CE and improve resource efficiency. The integration of multiple sustainable development solutions and approaches in the CE reflects the SDGs; furthermore, a transition to a CE is a unifying framework that reaches beyond specific SDGs (UNEP, 2019).

2.2 Strategies Supporting the Implementation of a CE

The CE can be implemented through a variety of strategies, government practices, business models, and consumer behaviours, each of which focuses on changing the way materials flow within the economy. CE strategies aim to increase the cycling of resources by prolonging the number of times products are used (e.g., through the selection of durable materials, enhanced maintenance, design for repair, and sharing) or by closing the loop to reuse materials through recycling (e.g., design for disassembly, design of packaging to enable extraction of high-quality recycled materials) (Bocken *et al*., 2016). Implementing a CE requires changes throughout the value chain, including extraction, material sourcing, design, manufacturing, distribution and sales, consumption and use, and end of life (Deloitte, 2019b).

Out of the many classification systems for circular strategies, the Panel selected a framework developed by Institut de l'environnement, du développement durable et de l'économie circulaire (EDDEC) consisting of 12 strategies grouped within four objectives, along with examples of their application (Table 2.1). This framework has been used in recent Canadian reports by the Smart Prosperity Institute (SPI) (2020c) and ECCC (2020a). It serves to organize thinking surrounding the application of the CE; the examples given below are not meant to be comprehensive but to illustrate the CE in practice. Importantly, this framework connects the means (strategies) with the ends (objectives) of a CE, which includes reducing resource consumption and preserving ecosystems, intensifying product use, extending the life of products and their components, and giving resources new life.

Circular strategies can also be framed as business models (Figure 2.2), which has the advantage of highlighting the business value of these practices (OECD, 2019b). Circular strategies are not all prioritized equally, as the effectiveness of these practices in achieving the goals of the CE follows a hierarchy, with reducing materials used or reusing finished products prioritized over recycling, which is prioritized over Waste to Energy (Box 2.1).

Table 2.1 Circular Strategies and their Applications

Strategies	Example of Application
REDUCE RESOURCE CONSUMPTION AND PRESERVE ECOSYSTEMS	
Eco-design	Ontario BioCar Initiative produces wheat-based bioplastic for automotive use (SPI, 2020b).
Process optimization	SMTC (Ontario) applies closed-loop water reuse in electronics manufacturing (SPI, 2020b).
Responsible consumption and procurement	Trent University's procurement policy targets "products with attributes such as energy efficiency, recycled content… and minimal packaging" (Trent University, 2017).
INTENSIFY PRODUCT USE	
Sharing economy	Ottawa Tool Library (2020) and Vancouver Tool Library (2020) provide access to tools.
Short-term renting	Chic Marie (Quebec) provides a designer clothing rental service (Teigeiro *et al.*, 2018).
EXTEND THE LIFE OF PRODUCTS AND THEIR COMPONENTS	
Maintenance and repair	The Bike Kitchen at the University of British Columbia provides space and learning resources for bike repair (The Bike Kitchen, n.d.).
Refurbishing	Pools and Spas Poseidon, Quebec provides a spa remanufacturing service with a two-year warranty
Donating and reselling	Canadian One More Bite program donates unsold food, increasing the rate of diverted food waste by 90% (SPI, 2020b).
Performance economy or functional economy (e.g., PaaS)	HP's Instant Ink has reduced its environmental impact by between 59–74% from the linear model due to efficient materials use and distribution (HP, 2020).
GIVE RESOURCES A NEW USE	
Industrial ecology	The Centre de transfert technologique en écologie industrielle (CTTÉI) holds matchmaking events to help companies that produce waste connect with companies in need of materials (ECCC, 2019b).
Recycling and composting	Soleno (Quebec) uses locally sourced, high-density polyethylene containers to make stormwater pipes (Teigeiro *et al.*, 2018).
Energy recovery (generating energy from waste)	Enerkem (Quebec) produces "methanol and ethanol from non-recyclable, non-compostable municipal solid waste" (Enerkem, 2021).

The framework developed by l'Institut EDDEC presents four circular objectives (blue rows) connected with twelve strategies.

Box 2.1 Compatibility of Waste-to-Energy with the CE

Waste-to-Energy refers to a broad range of practices, including incineration of waste, anaerobic digestion of biodegradable waste, production of fuels (liquid, solid, or gaseous) from waste, and more (EC, 2017a). These practices have different environmental impacts and are considered differently in the waste hierarchy (EC, 2017a). For example, in 2019, the EU Technical Expert Group on Sustainable Finance removed waste-to-energy practices based on incineration from its taxonomy of environmentally sustainable economic activities on the grounds that "it causes harm to the environmental objectives of a circular economy: waste prevention and recycling" (EU TEG, 2019). However, the taxonomy still includes waste-to-energy practices such as the anaerobic digestion of biowaste and gas capture from landfill.

Canada had 20 waste-to-energy facilities in 2018, in every province except Newfoundland and Labrador, Nova Scotia, and Alberta, and none of the territories (StatCan, 2021d). Charlottetown, Prince Edward Island has operated a waste-to-energy system for over 35 years based on the incineration of household waste, biomass, and petroleum. The federal government recently committed $3.5 million to upgrade and expand the facility as part of the Low Carbon Economy Fund, which is expected to result in diverting 23,000 tonnes of organic waste from landfill, as well as reducing the amount of petroleum burned at the facility (Davis, 2019).

In the view of the Panel, waste-to-energy can be a part of a CE as an alternative to landfilling, as not all waste can be recycled or reused. Incineration of waste for energy should be considered as a last resort among CE strategies for processing waste, as it does not preserve materials at their highest value and thus is generally not aligned with the core goals of the CE. Moreover, incineration of waste for energy creates barriers to achieving higher recycling rates due to the need to continue to supply feedstock to existing waste incineration facilities (EC, 2017a). Thus, investment in incineration infrastructure may be incompatible with advancing the transition towards a CE.

Figure 2.2 Circular Business Models

These five circular business models are proposed and described by the OECD (2019b). The product-service system business model as defined here includes PaaS, as well as rentals and services that supplement product sales, such as maintenance services or take-back agreements. The circular supply and resource recovery models can be seen as complementary: circular supply is the model adopted by businesses seeking to obtain or provide alternatives to a scarce or costly material, and resource recovery is the model adopted by businesses seeking to create value from its by-products.

Both the objectives of intensifying product use and extending the life of products and components have the overarching goal of maximizing the number of people who can obtain services from a given amount of goods. Thus, business strategies such as remanufacturing and sharing have the potential to have wide-ranging impacts, including the reduction of GHG emissions (OECD, 2019b). Business practices extending the life of products and those providing product-service systems also both benefit from building long-term customer relationships (Fischer & Achterberg, 2016).

How services are provided has implications for ownership as well as product design and use. Repair, refurbishing, and reselling strategies retain customer ownership of products but still increase the provision of services to maintain and upgrade existing products rather than introducing new products and materials into the economy. Sharing, renting, and performance economy strategies go a step further. In these cases, the customer pays for access to a product or associated service as opposed to buying ownership of the product, challenging the assumption that a person needs to own an asset to have the associated service and enabling access for individuals unable to purchase the asset. Performance economy strategies that involve PaaS provide an incentive for circular design since increasing the number of use cycles for a product increases profit for businesses (Fischer & Achterberg, 2016).

Despite current academic interest in PaaS, these models are still only common in a handful of sectors, including the aircraft industry and digital content (Lay, 2014; OECD, 2019b). Among the earliest and best established of such models is managed print services (Visintin, 2014). In addition, a set of case studies observing how six large manufacturing companies implemented a CE determined that four of these companies used performance economy approaches and one involved a pay-per-use car share model (Parida *et al.*, 2019). Despite the current rarity of this model, a shift to PaaS across manufacturing industries is possible (Lay, 2014).

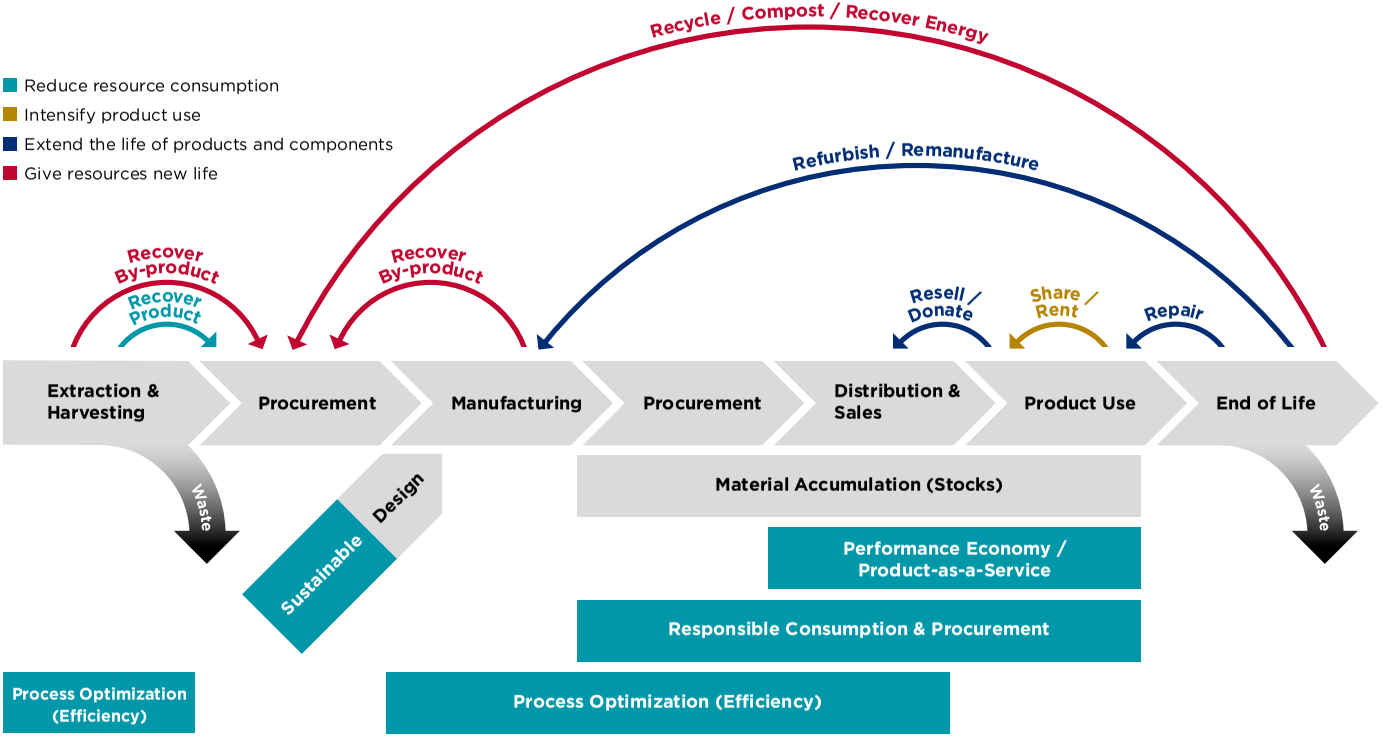


Figure 2.3 CE Strategies Create Loops in the Value Chain

CE strategies are represented as coloured loops or boxes, with colour indicating the related objectives identified by Institut EDDEC. Recovering products can be considered part of the process optimization strategy, and recovering by-products, recycling, composting, or recovering energy can be implemented as part of industrial ecology. Sustainable design includes elements such as reducing material, increasing durability, and increasing ability to remanufacture. Loops include technical flows (e.g., high-value recycling) and biological flows (e.g., composting), which have distinct mechanisms (for more information see Braungart *et al.*, 2007), but which, for simplicity, are presented without distinction in this figure. The Panel notes that not all materials can be completely cycled, and not all material needs can be met by cycled materials alone.

CE strategies and practices are implemented through loops of various scales at one or more points in the value chain, as shown in Figure 2.3:

- Waste at the extraction and harvesting phase can be minimized through by-product recovery, increasing returns.
- Circular procurement of materials benefits businesses by reducing exposure to price fluctuations of raw materials, limiting the impact of supply chain disruptions and possibly increasing consumer support (Deloitte, 2019b). The selection of durable materials during procurement extends product life.
- Circular design is crucial, as it determines the extent to which the product can be repaired and/or refurbished, enabling the recovery of materials back into production processes (Section 7.2.3) (Charter, 2018; SPI, 2020b). Design increases value and enhances circularity through improving durability or the ability to disassemble, repair, upgrade, or recycle components and materials (Bocken *et al.*, 2016). Standardized and modular design, for example, improves the ability to remove and reuse components (EMF, 2013). Design is also used to create products that consumers will like and use longer, effectively extending product life (Bocken *et al.*, 2016).
- The manufacturing stage is an opportunity to reduce waste through process optimization, which reduces costs (Deloitte, 2019b).
- Responsible and circular procurement of products and services represents an important lever for the government in advancing a CE (Section 7.1.5).
- The distribution and sales stage represents another opportunity for process optimization, reducing costs associated with packaging waste and inefficient transport (Deloitte, 2019b).
- At the product use stage, labelling increases customer awareness of CE benefits, which enables responsible consumption (Section 7.2.3). Sharing platforms and PaaS models can be implemented during this stage to increase product utilization and give consumers more flexible options for obtaining use of the product (Deloitte, 2019b).
- At end of life, giving products a second-use life through repair and remanufacture significantly reduces the use of raw materials (Deloitte, 2019b).

Not all loops described above are equally implemented in practice. Analysis of a set of global case studies indicates that most of the current implementation of CE practices deal with recovery and collection-disposal activities (Kalmykova *et al.*, 2018). Practices at the product use stage also represent a large portion of current CE implementation, but consumers would still benefit from institutional support in sharing and reusing products. In contrast, practices involving circular inputs (use of materials that are easily recycled or regenerated), manufacturing, distribution, and sales are implemented less often (Kalmykova *et al.*, 2018).

The environmental benefits of a CE are based on assumptions that secondary production activities (e.g., recycling) reduce primary production (Zink & Geyer, 2017). However, for this to happen, recycled or refurbished materials must be of the same quality and price as primary materials. If circular materials are not of the same quality as primary materials (or are not perceived to be of the same quality), they cannot be substituted for primary materials. If circular materials are lower cost or more efficient, it may increase demand for the material or otherwise result in surplus funds that may be spent on additional consumption elsewhere. This dynamic, in which circular practices lead to higher consumption that offsets environmental benefits, is known as a rebound effect (Zink & Geyer, 2017). The rebound effect should be considered when working towards the CE aim of reduced resource consumption.

2.3 Measuring Circularity

Despite the recent development and implementation of circular approaches, assessing the global impact of a CE remains limited, as impacts are most commonly measured for specific programs and resources. A CE can be measured through various sources of information, which can be applied to assess the impacts of circularity on the flow of materials, money, or emissions. Data estimates are currently available for resource productivity, material footprint, and waste generation. Societal measures of housing, mobility, health, and education are also important in ensuring that the transition towards a CE achieves related social equity goals (Schröder, 2020). A distinction should be made between the circularity of a nation, region, sector, or activities (material throughput and retention) and actions intended to promote circularity (e.g., sharing, better design). Ultimately, the ability to assess the effectiveness of circular approaches depends on the available information. Data required in Canada to measure the CE is discussed in Box 2.2.

2.3.1 Data Supporting Quantitative Measurements of Circularity

Obtaining the data required to assess CE approaches presents unique challenges due to the diverse resources involved in the value chain. Quantitative data, such as material resources accounts, as well as data on other resources used to support the value chain, such as energy and water, are key to providing a comprehensive understanding of flows within the economy. Even in jurisdictions where CE monitoring frameworks exist (e.g., the EU), a need for more comprehensive data on material stock and waste flow has been reported to effectively measure CE approaches (Mayer *et al.*, 2018).

Box 2.2 CE Data in Canada

A recent review of the data needed to improve Canada's capacity to measure the CE from Midsummer Analytics (2020) provides an overview of existing data and gaps following six categories:

Material and energy. Raw material and input data are compiled by Statistics Canada in its Physical Flow Accounts but are limited to water and energy use. Other departments collect accounts related to their own mandates (e.g., mining data: NRCan; fish stocks: Department of Fisheries and Oceans). This review noted that the Physical Flow Accounts would benefit from including biomass, metals ores, and non-metal minerals data in a similar manner to water and energy accounts. In addition, there is a need for improved measurement of the circularity of toxic materials.

Waste output. Although Canada collects data on many types of waste outputs, including municipal solid waste, air contaminants, and emissions from wastewater treatment plants, not all of the data are sufficiently detailed for assessing circularity. Additional information on the type of waste materials would allow better tracking of circular approaches such as recycling. Data on emissions of hazardous waste, such as those tracked by the National Pollutant Release Inventory, may be difficult to interpret over time, and several types of compounds released in the environment are not well tracked (e.g., dissipative losses). Limited data exist on unused extracted raw material.

Smarter design, production, distribution, and use. Statistics Canada collects statistics that could be used to assess improvements in product design and production. Among them is the Annual Environmental Protection Expenditures Survey, which provides information on how industries improve efficiencies of resource use. Statistics Canada also tracks data on the use of goods and services via the Households and the Environment Survey. Gaps exist for data on the distribution of goods and services, as well as on wholesale and retail trade.

Extension of lifespans. Little data are collected to assess company and household repair, reuse, remanufacture, or refurbishing.

Replacement of goods with services. No data are currently collected on the economic shift from goods to services in Canada.

Waste into input. Data on the transformation of waste into resources are collected as part of Statistics Canada's Waste Management Industry Survey, although not collected at a level of detail required to measure CE.

Aggregate-level data are particularly useful in providing a system-wide perspective of material flows and help with the macro-level assessment of the impact of circular approaches. The Global Reporting Initiative is used to disclose a number of sustainability datasets, including granular data on material use and reuse, such as waste rock and tailings in the mining sector (GRI, 2014).

Information beyond material accounts is also required for assessing the broader potential of a CE. For example, the Circulytics tools developed by the EMF use information on businesses, education, and labour force skills along with more standard measurement frameworks for material flows to assess an organization's ability to transition to a CE (EMF, 2019c).

2.3.2 Indicators of a CE

The assessment of performance in relation to CE principles and wider national and international sustainability goals can be quantified by appropriate indicators (Su *et al.*, 2013; Pauliuk, 2018). Because existing indicators for environmental performance or resource efficiency do not necessarily reflect the scope of CE goals and principles, CE-specific indicators have been proposed or developed (Geng *et al.*, 2013; EMF, 2015d; Pauliuk, 2018).

CE indicators can be grouped into three levels: micro (e.g., organizations, products, consumers), meso (e.g., symbiosis association, eco-industrial parks), and macro (e.g., city, province, region, or country) (Saidani *et al.*, 2017; Pauliuk, 2018). In addition to operating on these economic and geographic scopes, indicators can quantify different layers (e.g., monetary, mass, energy) and use different variable types (flows, stocks, stock changes) (Pauliuk, 2018). The World Business Council for Sustainable Development has developed a framework based on material flows within company boundaries to provide companies with guidance to effectively transition to a CE at the organizational level (WBCSD, 2020).

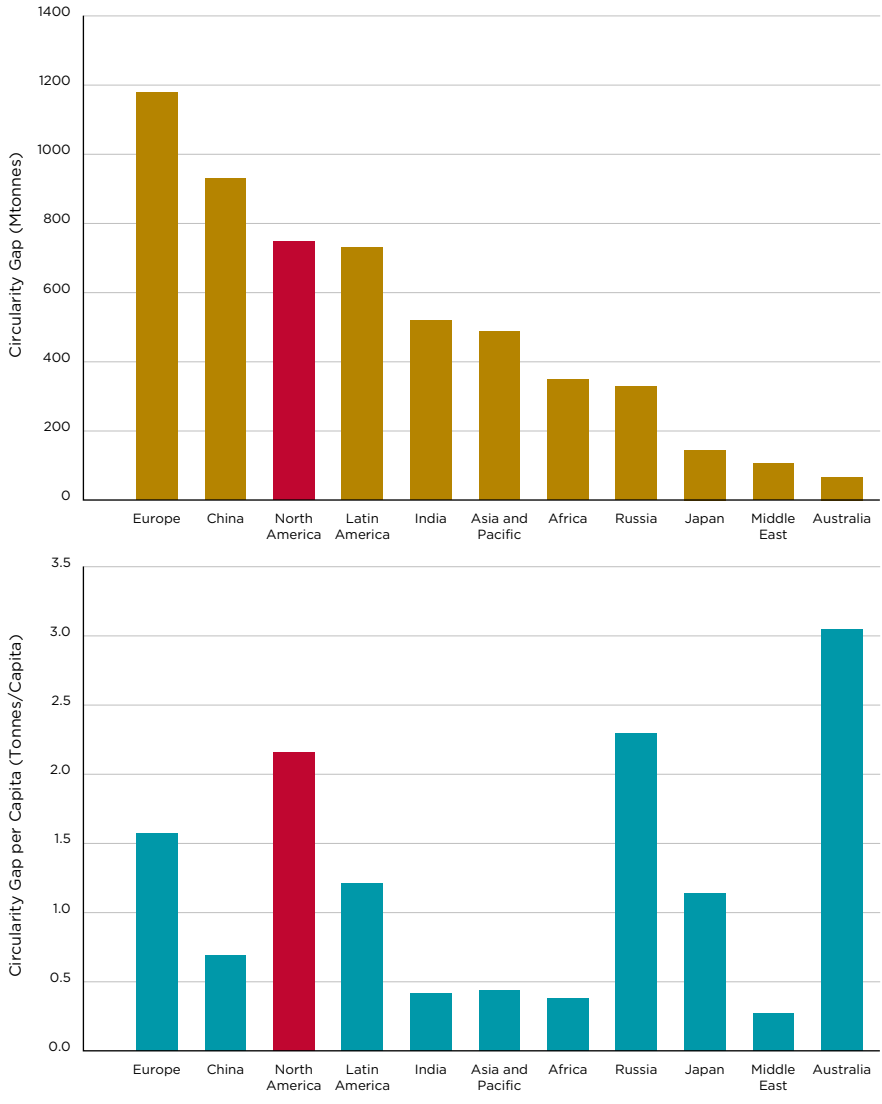
The EMF highlights four specific types of CE metrics: "resource productivity, circular activities, waste generation, (and) energy and GHG emissions" (EMF, 2015b; as cited by Pauliuk, 2018). These categories apply to both micro and macro levels of the economy. Many indicators at the product and organizational level express the performance of the assessed system, product or process as a percentage of the performance of a theoretical ideal system. In the case of the CE, this is "a perfectly and indefinitely closed material loop" (Pauliuk, 2018).

CE indicators developed outside of Canada typically measure the post-implementation impact of CE policies and strategies (Deloitte, 2019b). Proposed indicators for Canada developed by Deloitte (2019b) were designed to reflect both international best practices in monitoring the CE, as well as issues specific to the Canadian context. These indicators are intended to convey the potential impacts of circular initiatives, and are measured along a scale from "no impact" to "significant positive impact," with an additional score given to indicate if an initiative has potential negative effects, which allows potential trade-offs to be explored. These indicators could be revised to ensure they remain consistent with Canadian goals or strategies such as the Pan-Canadian Framework on Clean Growth and Climate Change (Deloitte, 2019b).

The choice of CE indicators is affected by the level of intensity of material use, the effects and impacts of the material use, and the strategic characteristics of materials (Majeau-Bettez, 2020). Indicators of environmental impacts include primary material substitution and production of quality secondary materials. Socio-economic indicators include employment, procurement, and quality of life (Majeau-Bettez, 2020).

CE attainment is commonly described as a circularity gap or circularity rate.

Several metrics have been developed to quantify the level of circularity at broad scales. *Circularity gap* analyses can be performed at various scales and using various methodologies. Aguilar-Hernandez *et al.* (2019) present a circularity gap measurement reflecting the amount of waste that could theoretically be recovered and cycled back into the economy. Figure 2.4 illustrates the variation in circularity gaps among several countries and regions in 2011. Although an estimate of the amount of material available for reuse allows for the identification of countries with high potential for circularity, such an assessment also benefits from considering population or GDP to make relative comparisons (Aguilar-Hernandez *et al.*, 2019). Although the ranking may have changed since 2011, these data show that the potential for CE in North America is among the highest in the world based on a high circularity gap value.



Data Source: Aguilar-Hernandez *et al.* (2019)

Figure 2.4 Circularity Gap in Million Tonnes (top) and Tonnes per Capita (bottom) for Selected Regions and Countries in 2011

A higher circularity gap value means that more material is available for recovery and reuse. High circularity gap values stem from high waste generation in all areas except Europe, where it is the result of the almost equal contribution of waste generation and stock depletion. North America has the third-highest circularity gap and circularity gap per capita values, highlighting the high potential for CE implementation for this region. These circularity gaps are not comparable to those calculated using the Panel's model in the next section due to methodological differences.

The Panel notes that while the circularity gap is a helpful framing which allows for comparisons between countries and the establishment of targets for adoption by stakeholders, it is not a complete measure of material use and should not be used to infer that a desirable scenario might reduce the circularity gap to zero. Not all material can be fully recycled, as losses always occur along the value chain, and not all material production needs can be met by recycling; thus, both recycled and virgin materials would be needed to support growing economies.

The *circularity rate* is a common indicator used to assess how circular a given economy is. The circularity rate measures the contribution of recycled and recovered materials to total material use. An increase in circularity rate thus indicates replacing primary materials with secondary materials, reducing the need for material extraction (Eurostat, 2020). This indicator, expressed as a percentage, can be generated for specific materials (e.g. to assess the circularity of specific value chains) for groups of commodities (e.g., raw materials), or even for an entire economy (regional to global). Since 2018, the Circularity Gap Reporting Initiative has annually published the global circularity metric, which declined from 9.1% in 2018 to 8.6% in 2020, indicating that continued material extraction and stock build-up outpace increases in resource cycling (Circle Economy, 2020b). The Circularity Gap Reporting Initiative notes that data to inform stakeholder decision-making should be "collected, consolidated, and made available globally" (Circle Economy, 2020b). Although no comprehensive circular analysis has been performed for all of Canada, such analysis exists for the province of Quebec (Box 2.3) and is currently being undertaken for the city of Toronto (ECCC, 2020a).

Box 2.3 The Circularity Rate in Quebec

A report by Circle Economy (2021) has determined that Quebec is currently 3.5% circular, well below the global 8.6% metric. Quebec also has a material footprint of 32 tonnes per person per year, which is higher than average for Canada and above the EU average of 20 tonnes per person per year. The report also finds that Quebec is well positioned to improve its circularity. Specifically, the province could increase its circularity to 9.8%, and reduce its material footprint to 16.6 tonnes per person by implementing a combination of six circularity measures: "(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" (Circle Economy, 2021). Given that doubling the world's circularity would contribute to limiting global temperature change to under 2°C (CGRI, 2021), nearly tripling Quebec's circularity would be significant. These circularity rates are not comparable to those calculated using the Panel's model in the next section due to methodological differences.

The CE requires macro-economic indicators that better reflect well-being than GDP does.

According to the Organisation for Economic Co-operation and Development (OECD):

> *[GDP] is the standard measure of the value-added…through the production of goods and services in a country during a certain period. As such, it also measures the income earned from that production, or the total amount spent on final goods and services (fewer imports). While GDP is the single most important indicator to capture economic activity, it falls short of providing a suitable measure of people's material well-being for which alternative indicators may be more appropriate.*
>
> OECD, 2021a

The Panel notes that GDP has many deficiencies related to assessing well-being. It includes many indicators that can increase when well-being may be low or deteriorating (for example, household expenditures on health care, repairs, commuting, and home security measures, as well as government expenditures on police, the military, and environmental protection). Equally problematic as a measure of well-being is what is left out of GDP, such as voluntary work, unpaid housework, leisure time, capital depreciation, damage to the environment, and the depletion of natural resources. In addition, GDP fails to capture the distribution of economic output among different groups in the population (Victor, 2019). Material flow analysis and related indicators such as circularity rate provide a macro-economic perspective of the Canadian economy that differs from a strictly monetary analysis that focuses on GDP.

2.4 Modelling Material Flows to Estimate the Potential Impact of the CE in Canada

A material flow analysis takes into account the full value chain, beginning with the extraction or import of commodities, through to the creation and use of goods and services that arise from the processing of these commodities for both domestic and international markets. The analysis can then be visualized by way of a Sankey diagram (Figure 2.5), which demonstrates the potential for circular measures that modify material usage and flow throughout the value chain, which has implications for other metrics such as energy, emissions, and water use. Material flow analysis

also ensures that all the direct material inputs to the economy are accounted for. Materials are either accumulated within the economy, which means they remain in the economy for more than a year, or they are recycled or used for backfilling, exported, or disposed of back into the environment as dissipative flows, air and water emissions, or landfill. A material flow analysis also helps to identify potential leverage points for advancing a CE in Canada.

The Panel reviewed the sources of data currently available in Canada on material accounts for four types of commodities: biomass, non-metallic minerals, metal ores, and fossil energy materials. Further analyses are needed on specific commodities to address the limitations of an aggregate approach; assumptions and limitations of the model are noted in the Appendix. Data were retrieved from various sources, including the ECCC national database and global databases on natural resources published by the International Resource Panel. The Panel observed that comprehensive material flow accounts like those reported by Eurostat are not available in Canada. Estimations were made when Canadian data did not exist by adjusting the EU material accounts for Canada using the relative size of GDP in the EU27 and in Canada. A summary of the approach used to estimate circularity in Canada can be found in the Appendix, and further details are available in Victor and Chapariha (2021). Data used for this analysis were extracted for 2017 and then adjusted to 2021 based on actual 2020 GDP values and forecasts for 2021. A summary of the Canadian material flow database for 2021 variables is presented in Table A.2 of the Appendix.

2.4.1 Canada's Current Level of Circularity

Using the estimated Canadian material flow database, it is possible to infer a circularity rate for Canada taking into account: recycling and backfilling; the material intensity of products determined by design; and product functionality, durability, reuse, reparability, and sharing.

The current circularity rate for Canada is estimated at 6.1%.

The Panel's material flow model (referred to as "the SankeySim model") estimates the current circularity rate for Canada is 6.1%.[2] Because the approach adopted to generate this estimate is similar to that used in the EU, comparisons between Canada and EU member states can be made; however, the Panel's methodology is different from and not comparable with that used to determine the circularity rate

2 This is calculated as: 100 × Recycling / (Recycling + Natural Resource Extraction + Imports − Exports).

for Quebec (Box 2.3). The EU economy had a circularity rate of 11.5% in 2017.[3] Large variations in circularity rates (from 1.7% to 29.7%) exist between EU member states. Low rates (Ireland, Romania) stem from a low percentage of recycling and backfilling. The highest value is reported for the Netherlands (29.7%). The Panel notes that Scandinavian countries such as Finland and Sweden, which rely on natural resource extraction, share a similar circularity rate to that of Canada. A detailed list of circularity rates within the EU27, as well as contributing factors, are available in Victor and Chapariha (2021).

Current material flows show that Canada's economy relies almost exclusively on the extraction of its natural resources.

The Panel converted the Canadian material flow database into a Sankey diagram to visualize the flow of each commodity type along the value chain. Figure 2.5 illustrates material flows in the Canadian economy in 2021 for the four commodity types and shows the extent to which Canada relies on domestic natural resource extraction to support its economy. Most extracted fossil energy resources are exported or lost as emissions. Close to 80% of all processed materials which are not exported are being used, with 16% entering waste treatment and 84% accumulating to the current stock of material. Current circular approaches include backfilling and recycling, representing 31% and 45% of treated waste materials, respectively. The diagram illustrates that little material is currently used for recycling and backfilling relative to the total amount of processed material and material use. Other circular approaches, such as product durability and sharing, may increase the length of the product life-cycle and reduce the need for newly processed material. The impacts of such approaches are further explored in the report by applying selected scenarios to model future circularity in Canada.

3 Note that the Eurostat circularity rate excludes imported waste intended for recovery and adds exported waste intended for recovery abroad. Equivalent data for Canada are unavailable, so the circularity rate calculated in the SankeySim model does not allow for this refinement. The implicit assumption is that these imports and exports of materials for recovery are equal. For a comprehensive discussion of this measure of the circularity rate, see Eurostat (2018).

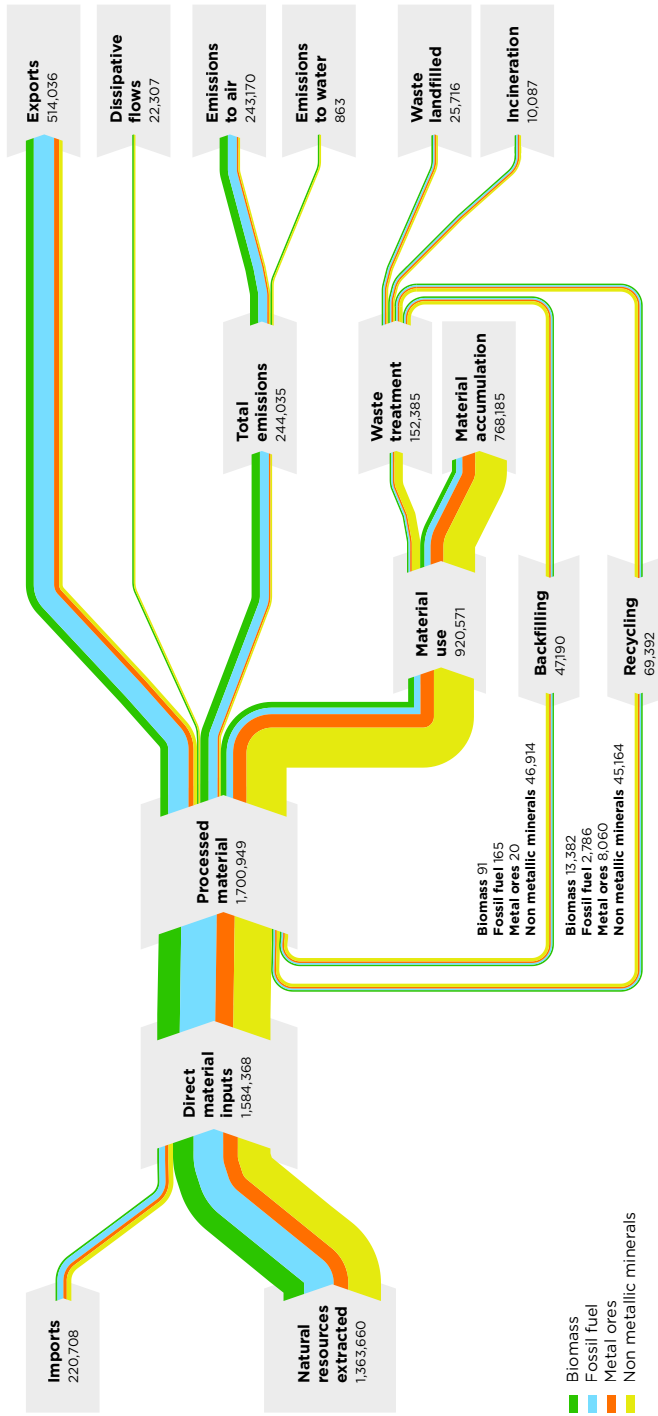


Figure 2.5 Sankey Diagram of Estimated Material Flows in Canada, 2021 (Thousand Tonnes)

This figure shows the estimated flow of materials in the Canadian economy from resource extraction and imports through to exports, emissions, waste, and material use. The majority of exports are fossil fuels, while the majority of material use and accumulation in the system are non-metallic minerals.

2.4.2 Scenarios for Estimating the Potential for CE Approaches in the Canadian Context

To assess the potential of CE approaches on material flows in Canada, the Panel coded the material flows data into a dynamic model, allowing the selection of various values for a series of circular approaches. These approaches include increased recycling and backfilling, reductions in the material intensity of products through better design, increased product functionality, durability, reuse, reparability, and sharing. As one of the desired outcomes of a CE is to reduce raw material use, the SankeySim model focuses solely on the flow of materials in the economy. The model structure could be duplicated for different regions and sectors in Canada depending on the availability of data, but that has not been done for this report.

The SankeySim model starts from a provisional material flow account for Canada in 2017 similar to the material flow accounts produced by Eurostat. These accounts include domestic extraction, imports, domestic material consumption, waste, and exports (Eurostat, 2020). The model simulates the impacts of changes affecting material flows in the economy, including the use and disposal of materials and the impacts these changes have on the system. Circularity gaps can be estimated for various scenarios as the difference between total processed material and the contribution of non-virgin materials from recycling and backfilling. In addition, the model can provide an estimate of the overall circularity rate for a given scenario, and these calculated rates can further be compared to that calculated for 2021 (6.1%).

In selecting these scenarios, the Panel noted that none of them are designed to be ideal for Canada, and some of the targets will be challenging to achieve (e.g., a 30% increase in durability, sharing, and production efficiency by 2040 across the entire economy). As such, the scenarios should be seen as an early attempt at scoping the effects of combined circular measures on material inputs and waste to and from the economy, as well as on the circularity of the Canadian economy overall. The parameters entered in the model for each scenario presented in this section are provided in Table A.3 of the Appendix.

The four selected scenarios are:

Scenario 1. The *business-as-usual (BAU)* scenario is based on the continuation of the current pattern of material use and disposition for the next 20 years.

Scenario 2. The *EU27* scenario is based on material flows and disposition if Canada transitioned over 20 years to the average performance of the EU27 in 2017. In this scenario, values for product durability, sharing, and production efficiency are set at a 30% increase.

Scenario 3. The *France* scenario is based on material flows and disposition if Canada transitioned to the performance of France in 2017 over 20 years. France is among the leaders in the CE within the EU27 and was selected to estimate the impact of a significant increase in the recycling rate in addition to the other variables included in Scenario 2. Set values for this scenario include a 33% increase in product durability, sharing, and production efficiency, and a 46% increase in the recycling rate.

Scenario 4. The *EU27 + net-zero* scenario is the same as Scenario 2 with the addition of a net-zero target for GHG emissions in 2050. This scenario was selected to estimate the impacts of replacing energy from fossil fuels with energy from renewable sources on requirements for materials.

A BAU scenario would increase wastes and material inputs by 40% by 2040.

The SankeySim model developed for this assessment was used to evaluate the implications of not changing current CE practices on material flows in Canada. The BAU scenario assumes that no change in circular measures will occur for the next 20 years, with a circularity rate maintained at 6.1%.

Figure 2.6 provides an overview of the material flows in 2040 using this approach. If the Canadian economy grows at 1.8% per year to 2040 with no increase in circularity, waste[4] will increase by an estimated 118 million tonnes, and the circularity gap (i.e. required new material inputs from extraction and imports) will increase by an estimated 640 million tonnes (an increase of 40%) by 2040. Total emissions will also increase by 40% by 2040 under this scenario. The relative sizes of the flows in this figure are similar to those presented in Figure 2.5.

4 The total of emissions, dissipative flows, and landfilling.

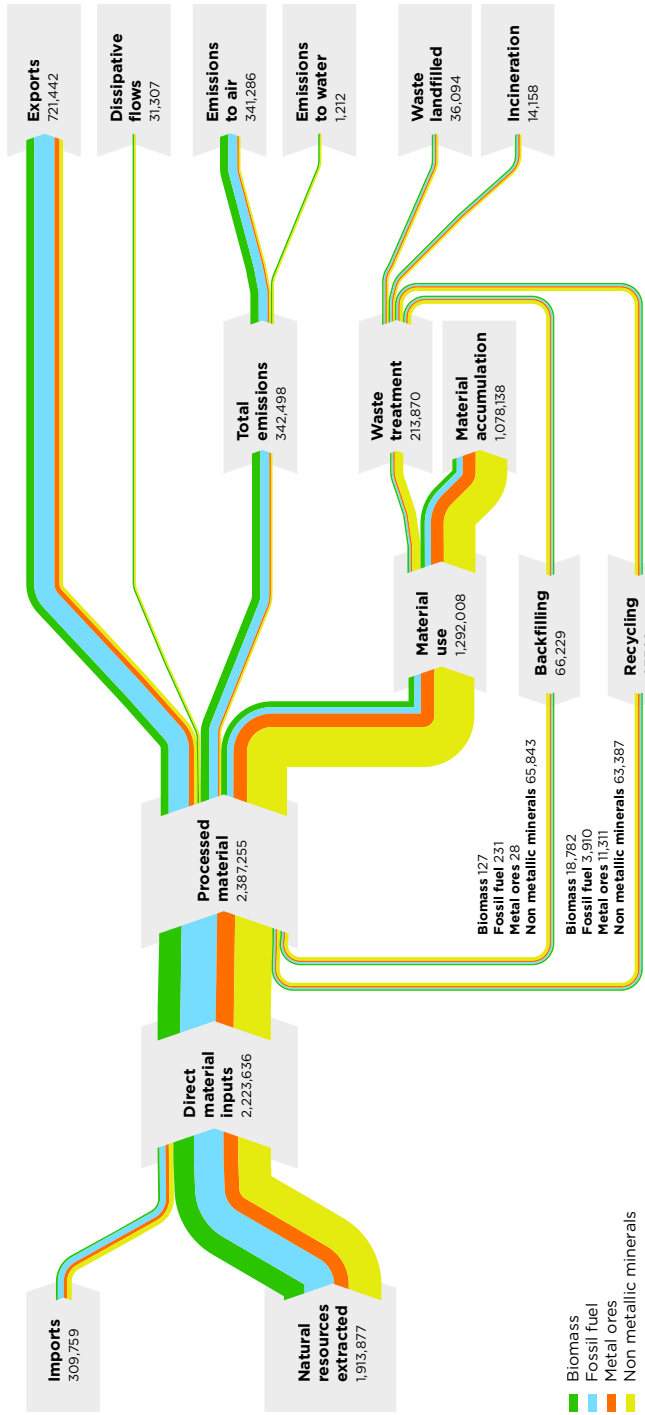


Figure 2.6 Sankey Diagram for the BAU Scenario

This figure shows the projected flow of materials in the Canadian economy in 2040 assuming no change in circularity, from resource extraction and imports through to exports, emissions, waste, and material use.

By performing at the level of the EU27 average, Canada could achieve a 13% reduction in waste and a 40% reduction in material inputs.

Data on average circularity performance in the EU27 can be used to assess the impacts of circularity measures on material use. In the EU27, the circularity rate was 11.5% in 2017, and three circular approaches are the most significant contributors to that value: product durability, production efficiency, and sharing, set at a 30% increase each. Using these EU27 performance values, the SankeySim model was applied to estimate the impact of EU circular approaches on the Canadian material flows for the next 20 years. The results of this scenario are presented in Figure 2.7.

The EU27 scenario results in a substantial reduction in material inputs compared to current levels (approximately -40%; a circularity gap reduction of 596 million tonnes) and a modest reduction in wastes (13%; 39 million tonnes) in 2040. The circularity rate increases to 14.4% by 2040.

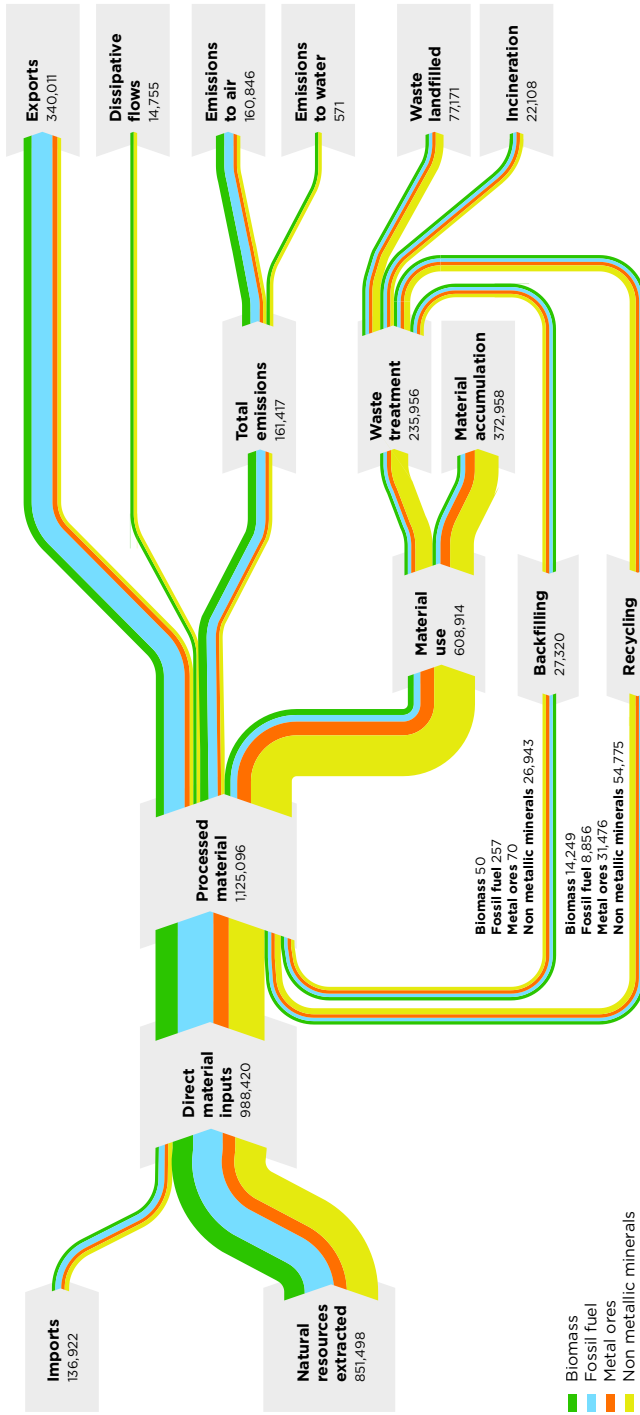


Figure 2.7 Sankey Diagram for the EU27 Scenario

This figure shows material flows and disposition in 2040 if Canada transitioned over 20 years to the average performance of the EU27 in 2017. In this scenario, a 30% increase in durability, sharing, and product efficiency leads to a reduction in material input of 40% and a reduction in waste production of 13%. Under this scenario, the circularity rate of Canada would increase to 14.4% (more than double the current level).

By performing at the level of France, Canada could achieve a 26% reduction in waste and a 44% reduction in material inputs.

Recycling represents a key feature of the CE in some EU countries, contributing to high circularity rates. With this scenario, the Panel wanted to test ambitious targets, such as France's, which has a 33% increase in durability, sharing, and production efficiency, and a 46% increase in recycling rate. As such, France is a leader in terms of circularity rate (18.8%, compared to 11.5% for the EU27). Figure 2.8 illustrates the material flows in Canada in 20 years, assuming a transition to France's circularity approaches.

This scenario results in an even greater reduction than the EU27 scenario in material inputs (approximately 44% less than the current level) and waste (approximately 26% less) by 2040. Canada's circularity rate increases to 21.3%, waste is reduced by an estimated 76 million tonnes, and the circularity gap is reduced by 703 million tonnes. This scenario highlights that recycling is an effective measure to increase circularity rates.

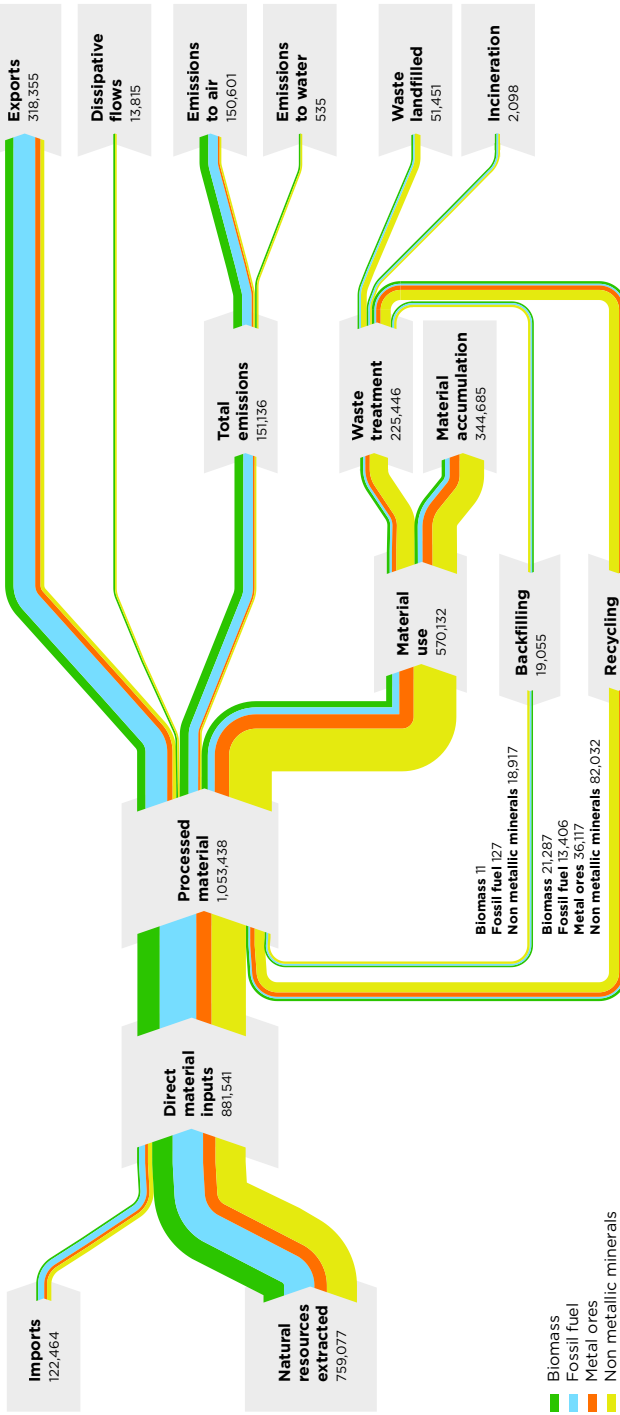


Figure 2.8 Sankey Diagram for the France Scenario

This figure shows material flows and disposition in 2040 are presented for Canada over 20 years using France's 2017 performance. This scenario is similar to the EU27 scenario, with the exception of a much higher recycling rate (46%). Under this scenario, greater reductions in both material inputs (-44%) and waste (-26%) are achieved, showing the effectiveness of recycling for the economy.

By performing at the level of the EU27 and with Net-Zero GHG Emissions by 2050, Canada would reduce waste but maintain the current level of material input requirements due to increased metal ore extraction to support renewable energy.

To further evaluate the impacts of the EU27 approach, an additional scenario was created to evaluate the implications of a net-zero target for GHG emissions in 2050. In this scenario, energy produced from fossil fuels is replaced with energy produced from renewable sources. This scenario aims to evaluate the impacts of an energy transition (assuming no change in demand) on requirements for materials, using the same values for durability, sharing, and production efficiency as for the EU27 scenario. The results of this fourth scenario are presented in Figure 2.9.

The effect of Canada transitioning to net-zero GHG emissions has significant implications for material flows, largely because the material requirements for one gigawatt of energy derived from wind and solar energy are considerably higher than for fossil fuels. Compared to the EU27 disposition scenario, the EU27 + net-zero scenario shows an increased circularity rate of 20.3% and a much-increased circularity gap in terms of tonnage of materials. Specifically, the transition to net-zero emissions will increase the circularity gap by 64% compared to the EU27 scenario. Waste reduction is increased, reflecting the decline in GHG emissions, but material reduction, while still positive, is much lower compared to the EU27 scenario. The EU27 + net-zero scenario illustrates the cascading effects of reducing one form of waste on overall material use. To replace energy produced by fossil fuels, the extraction of metal ores would significantly increase to meet the demand needed to support renewable energy infrastructure (Section 6.5). It also highlights how an increase in material demand can increase the circularity gap (the need for virgin materials) despite increasing circularity rates (the percentage of secondary materials in total processed materials).

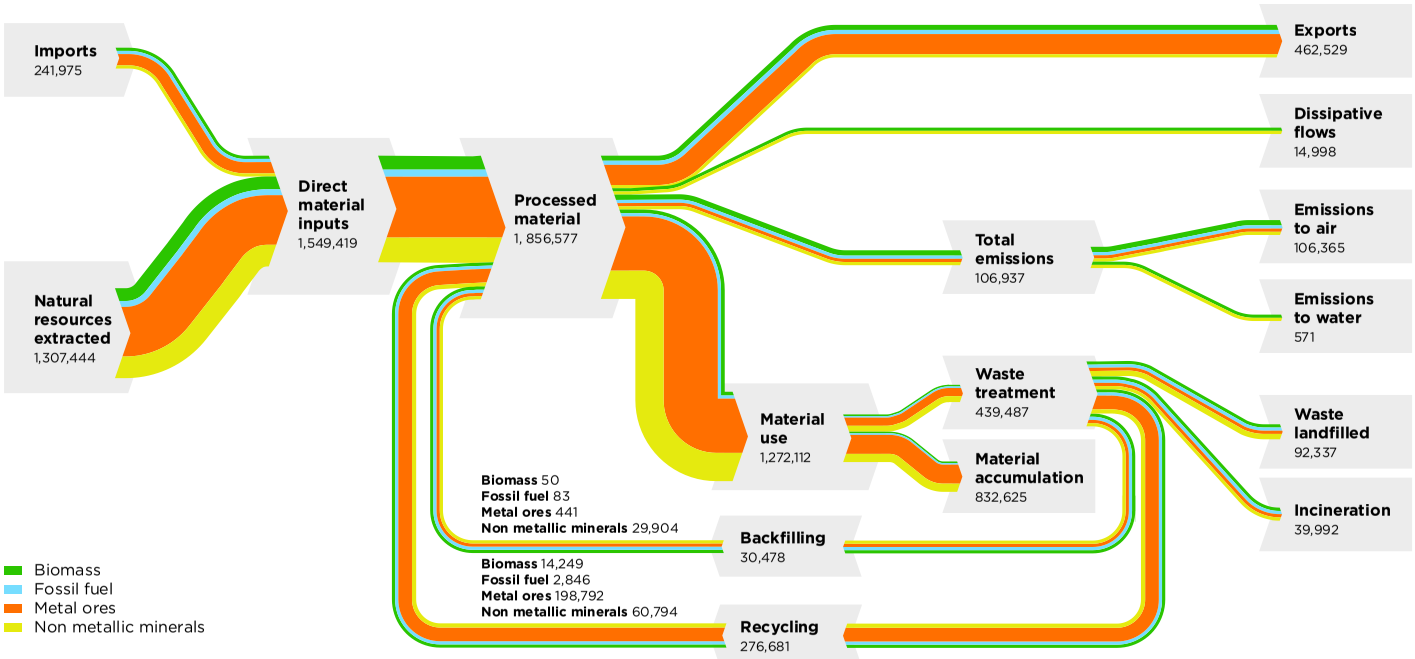


Figure 2.9 Sankey Diagram for the EU27 + Net-Zero Scenario

This figure shows the material flows in 2040 if Canada transitioned to EU27 performance with a net-zero target for GHG emissions in 2050. Under this scenario, almost no change in the total amount of material inputs and a 27% reduction in waste are observed by 2040. A major shift in the type of material inputs is observed, away from fossil fuels and towards the metal ores needed to support renewable energy production. Under this scenario, the circularity rate of Canada would increase to 20.3% (more than three times the current rate).

3

Factors Relevant to a CE in Canada

3.1 Geographic and Jurisdictional Context

3.2 Economic Context

3.3 Environmental Context

3.4 Social Context

Chapter Findings

- As a natural resource-rich country with strong public support for environmental protection, Canada would need a CE approach adapted to its unique economic, environmental, and social conditions.
- With highly integrated supply chains, the Canada–U.S. trade relationship will be important to a CE transition, providing opportunities for collaboration but also acting as a potential barrier if a CE transition were to be initiated unilaterally in Canada.
- Indigenous perspectives on stewardship of land and resources align with some CE principles. CE approaches in Canada would benefit from being inclusive and respectful of these perspectives.

Canada's unique geographic, jurisdictional, economic, environmental, and social context will shape its approach to transitioning towards a CE. These factors — including Canada's large geographic size and low population density, its close trading relationship with the United States, and its high resource consumption rates — present opportunities and challenges for a transition towards the CE in Canada. A made-in-Canada approach to the CE will likely need to be distinct from the leading practices in Europe and Asia, where CE practices have been adopted for a longer time and adapted to a context that differs from Canada in important ways. This chapter provides context on the current situation in Canada and highlights specific challenges and opportunities which will be further developed in Chapters 5 and 6.

3.1 Geographic and Jurisdictional Context

Canada's large geographical size and relatively small population will affect what practices and programs will best support the transition towards a CE in this country. The fragmented governance structure in Canada also influences how and where CE practices could be implemented.

Canada's approach to the CE must be tailored to its geography and population distribution.

Canada is a geographically large country that has a low population density compared with other countries, and major cities are separated by significant distances (StatCan, 2017), which creates logistical challenges when implementing nation-wide CE strategies (Deloitte, 2019b). Currently, many CE strategies in Canada have been implemented in municipal regions or cities (Section 4.2), with Canada's metropolitan areas containing over 70% of the population as of 2020 (StatCan, 2021c). Moreover, as most of the Canadian population lives along the U.S. border (StatCan, 2017), cross-border CE initiatives have been developed (Section 4.3). Rural and remote areas face challenges to participation in the CE that involve not only distance but also significant deficits in infrastructure (Northern Public Affairs, 2016; ECCC, 2020a). These challenges for the CE, and possibilities to mitigate these challenges by developing regional circular initiatives, are further discussed in Section 5.1. Ultimately, economic, environmental, and social differences between urban and non-urban areas of the country will need to be considered when designing and implementing CE strategies in Canada.

Canada's jurisdictional structure may complicate the policy harmonization that is necessary to implement the transition towards a CE.

Federal, provincial/territorial, and municipal governments in Canada have jurisdiction over different areas. In the context of the CE, this means that each level of government has certain roles and responsibilities in implementing a transition towards the CE. For example, the federal government has a responsibility for national and international affairs, including implementing national environmental policies and managing Canada's global competitiveness. Provincial governments are involved in health care, education, and some natural resource activities within their jurisdictions, while municipal governments have specific responsibilities for local community needs like public transportation, land use, and water systems (Deloitte, 2019b).

The division of power and responsibilities among levels of government has allowed some jurisdictions to actively pursue CE practices within their own regions (Section 4.2), but experts have also identified jurisdictional complexity and the absence of coordinated policies as barriers to advancing a CE in Canada

(Deloitte, 2019b; CELC & GLOBE, 2020). Overall, collaboration, coordination, and harmonization of policies and strategies among levels of government are important to the implementation and success of CE initiatives (Section 8.2). This coordination includes Indigenous governments, who are involved in the management of many CE areas, such as land and resource use, economic development, and education (CIRNAC, 2020). Engaging with Indigenous groups and communities is thus an important component of the transition towards the CE (see Section 3.4 for Indigenous approaches to the CE in Canada).

3.2 Economic Context

Canada's economy includes a strong natural resource sector, a close relationship with the United States, and the exportation of waste. A transition towards a CE in Canada must consider all of these factors, as well as the general composition of the Canadian economy, which is primarily comprised of small- and medium-sized enterprises (SMEs) that face their own opportunities and barriers (ECCC, 2019b). In 2016, SMEs contributed over 55% of Canada's GDP, and in 2019, SMEs employed 88% of Canada's private labour force (ISED, 2020). Thus, experts have noted that CE policies in Canada need to consider opportunities and risks specific to such businesses (ECCC, 2019b).

The importance of natural resources to the Canadian economy requires a unique approach to the CE.

In 2019, natural resources directly accounted for approximately 11.5% of Canada's nominal GDP, as well as approximately 888,000 jobs (NRCan, 2020b), representing about 4.6% of the Canadian workforce.[5] Natural resource exports make up nearly half the total value of all merchandise exports from Canada, and were valued between $201 and $264 billion annually from 2015 to 2019 (NRCan, 2016, 2017a, 2018c, 2019a, 2020b). Energy exports contributed to approximately half the value of all of Canada's natural resource exports during this time, followed by minerals and mining (35%); forestry[6] (14%); and hunting, fishing, and water (1%) (StatCan, 2021f). Canada is aiming to grow its natural resource exports to $350 billion by 2025, a 40% increase from 2017 (ISED, 2018). Part of this plan includes fostering innovation in Canada's natural resources sector by implementing CE measures (ISED, 2018). Resource extraction is also sometimes linked to regional identities (Clermont *et al.*, 2019; ECCC, 2019b).

5 The total Canadian workforce as of December 2019 was approximately 19,127,400 (StatCan, 2020b).

6 Although the term *forestry* may be used to refer specifically to planting, managing, and caring for forests, while *forest sector* may be used to characterize a broader range of activities, these terms are used interchangeably in this report.

Canada is in an unusual position among countries beginning to pursue a CE due to its status as a natural resource-producing country (ECCC, 2019b). Although a few countries with significant natural resource sectors have made progress on the CE — such as Finland and the Netherlands, which have strong forestry and agriculture sectors respectively (Deloitte, 2019b; WER & CBS, 2019) — international action on the CE is largely occurring in countries and regions in which natural resource extraction does not play a major economic role. In these jurisdictions, progress towards a CE is driven in large part by concerns about the scarcity and costs of primary natural resources. Because these concerns are less pressing for Canada and because of the importance of natural resource exports to the Canadian economy, there is little incentive to reduce natural resource extraction and optimize extraction to reduce associated waste. As a result, barriers to circularity in Canada's natural resource sectors may have developed or been left unaddressed (ECCC, 2019b; Kellam *et al.*, 2020). Historic extractive practices, for example in mining, have resulted in the production of a significant amount of waste that has accumulated over time and must now be managed (Kuyek, 2006). Moving forward, natural resource practices that incorporate circularity, such as re-mining and decontamination of mining residuals, could help address these legacy impacts (Kellam *et al.*, 2020). Overall, Canada will require an approach to the CE that recognizes the economic importance of the natural resources sector, as well as the environmental impacts often associated with contamination (ECCC, 2020c; as cited in Thompson & Piercey, 2021) and long-term impacts on ecosystems (CCA, 2019) and biodiversity loss (IRP, 2019).

Because Canada plays an essential role in the global economy as an exporter of energy and raw materials, one of the most important impacts of a global transition towards a CE is the possible reduction in international demand for Canada's natural resource exports (Kellam *et al.*, 2020). Reduced demand for Canada's natural resource exports would impact different parts of the country unequally; for example, rural and remote communities of Canada may be more dependent on particular resources for their socio-economic well-being (Petigara *et al.*, 2012) and thus could feel a greater economic impact. In addition, these areas face challenges in transitioning away from natural resource extraction and towards a more circular model due to difficulties in establishing material loops over large distances, combined with a lack of transport, energy, and communications infrastructure (Section 5.1). In general, the reduction of resource extraction and use of resources would be disruptive for resource extraction industries in the short term. Despite these challenges, the CE also provides significant opportunities for Canada to grow its resource sector by increasing the value of natural resources while reducing environmental impacts and optimizing extraction processes (Kellam *et al.*, 2020). The potential opportunities of a transition towards a CE for Canada's natural resource sector are further explored in Section 6.5.

Canada's economic relationship with the United States will significantly affect the transition towards a CE in this country.

The Canadian economy is heavily dependent on its trade relationship with the United States. Canada's trade with the United States constitutes approximately three quarters of the value of all of Canada's merchandise exports, half of all merchandise imports, and 63% of all bilateral trade (GAC, 2020a). In addition, approximately 75% of Canada's natural resource exports went to the United States in 2017–2018 (NRCan, 2018d, 2019a). Current Canada–U.S. trade also involves important commodities in the context of the CE: the United States is currently the largest importer of Canada's plastic waste and a major importer of Canada's e-waste (CIMT, 2021a, 2021b). As such, waste trade with the United States has been suggested as a valuable opportunity to advance CE in North America (ECCC, 2019b).

Canada–U.S. trade is characterized not just by high volume but also high levels of supply chain integration (GAC, 2020b). The proximity of much of the Canadian population to the United States border, combined with existing trade agreements, makes it highly cost-effective for many businesses to create cross-border supply chains (Levesque, 2011). Indeed, for some markets in the United States, a Canadian production or distribution centre is closer than the nearest domestic source (Levesque, 2011). The supply chain for automotive manufacturing is especially integrated. This sector accounted for 18.7% of the value of Canadian imports in 2019 and 15.6% of the value of Canadian exports, representing the second-largest share of Canada's exports after energy products (19.2%) (GAC, 2020b). Trade with the United States accounts for 75% of the automotive sector's imports and 96% of the sector's exports (GAC, 2020b). Overall, automotive parts may cross the Canada–U.S. border six or more times (Levesque, 2011). The existence of such integrated supply chains increases the importance of harmonizing CE policy between the United States and Canada.

Remanufactured goods are also traded across the Canada–U.S. border. The United States is a major remanufacturing hub, and Canada is the largest market for U.S. exports of remanufactured goods across a variety of sectors, constituting nearly 20% of the total value of such exports in 2011 (USITC, 2012). In addition, the recent Canada–U.S.–Mexico Agreement (CUSMA) includes a provision on remanufactured goods that may help to facilitate a CE (GAC, 2020c). Specifically, Article 4.4 states that recovered material used in remanufactured goods is treated as originating from the country in which it is recovered (CUSMA, 2018). However, competition from the remanufacturing sector in the United States could also be a potential barrier to increasing domestic remanufacturing capacity in Canada (Box 3.1).

Box 3.1 Value-Retention Processes in Canada

A core aim of the CE is to retain materials at their highest value. Value-retention processes include reuse, repair, refurbishment, and remanufacturing. ECCC (2021) reports that in 2019, value-retention processes within six major sectors in Canada (aerospace, automotive, electronics, home appliances, heavy-duty/off-road equipment, furniture) were worth approximately $44 billion in revenue to the Canadian economy and supported approximately 380,000 jobs in Canada. Value-retention activities within these sectors in 2019 also resulted in the avoidance of at least 1,620 kilotonnes of CO_2 emissions per year and material savings of 465 kilotonnes per year.

Canada currently relies on waste exports, and the transition towards a CE requires Canada to ensure this material is reused or recycled either domestically or overseas.

Historically, a significant portion of Canada's waste — particularly plastic — has been exported to other countries, although recent bans on waste imports in Asia have seriously disrupted waste management in Canada (Lewis & Hayes, 2019). The effect of CE policies on Canada's waste exports is presently unclear. Investment in domestic recycling and material/energy recovery could reduce waste exports in Canada. Alternatively, policies facilitating the transition to CE could incentivize the export of recyclable waste; for example, by allowing exported recyclable materials to count as progress towards recycling targets. Such a trend has been observed in the EU (Kettunen *et al.*, 2019). The desirability of such exporting depends on what happens to exported materials.

From a global perspective, trade in recyclable waste is an example of the CE (Liu *et al.*, 2018) and helps to direct such materials to countries with advantages in sorting and processing capacity (OECD, 2018). Moreover, trade in recyclable waste can be an important part of a CE for a country such as Canada. Some regions of the country may lack the processing capacity to recycle waste generated therein (Section 5.1). Furthermore, given that insufficient feedstock is a problem in Europe

(Section 5.3) and that Canada's geography makes it challenging to collect materials over long distances (Section 5.1), Canada may face challenges supporting reliable feedstocks for domestic recycling. However, as waste and recyclable materials are not consistently classified and tracked, it is difficult to ensure that they are, in fact, recycled at their destination (Sections 5.4 and 5.5), which can have negative environmental consequences for developing countries (Section 5.6). Canada could reduce the environmental impact of its waste exports in developing countries by "transferring waste management and recycling technologies, investing in R&D, and training local employees," as well as working to implement global EPR systems across developed and developing countries (Liu *et al.*, 2018). In addition, because the absence of classifications and standards is a key barrier to a productive trade in end-of-life materials (Section 5.5), trade policies are important levers to ensure that valuable recyclables are traded without allowing exports to effectively serve as overseas landfilling (Section 7.4).

Canada lacks comprehensive data on recycling and industrial capacity.

To devise a CE strategy for Canada, it is vital to be aware of the existing recycling capacity. Incentives for products designed for ease of material recovery will be unlikely to actually increase recycling in the absence of supportive infrastructure. Some information is available on the number of waste diversion facilities in Canada and waste diversion rates. As of 2018, there were 895 publicly owned material recovery facilities in Canada, 576 composting facilities, and 61 anaerobic digestion facilities (StatCan, 2021d). Approximately 9.8 million tonnes of non-hazardous materials were diverted to recycling or composting through companies or waste management organizations (StatCan, 2021e). The Panel notes that there is little comprehensive and up-to-date information on recycling capacity in Canada overall, with some exceptions, such as the plastics sector (Section 4.1.5). While it is likely that the transition towards a CE will require increased recycling capacity, without a more accurate assessment of existing capacity, it is difficult to determine what investments are necessary.

3.3 Environmental Context

In its definition of the CE, the Panel identifies a transition towards the CE as a way to bring humans closer to living within the Earth's planetary boundaries. By reducing the need for new raw materials and optimizing the value chain, the CE will, in turn, help reduce associated pollution and waste. This section places the CE within the Canadian environmental context: the high level of natural resource extraction needed to meet domestic and international demand has led to growing environmental pressures that are associated with a range of legacy and current issues, including landscape degradation, pollution, and loss of biodiversity (CCA, 2019). As discussed in Section 2.4, the Panel's model projects that if Canada does not implement additional circularity measures, material extraction and imports, waste, and emissions will continue to increase (Section 2.4.2).

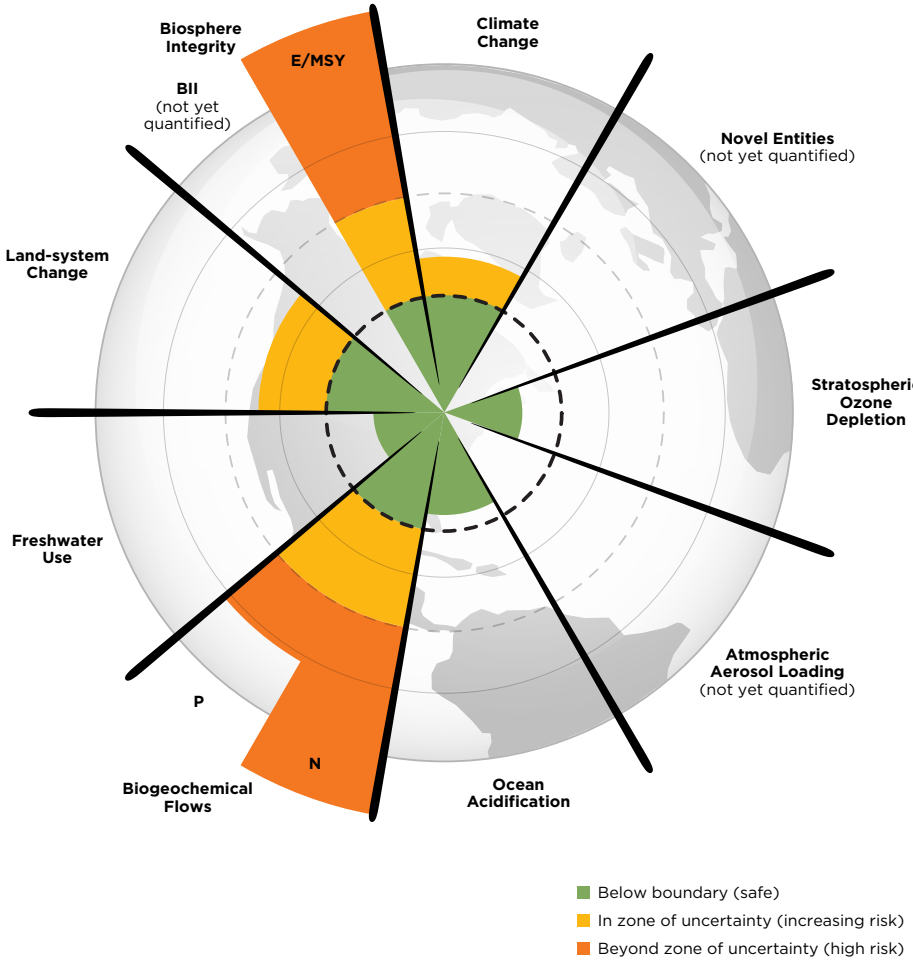
Canada has among the highest per capita consumption rates of materials, energy, and water in the world.

Canada's abundant resources and vast geography may have contributed to the development of a culture of consumption and wastefulness that has made it one of the most materials- and energy-intensive economies in the world (ECCC, 2019b). Canada has the sixth-highest rate of material consumption in the OECD at 28.7 tonnes per capita, nearly double the average of 14.6 tonnes per capita (OECD, 2021e). Canada also has one of the lowest levels of material productivity (economic output per unit of materials consumed) in the OECD (OECD, 2021d). Furthermore, Canada has the second-highest rate of energy use per capita in the world, at 7,631 kilograms of oil equivalent per capita in 2015 (World Bank, 2021). Approximately 16% of Canada's total primary energy supply comes from renewable energy, compared to 76% from fossil fuels and 8% from nuclear (NRCan, 2020a). Canada ranked fifth in the OECD for water withdrawals in 2015 at 855 cubic metres per capita (OECD, 2021c). The demand for resources in Canada is expected to increase in the near future, given the projected domestic population growth of about 49 million people by 2050 (StatCan, 2019), coupled with increasing energy demand driven largely by the industrial sector (NEB, 2016) and increased global demand for food (Valin *et al.*, 2014).

While these figures provide a high-level overview of Canada's consumption patterns, it is important to note that material, energy, and water use in Canada vary widely by region and by sector. A CE strategy to increase the sustainability of consumption and the efficiency of resource use in Canada will need to be adapted to these specific sectoral and regional differences. Water and energy use in Canada across industrial sectors is a major environmental consideration for the CE transition; water consumption is also a significant area of concern, in particular, in high-population-density areas or in central Canada where water availability can be limited.

Planetary boundaries define a safe operating space for human activities.

The planetary boundaries framework has allowed researchers to assess how nine key variables have changed as a function of human activities since 1950 and the extent to which these changes risk destabilizing earth systems (Rockström, 2009). Globally, as of 2015, the boundaries for extinction rate and biochemical nutrient flows (phosphorus and nitrogen) are considered at high risk of causing serious impacts due to the dramatic levels at which they have been exceeded (Steffen *et al*., 2015). Land-system change and climate change are also assessed as beyond the safe operating boundary, at increasing risk of negative impacts (Steffen *et al*., 2015) (Figure 3.1). Similar trends have been reported for biodiversity globally (-68% from 1970-2016) and specifically for North America (-33%) by the Living Planet Index (WWF, 2020). The boundaries may vary across countries, and little information is currently available on those exceeded in Canada. Fanning and O'Neill (2016) evaluated boundaries specific to Canada for four indicators (nutrients, carbon as proxy for climate change, land footprint, and freshwater use) and reported that carbon has exceeded safe boundaries over threefold, and phosphorus — one of the key nutrients responsible for eutrophication in aquatic ecosystems — has exceeded safe boundaries by 24%.



Source: J. Lokrantz/Azote based on Steffen *et al.* (2015)

Figure 3.1 The State of Variables Relative to Identified Planetary Boundaries Globally as of 2015

The green shaded regions represent the safe operating space, the yellow regions represent a zone of increasing risk, and the orange regions indicate regions of high risk.

(P indicates phosphorus; N indicates nitrogen; E/MSY is a measure of extinction rate, extinctions per million species-years; BII indicates Biodiversity Intactness Index).

3.4 Social Context

It is unclear what effect a transition towards a CE might have on social issues like income inequality and environmental justice, but there is strong support for environmental protection among the Canadian public, and there is evidence that the current linear economic system is perpetuating socio-economic and environmental inequality. Implementing CE practices offers opportunities to change these linear practices; it is also a way to initiate collaborative partnerships with Indigenous communities.

Income inequality and linear economic practices that expose marginalized groups to environmental harms should be considered in the transition towards a CE.

The linear economy is responsible for massive inequality, which could be reproduced in a CE without sufficient consideration of the socio-economic impacts of the CE transition (Section 6.4). Among OECD countries, Canada ranks squarely in the middle of the pack on income inequality, and many countries that are currently leading on the CE — including Finland, the Netherlands, and France — have lower levels of income inequality than Canada (OECD, 2021b). However, some provinces compare favourably to these countries with respect to income inequality, including Quebec, New Brunswick, and Prince Edward Island, which have the lowest levels of inequality in the country. By comparison, Ontario, British Columbia, and Alberta have the highest levels of inequality (StatCan, 2021g). The impact of the CE on income inequality in Canada is unclear. Since the CE is often more labour intensive than the linear economy (Wijkman & Skånberg, 2015), there are opportunities for the CE to create jobs (Section 6.2). However, the transition to a CE is not guaranteed to reduce income inequality, and there is evidence that some CE-related business models such as the sharing economy (Section 2.2) may actually exacerbate income inequality (Section 5.6). Nevertheless, addressing income inequality will be vital to achieving the environmental goals of the CE, as evidence suggests that income inequality may hinder actions to implement sustainable practices, transition to a low-carbon economy, and address climate change (Thorwaldsson, 2019).

Practices within the current linear economy also result in disproportional harm towards marginalized communities in Canada. For example, in Vancouver, Toronto, and Montréal, higher levels of air pollutants have been documented in majority-racialized, immigrant, or low-income areas of the cities, relative to majority non-marginalized areas (Giang & Castellani, 2020). In the view of the Panel, the transition towards the CE presents an opportunity to re-evaluate practices like waste management and consumption rates that contribute to these discrepancies, and change them in ways that support social equity and environmental justice (Section 6.4).

Public support for environmental protection is strong in Canada.

While there are currently challenges around public awareness and understanding of the CE in Canada (Deloitte, 2019b) (Section 5.6), public polling has found high levels of support for government action to protect the environment, address climate change, develop clean and renewable energy, and reduce GHG emissions and dependence on fossil fuels (EcoAnalytics, 2016). Polls have also found that a significant majority of Canadians (~66%) want Canada to be among world leaders in clean energy and clean technology, although support is somewhat lower in Alberta and among Canadians over 45 years old (Abacus Data, 2020). Polling has also found widespread support for other CE-related measures, such as bans on single-use plastics, although the COVID-19 pandemic has reduced support for such a ban, which fell from 70% support in 2019 to 58% in 2020 (Kitz *et al.*, 2020). Notably, polls have also found a lower level of support in Canada for some CE-related measures compared to the rest of the world; for instance, Canadians are slightly below the global average with respect to support for buying second-hand goods, avoiding excess packaging, reducing energy and water use, and recycling (Ipsos, 2020).

Collaboration and partnerships with Indigenous communities will be essential to the development of inclusive and respectful CE approaches in Canada.

Learning from Indigenous knowledge and practices helps inform the development of a CE, as CE principles may align with Indigenous perspectives on responsible stewardship of land and resources (ECCC, 2020a). The concept of circularity is a dominant feature in many Indigenous cultures in defining the relationship between people and the land. Indigenous perspectives on the natural environment offer alternative ways of conceiving of "democracy, waste, well-being, society and nature" (Friant *et al.*, 2020). For example, Indigenous concepts such as seventh-generation decision-making promote environmental stewardship and advance sustainable, long-term resource management (Clarkson *et al.*, 1992; Mortillaro, 2021).

Numerous Indigenous-led organizations and community programs are at the leading edge of sustainable use and land management practices. In Ontario, the Nishnawbe Aski Nation has partnered with the Recycling Council of Ontario and Indigenous Services Canada to advance the CE in 49 communities through the implementation of waste management programs aligned with Nishnawbe Aski Nation values (RCO, 2020). First Nation Growers supports community gardening in some of Canada's most remote First Nation and Inuit communities, with the goal of developing circular, self-sustaining agricultural industries (FNG, 2020). In Manitoba, the Centre for Indigenous Environmental Resources (CIER) is working on a CE approach to minimize solid waste via local pilot projects (ECCC, 2019b; CIER, n.d.). The Collaborative Leadership Initiative is a program where Indigenous and municipal leaders from communities in Manitoba work together to address shared social and environmental concerns (CLI, 2021). This initiative has included a conference on exploring CE strategies in Manitoba (Wong, 2021).

These Indigenous-led CE approaches aim to realize the environmental, economic, and social gains of the CE by encompassing Indigenous values, including establishing opportunities for productive, long-term partnerships; fostering local jobs and community engagement; prioritizing land protections; and leveraging related work, including climate change mitigation and food security practices. Engagement with Indigenous governments, organizations, and Indigenous-owned businesses is an important opportunity to advance successful and inclusive CE practices in Canada and to ensure a successful transition towards the CE (ECCC, 2020a). However, there are policy and jurisdictional challenges facing Indigenous communities, such as access to capital (Section 5.3), that may be barriers to the development of an Indigenous-led CE.

4

The Current State of the CE in Canada

4.1 Sectoral Initiatives and the CE

4.2 Jurisdictional Strengths

4.3 Partnerships and NGOs

4.4 Research Strengths

4.5 Skills Strengths

Chapter Findings

- Canada has begun to develop CE approaches in a variety of different sectors, notably in mining and minerals, forestry, fossil fuels, construction, food, plastics, electronics, and textiles.
- Governments at various levels (federal, provincial, territorial, and municipal) are beginning to adopt CE terminology and practices in policy.
- Work on the CE in Canada has been driven by partnerships and collaborations among NGOs, research institutes, and municipalities in Canada. The province of Quebec has been especially active in implementing and supporting CE initiatives.

Several sectors and industries in Canada have started their transition to a CE by experimenting with circular strategies and practices, and governments operating at all levels (from federal to municipal) are pursuing initiatives to facilitate the adoption of the CE within society. Building on existing CE initiatives and pilot projects in these sectors and jurisdictions will be an important step to transitioning towards a CE in Canada. In addition to individual CE programs that focus on specific sectors and efficiencies, the Panel notes that coordinated cross-sectoral strategies, systems-wide change, and a national roadmap will be necessary for a successful transition towards a CE. This chapter provides a snapshot of the state of the CE in Canada by documenting some of the CE initiatives and programs that have been developed across the country.

4.1 Sectoral Initiatives and the CE

Although the CE can be applied to a wide range of sectors, the Panel selected sectors for discussion that are particularly relevant to the implementation of the CE in Canada. These represent major sectors in the Canadian economy, as well as those in which significant progress in implementing a CE has already been made.

4.1.1 Mining

Mining and minerals account for 5% of Canada's nominal GDP (NRCan, 2019b). Worldwide, mining generates 100 billion tonnes of solid waste annually (Rankin, 2015; as cited in Tayebi-Khorami *et al.*, 2019). Mining produces waste that can be reprocessed to improve sustainability in mining and derive additional economic value. This includes primary materials (e.g., gold, nickel, cobalt, and tungsten), as

well as mining by-products that can also be used by other sectors (e.g., agroforestry, wastewater treatment) (NRCan, 2019b). Canada also stands to benefit from growth in industries reprocessing secondary metals such as steel (IISD, 2018a). Copper is a particularly opportune material for circular sourcing and recovery due to projected demand growth combined with increasing limitations on the grade and accessibility of copper ore supplies (MGI, 2017; Esposito *et al.*, 2018).

Clean energy technologies — including solar panels, wind turbines, and batteries — are expected to increase demand for certain minerals and metals in the coming decades (Hund *et al.*, 2020). While recycling and reuse of minerals will be important for meeting this demand (and helping to reduce emissions) (Box 4.1), even with significant increases in recycling rates, new material will still be necessary to meet the predicted demand (Hund *et al.*, 2020). Indeed, the SankeySim model developed for this assessment projects that a transition to net-zero GHG emissions in Canada (Section 2.4.2) would result in a significant increase in the extraction of metal ores to meet the demand for materials such as aluminum and technology metals needed support renewable energy infrastructures. This represents an opportunity to continue growing Canada's mining sector while also reducing GHG emissions. For example, Canada produces 14 of the 19 metals required for solar panels (ISED, 2018). Increased mining activity, however, would need to be balanced with its effects on other sustainability goals, such as emissions/carbon-neutrality targets and biodiversity goals. As an exporter of minerals and metals (NRCan, 2019b), Canada is also situated within, and must consider, the larger context of global networks that Canadian mining activity supplies.

Box 4.1 Circularity in Clean Technology

As the demand for clean energy technology increases, incorporating circular principles is becoming more important to manage the materials and products used and created by the sector (IRENA & IEA-PVPS, 2016; Hao *et al.*, 2020). One example is managing the end of life of solar panels. It is estimated that by 2030, solar panel waste in Canada could cumulatively reach 13,000 tonnes (IRENA & IEA-PVPS, 2016). Canada does not have solar panel recycling facilities, and panels that are to be recycled are typically shipped to facilities in the United States (Matthews, 2020). To maximize the lifespan and use of these panels and to minimize waste, solar panel refurbishing, repair, and recycling capacity is important (IRENA & IEA-PVPS, 2016). Indeed, consideration of circular principles will be important for all new and emerging clean technology to mitigate waste and lower environmental impacts.

Several CE-related initiatives have been launched in Canada's mining sector. The Canadian Minerals and Metals Plan aims to reduce the environmental impacts of mining and support the development of a CE for the mining sector in which waste is transformed into useful products; the plan has identified the CE as a key area for action (NRCan, 2019b). The Canadian Mining Innovation Council has developed a Towards Zero Waste Mining innovation strategy that aims to minimize waste, improve water quality, increase energy efficiency, and reduce GHG emissions (CMIC, 2017). In addition, in 2017, CanmetMINING at NRCan, in collaboration with the Green Mining Innovation Intergovernmental Working Group, launched the Mining Value from Waste pilot project, which focuses on reducing the environmental, social, and economic impacts of mine waste in order to support the transition to a circular, low-carbon economy (NRCan, 2018b). The project aims to recover materials from tailings, thereby increasing value and reducing liability. As of 2018, Alberta, Ontario, Nova Scotia, British Columbia, and Newfoundland and Labrador were participating in the program (NRCan, 2018b). Federal Budget 2021 also included funding for the development of a Critical Battery Minerals Centre of Excellence at NRCan to coordinate programs on critical mineral mining (GC, 2021b).

At the provincial level, Quebec has developed its own Plan for the Development of Critical and Strategic Minerals, which addresses the need to adopt CE practices within the mining sector (Gov. of QC, 2020). Proposals include support for research on comprehensive value chains for minerals in Quebec, business models that support CE projects in the mineral sector, and innovations for reclaiming mine tailings (Gov. of QC, 2020). A study from the Institut EDDEC evaluated the potential of 41 different strategies for promoting circularity within the metal industry in Quebec, with a focus on copper, lithium, and iron. Thirteen strategies of relevance were highlighted and fall under categories related to more efficient uses of resources (e.g., improved mineral extraction efficiencies, usage of minerals/metals that are left in unused urban infrastructure), intensified product use and increased product lifespan (e.g., building and material designs that allow for the reuse of steel beams from buildings, reuse of aging lithium-ion batteries from cars for energy storage), and giving new life to resources (e.g., recycling processes and recovery of resources from extraction waste products) (EDDEC, 2018).

4.1.2 Forestry

Canada's forestry industry has already begun to explore the circular bioeconomy. For example, Anomera Inc. from Montréal has developed a replacement for plastic microbeads in cosmetics using cellulose from wood waste and pulp, and Canadian Salvaged Timber uses reclaimed wood to produce furniture and building materials (NRCan, 2018a). Researchers at the University of Alberta are examining ways of

using lignin, a by-product of pulp and paper processing, to produce biofuels (Kryzanowski, 2019). In addition, several jurisdictions at various levels are revising building codes to allow for wood-frame high-rise buildings, which replace steel and cement with wood. Wood frame buildings reduce carbon emissions by lowering the demand for energy-intensive materials like steel and cement, and also by storing carbon; wood-frame buildings also increase energy efficiency (Kellam *et al.*, 2020). Indeed, because the forestry industry in Canada is relatively advanced with respect to resource efficiency, it could serve as a model industry for demonstrating how to support the CE and create jobs (Deloitte, 2019b). Federal Budget 2021 also included funding to NRCan to support a forest-based bioeconomy in Canada (GC, 2021c).

The CE also presents opportunities for Canada's forestry sector to produce bioenergy and cardboard. For example, Finland's use of sustainably managed timber for the production of renewable bioenergy (representing 26% of Finland's energy production) could be replicated in Canada (Deloitte, 2019b). Existing Canadian pulp and paper mills, with assistance from NRCan, have begun to explore the viability of retrofitting their operations to become bio-refineries that produce biofuels and chemicals from biomass (Bauer, 2016; NRCan, 2018c). In addition, according to estimates from U.K. packaging company DS Smith, demand for cardboard packaging to replace plastic is expected to be valued at US$700 million in Europe and the United States between 2018 and 2022 (DS Smith & White Space, 2019; as cited in J.P. Morgan, 2019), which presents significant export opportunities for Canada. CE approaches that focus on material recovery and reuse could help the forestry industry in Canada become more sustainable by reducing the harvesting of old-growth forests (Kellam *et al.*, 2020).

4.1.3 Fossil Fuels and Carbon Capture

Canada is the sixth-largest energy producer in the world as of 2018 (NRCan, 2020a), and its oil and gas sector has one of the highest emissions intensities in the world (Rystad Energy, 2020). Canada relies heavily on fossil fuels to meet its energy needs, which may be a significant challenge for the transition towards a CE (Deloitte, 2019b). Reducing dependence on fossil fuels will be an important element of the transition towards a CE. Renewable natural gas, produced by the decomposition of organic waste, represents one potential opportunity for more circular energy. For example, Canadian natural gas company Fortis BC has set a goal to make 15% of its natural gas portfolio renewable by 2030 by capturing and purifying gas from organic sources (Fortis BC, 2020), and the City of Toronto is pursuing circularity in renewable natural gas by working with Enbridge to produce biogas from Toronto's Green Bin organic waste (City of Toronto, 2019c).

The fossil fuel industry is beginning to adopt circular practices in the capture of methane — which has a high global warming potential — for energy recovery. Flared methane is a resource that is otherwise wasted and methane capture can maximize resource use efficiency and lower overall emissions. Globally, 14 billion cubic feet of methane waste emissions are flared every day — the energy equivalent of approximately four million barrels of oil (SPI, 2016). Canadian companies such as Questor Technology have developed technology to capture methane emissions produced by oil and gas extraction, which is already in use in Canada. The federal government has committed to reducing methane emissions in Canada by 40 to 45% below 2012 levels by 2025 and recently finalized equivalency agreements with western provinces that provide strengthened regulations to achieve this goal (ECCC, 2020d).

Another potential area for circularity in Canada's fossil fuel industry is extracting lithium from saltwater brine waste used in oil wells (Rieger, 2020; Smith, 2020). The global market for lithium is expected to grow significantly over the next decade, as it is a vital component of electric vehicle batteries. Moreover, extracting lithium from brine is both less environmentally harmful and more cost-effective than traditional hard rock lithium mining (Desjardins, 2015). The Calgary-based company Summit Nanotech is working on clean lithium extraction processes that are powered by renewable energy sources like solar, wind, and geothermal (Summit Nanotech, 2020).

The fossil fuel industry has also explored carbon capture and recycling, in which CO_2 is extracted from the atmosphere via a chemical process and used for various applications. For example, captured carbon can be combined with hydrogen and oxygen to create fuel. A pilot project in Squamish, British Columbia, by Canadian company Carbon Engineering currently extracts about one tonne of CO_2 per day and produces two barrels of fuel, but also generates roughly a half-tonne of CO_2 emissions due to its reliance on natural gas power (Keith *et al.*, 2018; Weber, 2018). While renewable sources of energy could reduce these emissions, the environmental and circular benefits of this technology have also been questioned on the grounds that the fuel produced by this process will simply be burned and reintroduced into the atmosphere (CIEL, 2019).

Captured carbon can also be used in concrete production (where carbon is sequestered as calcium or magnesium carbonates) (reviewed in Ravikumar *et al.*, 2021) or in enhanced oil recovery, a process in which captured CO_2 is injected into depleted oil wells to extract otherwise inaccessible oil (CIEL, 2019). These uses for captured carbon are also controversial, as there are concerns about the true carbon sequestration potential of captured carbon concrete (Ravikumar *et al.*, 2021) and the use of captured carbon to produce oil that may be burned and result in additional fossil fuel emissions (CIEL, 2019). Research has also indicated that

the effects of carbon removal and carbon emissions may not be one-to-one; that is, to compensate for a given amount of carbon emitted, a higher amount must be removed (Zickfeld *et al.*, 2021). Despite these concerns, some companies using enhanced oil recovery technology report "net negative" carbon emissions as they store more carbon than they are producing and emitting (Whitecap Resources, 2020). In Federal Budget 2021, the Government of Canada announced proposals for an investment tax credit for investments in carbon capture, utilization, and storage projects (GC, 2021c). The budget also set out $319 million in funding for NRCan to support work that improves the "commercial viability of carbon capture, utilization, and storage technologies" (GC, 2021c).

Ultimately, the transition towards a CE will require moving away from fossil fuels and towards renewable sources of energy (EMF, 2015b; Ghisellini *et al.*, 2016). Whether and how to include fossil fuels in Canada's CE strategy is an ongoing area of discussion among experts (ECCC, 2019b).

4.1.4 Construction

Construction is the largest global consumer of raw materials (Arup, 2016; WEF, 2016). A 2015 report found that around 3.4 million tonnes of construction, renovation, and demolition waste is landfilled in Canada (Guy Perry and Associates & Kelleher Environmental, 2015; as cited in CCME, 2019). The World Economic Forum (2016) projects that even modest improvements in resource productivity in the construction sector would have significant savings benefits; globally, a 1% increase in productivity could translate into US$100 billion in savings for the industry. Strategies such as early product planning and "lean" principles can be implemented for significant returns (WEF, 2016). Design for longevity and ease of maintenance are important principles in circular construction, as is the reuse of assets such as elevators and the selection of materials that are recycled (e.g., steel) and can easily be reused or recycled at end of life (Brankin *et al.*, 2020). Additional methods for increasing circularity and improving efficiency include incorporating existing structures into new designs and rethinking the use of formwork (concrete moulds), which produces a large amount of timber waste (Esposito *et al.*, 2018).

There are significant opportunities to advance a CE in Canada's construction sector. An analysis by the Smart Prosperity Institute (2020a) found that the construction sector is the most economically important to Canada among those sectors with the potential for circular approaches, and used building materials are the second most economically important core product for a CE in Canada. However, collaboration and coordination across industry, government, and consumers, as well as tools such as life-cycle analysis, will be necessary to take

advantage of the significant opportunities to reduce resource consumption in the construction industry in Canada (Raufflet *et al.*, 2019a).

The construction industry in Canada has begun to make some progress on the CE. In British Columbia, the construction firm Unbuilders has developed a circular approach to demolition that recovers construction materials from buildings for reuse (Kellam *et al.*, 2020). In addition, the Canadian Construction Association's Lean Construction Institute exists as a platform for collaboration among participants at multiple stages of the construction supply chain (WEF, 2016). Policies supporting CE in the construction industry have also gained traction in Canada; for example, the Canada-wide Action Plan for Extended Producer Responsibility required jurisdictions to incorporate construction materials into existing EPR programs by 2017 (CCME, 2009). As of 2017 though, little progress had been made nationally on implementing these EPR schemes for construction materials (Arnold, 2019). Some provinces are pursuing waste regulation independently; in Quebec, the Stratégie de valorisation de la matière organique proposes improvements for access to infrastructure for recycling construction waste (MELCC, 2020). Other strategies that are being considered for minimizing construction waste in Canada include adaptive reuse, offsite modular construction, and designing buildings for easy disassembly (NZWC, 2021). Adaptive reuse involves repurposing obsolete buildings and/or reusing or recycling materials from the building; offsite modular construction uses pre-made construction components; and design for disassembly focuses on enabling the easy reconstruction and reuse of a building's components and materials (NZWC, 2021). In addition, the federal government's Greening Government Strategy committed to diverting 90% of all construction waste from landfills, as well as reducing the embodied carbon in major government construction projects by 30% and conducting life-cycle assessments by 2025 (GC, 2021a).

4.1.5 Plastics

In 2018, the Canadian Council for Ministers of the Environment (CCME) implemented the Canada-wide Strategy on Zero Plastic Waste, which takes a CE approach to plastics that focuses on the prevention of plastic waste and improved collection rates of plastic waste for material and energy recovery (CCME, 2018a). The strategy also helps Canada meet its commitments under the Ocean Plastics Charter, which was introduced in 2018 as part of Canada's G7 presidency. In 2020, the Canada Plastics Pact was launched with the goal of enabling cross-sectoral collaborations among stakeholders in order to reduce plastic waste and pollution (CPP, 2020). At the provincial level, the Plastics Alliance of Alberta, a collaboration among industry, academia, and government, was recently established to help support the development of a plastics CE in Alberta (Gov. of AB, 2020).

Businesses in Canada are also adopting circular practices with respect to plastics; for example, HP Canada has partnered with Montréal's Lavergne Group to manufacture new HP printer cartridges from recycled plastics (CC50, 2019). In 2020, five companies in Canada's food, beverage, and packaging sectors partnered with the Canadian Plastics Industry Association and the CTTÉI to form the Circular Plastics Taskforce (Canadian Plastics, 2020). The goal of the task force is to "optimize plastics management…throughout the recycling value chain," and it is in the process of assessing and piloting projects for optimization within Quebec, with the aim to expand nationally (CPT, 2020).

Canada has over 200 recycling facilities for plastics, although few are operating to capacity (CELC, 2019). As of 2019, six companies in Canada were moving towards commercialization of chemical recycling processes that convert waste plastic into compounds which can be used to make new plastics or fuels (Deloitte, 2019a). Only a small amount of consumed plastics — approximately 9% — is recycled in Canada (CELC, 2019; Deloitte, 2019a; SPI, 2019). In 2016, 86% of plastic waste in Canada was landfilled or lost to the environment; this plastic is estimated to be worth $7.8 billion (Deloitte, 2019a). Nearly half of plastic waste in Canada comes from packaging, a significant proportion of which is intended for single use (Deloitte, 2019a). Moreover, recent waste import bans in Asia have impacted Canada's plastic waste management (Section 3.2). As of 2019, Canada has five facilities for burning plastics for energy recovery (Deloitte, 2019a), but the role of incineration in the CE is debated (Box 2.1).

Experts have recommended that plastics be a priority focus for the CE in Canada and have provided policy recommendations to support the transition, including EPR requirements for plastics, standards for minimum recycled content in plastic products and packaging, bans on certain types of plastics and landfilling practices, and harmonized standards and indicators for plastics and plastic waste (CELC, 2019; SPI, 2019). In line with this, the Canada-wide Strategy on Zero Plastic Waste includes a target to reduce the amount of plastic waste produced per capita in Canada by 30% from 2014 to 2030 (CCME, 2018b; NZWC, 2021). The CE could also be advanced in the plastics sector by replacing fossil fuel-based plastics with alternatives from renewable sources, such as biomass and atmospheric gases (SPI, 2019) or reusing plastic packaging (NZWC, 2021), although life-cycle analyses of these options would need to be considered to assess their impact.

4.1.6 Food and Agriculture

The interconnected infrastructure of food systems makes this sector particularly suited to a CE, not only because CE principles are highly applicable to food waste but because food systems readily lend themselves to a framework focusing on communities and relationships (Fassio & Minotti, 2019). The University of

Gastronomic Sciences is currently classifying over 200 case histories dealing with the adoption of CE principles to food systems (Fassio & Minotti, 2019; UNISG, 2020).

A recent Canadian analysis by the Smart Prosperity Institute found that food products are the most economically important of twelve products that are currently the subject of CE initiatives (SPI, 2020a). In Canada, over a third of all food produced and distributed is never eaten (NZWC, 2018b), and preventable food waste has an economic value of at least $49 billion (Nikkel *et al.*, 2019). Therefore reducing food waste in Canada represents a significant economic opportunity. Some start-up companies are taking advantage of this opportunity; for example, the company Flashfood works with grocery stores to offer customers discounted prices on fresh food that is nearing its best-before date and would otherwise be wasted (Flashfood, 2021). Moreover, local food production that incorporates sustainable practices can help address food insecurity in remote communities (Fawcett-Atkinson, 2020). Prioritizing a CE for food would also help Canada meet SDG 12.3, which requires countries to reduce per capita food waste by half by 2030 (UN, 2015).

Addressing food waste in Canada will require developing benchmarks and metrics, as well as developing standardized categories for food waste (ECCC, 2019a). Formalizing national goals could also be helpful (NZWC, 2018b; ECCC, 2019a). For example, the National Zero Waste Council (NZWC) has provided guidelines for measuring food waste in Canada (NZWC, 2018a). In addition, the NZWC has developed a national Food Loss and Waste Strategy that aims to prevent and reduce food waste, recover uneaten food for people and animals, and recycle energy and nutrients from any remaining food waste (NZWC, 2018b). With partner organizations, the NZWC also runs the Love Food Hate Waste Canada initiative, a campaign to provide advice to the public about reducing household food waste (LFHWC, 2021). In 2020, the Government of Quebec released a strategy that outlines goals for managing and reducing organic waste, including the target of reducing or recovering 70% of all organic matter by 2030 (MELCC, 2020). The Our Food Future initiative is working with the Guelph and Wellington County municipal governments and collaborators to create Canada's first circular food economy (City of Guelph, 2020a). Businesses in the Canadian food industry are beginning to adopt circular practices as well; for example, Montréal-based Loop Mission recycles food waste into various products (Steuter-Martin, 2019).

Some circular practices are also being incorporated into agricultural settings. For example, multiple companies in Canada offer nutrient-recovery processes that capture wasted biosolids or remove nutrients from wastewater and transform the waste into effective fertilizers that are reused on farms (SPI, 2021). Another important circular practice that is being adopted in agriculture is diverting waste food, or food unfit for human consumption, to animal feed (SPI, 2021).

4.1.7 Electronics and Information Technology

Electronics manufacturing stands to benefit in particular from resource recovery business models, as electronic waste includes scarce materials with a high potential recovery value (EMF, 2018; Heyes *et al.*, 2018). These include gold, platinum, cobalt, rare earth elements, aluminum, and tin; indeed, it is estimated that there is "100 times more gold in a tonne of mobile phones than in a tonne of gold ore" (PACE, 2019). Globally, the material value embodied in electronics was estimated to be US$57 billion in 2019 (Forti *et al.*, 2020). Moreover, recovering these metals via electronics recycling is 2 to 10 times more energy efficient than producing metals from virgin ore (PACE, 2019). However, metals in electronic waste can also be very difficult to extract (PACE, 2019). Currently, the recycling rate for electronics is relatively low; in 2016, Canada recycled less than 14% of the total electronic waste generated that year (Baldé *et al.*, 2017; Forti *et al.*, 2020).[7] In 2019, 17.4% of e-waste was recycled globally, and world-leading Europe recycled 42.5% of its e-waste (Forti *et al.*, 2020).

All provinces in Canada have an EPR program for electronics, with the exception of Alberta, which has a product stewardship program (GEC, 2016). EPR programs place partial or full responsibility for products at their end of life on producers, while in product stewardship programs producers only hold a possible advisory role and end-of-life programs are funded by consumers or taxpayers, and run by public organizations or a delegated party (CCME, 2014). These EPR programs are often operated in collaboration with the Electronic Product Recycling Association (EPRA), an industry-led national organization that operates collection and recycling programs to help producers meet their responsibilities under EPR (EPRA, 2014; Giroux, 2014). The EPRA has also helped to develop consensus in Canada's electronic industry around best practices for EPR programs and has advised provinces on developing EPR policies (Leclerc & Badam, 2019). Among the territories, the governments of the Yukon and the Northwest Territories operate electronics recycling programs, and there are no end-of-life programs for electronics in Nunavut (EPRA, 2014), although individual communities have implemented electronic waste diversion programs (Oceans North, 2021).

Other circular approaches in the electronics sector include: (i) developing return programs and reverse logistics chains for electronics that incentivize consumers to return end-of-life products while also addressing concerns around the privacy of data that may be stored on those devices; (ii) transitioning to a PaaS business model for electronics, as well as leasing, rental, and subscription models; and (iii) making greater use of shared resources business models, such as cloud

7 This number is calculated by dividing the total "e-waste documented to be collected and recycled" in 2016 from Forti *et al.* (2020) by the total "e-waste generated in 2016" from Baldé *et al.* (2017).

computing (which increases the longevity and acceptance of refurbished products by transferring capabilities from a device to the cloud) (EMF, 2018; PACE, 2019). Product life extension is also a strong model for electronics, particularly since the sector has a high rate of product obsolescence (Satyro *et al.*, 2018; Harris, 2020). The organization Insertech, based in Quebec, trains unemployed individuals to repair broken technology to extend the lifetimes of various devices (Insertech, 2021). Moreover, the value of repair and resource recovery for electronics makes design for disassembly a particularly important practice (Deloitte, 2019b).

Companies providing information and communication technology services rather than goods can also adopt circular operations (Heyes *et al.*, 2018). A case study identified opportunities that include monitoring computer performance to reduce customer energy use, providing services such as printing on a per-use basis, providing a service to take back used equipment for refurbishment and resale, engaging with suppliers to provide more sustainable packaging, and providing remote rather than in-person support to reduce fuel use. The business in question considered monitoring performance and remote services as the most promising opportunities for implementation (Heyes *et al.*, 2018).

4.1.8 Textiles

The textiles industry has great potential for circularity due to the high volume of materials involved. Currently, both production and consumption of textiles are very linear, with significant amounts of non-renewable resources extracted to produce clothing that is often used for only a short time before being disposed of via landfill or incineration (EMF, 2017b). Trends such as overconsumption, the rise of fast fashion, decreased costs, and a lack of commercially viable closed-loop recycling infrastructure have led to increased levels of textile waste in Canada and the world in recent years (Storry & McKenzie, 2018; Colyn, 2019). Currently, about 85% of textiles are eventually landfilled, despite the fact that the vast majority of current post-consumer textile waste is of high enough quality to be reused or could be recycled if infrastructure were available (Colyn, 2019). Estimates for textile waste in Canada range from 500,000 tonnes annually (Storry & McKenzie, 2018) to over 955,000 tonnes annually (Colyn, 2019). It is further estimated that Canadians individually throw away an average of 31 to 37 kilograms of textiles each year (Colyn, 2019; Gray, 2019). Clothing is largely underutilized, particularly in high-income countries, providing significant opportunities for circular approaches (EMF, 2017b). It has been estimated that clothing underutilization and lack of recycling represents over US$500 billion annually in lost value globally (EMF, 2017b).

Increasing the circularity of textiles would also have positive environmental impacts, as textiles production is responsible for generating more annual GHG emissions than all international flights and maritime shipping combined, as well as releasing nearly half a million tonnes of plastic microfibres into the ocean annually (EMF, 2017b). Indeed, many textiles contain plastics. While polyethylene terephthalate (PET) is known to be used to produce plastic bottles, 60% of virgin PET is used to produce textile fibres (Colyn, 2019). Thus, addressing the problem of plastic waste requires a consideration of the role of plastics in textile waste.

Under the Canada-wide Action Plan for Extended Producer Responsibility, textiles were identified as a "phase two" priority, with an implementation goal of 2017 (CCME, 2009). However, that goal was not met (EPRC, 2017b). Nevertheless, progress on a CE for textiles has been happening at the local and regional levels in Canada. For example, the city of Markham, Ontario, banned textiles from household waste in 2018, following a pilot program that introduced bins around the city to collect textiles for diversion (Javed, 2017; Storry & McKenzie, 2018; Colyn, 2019). The collection bin pilot program was part of a textile diversion research study led by Diabetes Canada and York University, which included several other municipalities across Canada, such as Durham Region, King City, London, Brampton, and Toronto in Ontario, as well as Calgary, Alberta, and Vancouver, British Columbia (Langer, n.d.). In addition, Colchester County, Nova Scotia, introduced a textile recycling program in 2016, and Metro Vancouver is exploring additional policies and programs that could help to reduce textile waste and increase textile recycling (Storry & McKenzie, 2018; Colyn, 2019).

Other circular textiles initiatives in Canada include the Ontario Textile Diversion Collaborative (OTDC), a cross-sectoral group of stakeholders in the textiles sector (including municipalities, clothing brands, retailers, industry organizations, charities, NGOs, and academics) that aims to reduce textile waste and support the development of a textile recycling industry in Ontario (OTDC, 2019), and the Association For Textile Recycling (AFTeR) in Nova Scotia, which works to recover textiles for resale and recycling in order to help fund social causes such as supporting at-risk children and youth and marginalized people (AFTeR, n.d.). In Quebec, MUTREC is a group of experts from different organizations with diverse areas of expertise who collaborate to support CE practices in the textile industry (MUTREC, 2018).

4.1.9 Industrial Symbiosis and Eco-Industrial Parks

Industrial symbiosis is a relationship among firms in a close geographical area aimed at increasing competitive advantage through an exchange of materials, energy, water, and by-products (Chertow, 2000). This provides opportunities for circular business model strategies in which waste produced by one firm is used as

production inputs by another firm (Bocken *et al.*, 2016; NISP, 2019; Raufflet *et al.*, 2019a). There have been several initiatives in Canada promoting industrial symbiosis to advance the CE:

- In Quebec, RECYC-QUÉBEC has provided funding to 14 industrial symbiosis projects that fall under the heading of a CE, including projects involving food and construction waste (ECCC, 2019b). In 2021, RECYC-QUÉBEC announced funding of $3.3 million towards 15 new projects to support industrial symbiosis for the CE (RECYC-QUÉBEC, 2021b).
- The CTTÉI provides matchmaking events to help companies that produce waste connect with companies in need of materials. CTTÉI's Synergie Québec program has created 850 such synergies, launched 22 industrial symbiosis projects, and worked with over 2,700 organizations since 2015 (Jagou, 2021). The program has resulted in 17,800 tonnes of materials diverted from landfills, 9,200 tonnes of CO_2 emissions avoided, and $4.3 million in savings (Jagou, 2021).
- NISP Canada piloted industrial symbiosis programs in Metro Vancouver and Greater Edmonton over a period of 18 months, from October 2017 to March 2019, that engaged over 350 businesses (NISP, 2019). The pilot resulted in a $6.3 million economic impact for participating businesses (due to cost savings and additional sales related to the program), as well as 253,800 tonnes of waste diverted from landfills and 23,000 tonnes of CO_2 emissions avoided. Moreover, it is estimated that the program generated a return of $7 for every $1 of government investment (NISP, 2019).

Eco-industrial parks are an example of industrial symbiosis, where businesses within a particular geographical location collaborate and share resources and information in order to reduce their environmental impact, reduce waste and pollution, improve economic performance, and create a more sustainable economy (Hein *et al.*, 2015; Halonen & Seppänen, 2019). Eco-industrial parks are increasingly recognized as an important tool to implement circularity (Ghisellini *et al.*, 2016; LeBlanc *et al.*, 2016; Gómez *et al.*, 2018). In Canada, government support for eco-industrial parks tends to come from the municipal level. In other countries, national and sub-national governments have taken leadership roles in the development of these parks; however, there has been little support from higher levels of government in Canada (LeBlanc *et al.*, 2016). While definitions of an eco-industrial park vary, there are several industrial parks in Canada that seem to qualify, including:

- Burnside Industrial Park in Dartmouth, Nova Scotia (City of Edmonton, 2015; Bellantuono *et al.*, 2017)
- Pearson Eco-Business Zone in Toronto, Ontario (TRCA & Town of Caledon, 2014)
- Ross Industrial Park in Regina, Saskatchewan (TRCA, 2008)

- Taiga Nova Eco-Industrial Park in Fort McMurray, Alberta (Christian, 2014; TRCA & Town of Caledon, 2014; City of Edmonton, 2015)
- Innovista Eco-Innovation Park in Hinton, Alberta (TRCA & Town of Caledon, 2014; City of Edmonton, 2015; Bellantuono *et al*., 2017)
- Maplewood Project in Vancouver, British Columbia (City of Edmonton, 2015)
- Ontario East Wood Centre and Eco-Industrial Park in Edwardsburge/Cardinal, Ontario (TRCA & Town of Caledon, 2014)
- Daniel Gaudreau Eco-Industrial Park in Victoriaville, Quebec (Écoparc Industriel Daniel-Gaudreau, 2021).

4.2 Jurisdictional Strengths

Canada has already begun to develop and implement a CE at federal to local levels, albeit to a limited degree. In addition, Canada's jurisdictional structure has allowed for sub-national experimentation with local circular strategies that do not require a pan-Canadian consensus. Building on these existing successes will be vital to transition towards a CE in Canada, and this section describes some of the programs that are in place at different jurisdictional levels. However, while decentralized approaches are useful in the initial stages of the transition, a coordinated national approach will be needed to meaningfully advance the CE in Canada.

4.2.1 Federal Government

The federal government's early initiatives to address the deficiencies of the linear, take-make-use-waste economic model include the Canada-wide Action Plan on Extended Producer Responsibility as well as sector-specific programs such as the Sustainable Aquaculture Program. These initiatives have had mixed success (Sections 5.5 and 7.5). More recently, the federal government launched the Ocean Plastics Charter at the G7 Leaders' Summit in June 2018 (ECCC, 2020b), followed by the Canada-wide Strategy on Zero Plastic Waste (CCME, 2018a). The federal government is also pursuing circular procurement opportunities (Section 7.1.5). Other existing policies and initiatives that Canada could build upon to accelerate the transition to a CE include:

- The National Research Council of Canada Canadian Life Cycle Inventory (NRC, 2019)
- Greening Government Strategy (GC, 2021a)
- Smart City Challenge (INFC, 2020b)
- Clean Technology Data Strategy (GC, 2020b)
- Pan-Canadian Framework on Clean Growth and Climate Change (GC, 2016)

4.2.2 Provincial and Territorial Governments

At the provincial and territorial level, progress on the CE has mainly focused on waste management and plastics, and has often prioritized alignment with federal government initiatives like the CCME initiatives for EPR. However, some provinces and territories have advanced broader CE-specific programs that surpass federal ambitions. Major provincial/territorial government initiatives include sustainable government procurement, waste reduction funding, and EPR, with British Columbia, Quebec, and Ontario particularly driving the adoption of CE strategies.

British Columbia

The Government of British Columbia has focused on EPR for years and has developed stewardship plans for recyclable products, including electronics, tires, and batteries (Gov. of BC, 2020). The policy approach of "full product stewardship" used in British Columbia may be useful as a model for Canada, insofar as it provides a full range of signals for producers and clear legislation (McKerlie *et al.*, 2006). In 2016, the Government of British Columbia released the Climate Leadership Plan (Gov. of BC, 2016), followed by the CleanBC plan in 2019 (Gov. of BC, 2018). The Climate Leadership Plan identified natural gas, transportation, forestry, and agriculture as several of the key sectors of action in the province. Key components of the plan included the need for a waste-to-resource strategy in British Columbia and lowering GHG emissions by reducing the quantity of organic materials sent to landfills (Delphi Group, 2017).

Alberta

The Government of Alberta has expressed its intention to pursue a CE for plastics through improved diversion and recycling (Gov. of AB, 2020). It announced in 2021 that it is pursuing an EPR program for plastics, with public consultation and review underway (Gov. of AB, 2021a, 2021b). The Government of Alberta has also funded two carbon capture and storage projects (Gov. of AB, 2017).

Saskatchewan

The province of Saskatchewan facilitates EPR or stewardship programs for various materials in the province (Gov. of SK, 2020). The province's Solid Waste Management Strategy provides a timeline of long-term waste reduction goals that the province has committed to pursuing in the future, including reviews of the province's material stewardship programs and procurement policies, and multi-stakeholder engagement opportunities (Gov. of SK, 2020).

Manitoba

Through the 1990 *Waste Reduction and Prevention Act* (Gov. of MB, 1990), Manitoba has established stewardship programs for several categories of products, including electronic equipment, household hazardous waste, and packaging and printed paper (Gov. of MB, n.d.). In 2020, the province also ran the Conservation and Climate Fund program, a fund to support projects fighting the climate crisis; criteria for applications included a focus area on CE development (CGPIO, 2020).

Ontario

In 2016, the Government of Ontario passed the *Resource Recovery and Circular Economy Act*, which aims to minimize the use of raw materials, maximize the life of materials through resource recovery, and minimize waste generated by end-of-life products and packaging (Gov. of ON, 2016). The Act established individual producer responsibility in Ontario and the Resource Productivity and Recovery Authority to monitor progress, collect data from producers, and enforce compliance with the Act (MECC, 2017). The Act also requires the government to develop a Strategy for a Waste-Free Ontario, to be reviewed every 10 years (Gov. of ON, 2016); the first such strategy was produced in 2016. Ontario has been transitioning existing waste diversion programs to a full individual producer responsibility model, for product categories including tires, electrical and electronic equipment, and municipal hazardous waste (MECC, 2017). In addition, Ontario has introduced regulations that will shift responsibility for Ontario's Blue Box program away from a shared model between municipalities and producers, and fully towards producers, starting in 2023 (ECO, 2017; RPRA, n.d.).

Quebec

The approach of the Government of Quebec to the CE is notable for its comprehensive nature. In 2015, following consultations with stakeholders, the Government of Quebec implemented the Stratégie gouvernementale de développement durable 2015-2020, which focused on government objectives for advancing a green economy and included CE concepts (MDDELCC, 2015; Teigeiro *et al*., 2018; Jagou, 2021). The Government of Quebec has also developed several sector-specific programs for implementing CE practices, such as its Plan for the Development of Critical and Strategic Minerals and the Stratégie de valorisation de la matière organique (Gov. of QC, 2020; MELCC, 2020). Agri-food and energy have been identified as the sectors with the highest potential for circularity in the province, and metal production and construction have also been identified as sectors of interest (Teigeiro *et al*., 2018). In 2021, the Government of Quebec also announced a call for proposals through the Québec Research Society and Culture

Fund for the creation of a pan-Quebec circular economy research network, with the goal of integrating the various CE research programs in Quebec (FRQ, 2021).

RECYC-QUÉBEC, the province's recycling and waste management organization, is also an important stakeholder in the province's transition towards the CE. Among other activities, RECYC-QUÉBEC funds initiatives related to waste reduction, waste management, and the CE; partners with provincial/territorial, national, and international CE committees to share information and lessons learned; and funds research (RECYC-QUÉBEC, 2019). RECYC-QUÉBEC has also partnered with other departments in the Quebec government to conduct consultations on government strategies for incorporating CE practices and strategies in sustainable development policies (Korai & Whitmore, 2021).

Atlantic Canada

Several Atlantic provinces have developed EPR schemes in alignment with the national CCME plan for EPR. Prince Edward Island has established at least 11 EPR programs for materials; Nova Scotia has voluntary programs for returning certain materials, such as mercury-containing lamps; and New Brunswick has EPR regulations for electrical and electronic waste (EPRC, 2017a). In 2019, New Brunswick also announced plans for an EPR program for packaging and printed paper (Recycle NB, 2019). Nova Scotia's *Sustainable Development Goals Act* of 2019 identifies the importance of sustainability initiatives aligning with the CE; as of 2021, the Nova Scotia government is conducting public consultations on updates to the goals of the Act (Gov. of NS, 2019, 2021).

Yukon

In the *Our Clean Future* report, the Government of Yukon, alongside Indigenous groups, details goals and actions for the territory to achieve by 2030, related to emissions reduction, renewable energy, climate change adaptation, and a green economy (Gov. of YT, 2020). The strategy includes targets for the reduction of GHG emissions to levels lower than 30% of the territory's 2010 levels, increased use of biomass and renewable sources of energy for heating and electricity, and growing local food production (Gov. of YT, 2020). The strategy also aims to establish more CE practices in waste management to reduce waste levels per person by 10% by 2030 and increase waste diversion from landfills by 40% by 2025 (Gov. of YT, 2020). Specific actions proposed to achieve these targets include legislation to ban single-use bags, the implementation of EPR systems, and waste diversion systems in government buildings (Gov. of YT, 2020). Currently, the Yukon has a beverage container recycling program, as well as programs for tire and electronics recycling (Gov. of YT, 2021).

Northwest Territories

Specific programs in the Northwest Territories incorporate circular practices like the reduction of resource use and recycling; for example, a beverage container recycling program with a deposit system through which used containers are collected from residents and processed at centres in Yellowknife, Hay River, and Inuvik before being sent to southern facilities for recycling (Oceans North, 2021). The Government of the Northwest Territories has also implemented regulations on single-use plastic bags, charging 25 cents for each bag, and other communities throughout the North have implemented or proposed bans on single-use plastic bags. Utilizing the same recycling network that is used for the beverage container recycling program, the Government of the Northwest Territories has also operated an electronics recycling program since 2016 (Oceans North, 2021).

4.2.3 Municipalities

In the Canadian context, there are many opportunities for municipalities to address resource demands, leverage entrepreneurial opportunities, and create markets for recycled and remanufactured goods (NZWC, 2019). Several municipalities in Canada, including Toronto, Vancouver, Victoria, and Guelph, have focused policy efforts on waste management and sustainability initiatives to advance a CE. An integrated community approach has been adopted by the City of Guelph to create a circular food economy (City of Guelph, n.d.). Collaborations among regions in northern Canada and NGOs have led to the development of various recycling and take-back programs. Another municipality-based initiative is the Canadian Circular Cities and Regions Initiative, a recently launched collaboration between the NZWC, the Federation of Canadian Municipalities, the Recycling Council of Alberta, and RECYC-QUÉBEC that works to support peer-to-peer knowledge sharing and capacity building about the CE among local governments in Canada (CCRI, 2021).

Vancouver, British Columbia

Metro Vancouver implemented the Greenest City Action Plan in 2011, which aimed to make Vancouver the greenest city in the world by 2020 by achieving 10 goals in the areas of zero carbon, zero waste, and healthy ecosystems (City of Vancouver, 2015). The 2019–2020 implementation updates for the plan show that as of 2019,

progress had been made towards the targets for 9 of the 10 goals, with targets in green transportation and local food assets being met or exceeded (City of Vancouver, n.d.). Vancouver has also worked to advance the CE through its Zero Waste 2040 plan, which explicitly aims to support and grow the CE in the Metro Vancouver area (City of Vancouver, 2018). In addition, Vancouver has also developed a Zero Emissions Building Plan that sets limits on emissions and energy use in new construction projects (City of Vancouver, 2016); experts have recommended that CE initiatives should be integrated with efforts to address the embodied emissions of construction (Teshnizi, 2019). In 2013, Metro Vancouver developed the National Zero Waste Council to advance the CE and waste prevention, along with five of the largest metropolitan regions in Canada: Toronto, Montréal, Halifax, Calgary, and Edmonton (NZWC, n.d.). In addition, Vancouver participated in the National Industrial Symbiosis Program, which was launched in 2017 (Section 4.3).

Victoria, British Columbia

The City of Victoria recently approved the Zero Waste Victoria plan to reduce waste disposal by 50% by 2040. The plan explicitly draws on the CE framework and principles, and aims to support the development of circular practices in Victoria. The plan prioritizes five focus areas: single-use items and packaging, the built environment, food and organics, durable goods, and additional wastes (City of Victoria, 2021).

Richmond, British Columbia

The City of Richmond in British Columbia has adopted CE criteria in its procurements processes (City of Richmond, 2021).

Banff, Calgary, Edmonton, Lethbridge, and Strathcona County, Alberta

The Recycling Council of Alberta's Circular Cities Project, with funding from Alberta Ecotrust and the Government of Alberta, has helped four cities and one county in Alberta develop CE roadmaps and begin moving towards the implementation of CE strategies specific to each municipality (RCA, 2021). The City of Edmonton is also a participant in the National Industrial Symbiosis Program (Section 4.3).

Toronto, Ontario

The City of Toronto is working towards a CE in the delivery of all public services as a component of the city's Long Term Waste Management Strategy (City of Toronto, n.d.). The CE approach adopted by the city has included developing a CE procurement framework, formalizing an EPR policy, and convening a forum to create a shared economic vision for the Great Lakes region (City of Toronto, n.d.). Toronto is a participating city in the Circular Innovation City Challenge, which matches innovators in the CE with cities looking for CE-based solutions (CICC, n.d.-a, n.d.-b). The city is also developing sector-specific workshops to facilitate information sharing about circular procurement among city officials and vendors (City of Toronto, 2018).

City of Guelph and Wellington County, Ontario

The City of Guelph and Wellington County, with funding from Infrastructure Canada through the Smart Cities Challenge, have prioritized food waste, specifically circular food production and use with the Our Food Future initiative (City of Guelph, 2019). The traditional agricultural industry in the region has been leveraged to create a hub of food innovation that involves collaboration with community partners and institutions, like the University of Guelph (City of Guelph, n.d.). Guelph has awarded grants to businesses, not-for-profits, and social enterprises to develop new and existing circular food initiatives and practices (City of Guelph, 2020b). The program provides recipients with guidance and advice from industry experts and includes an educational program on circularity and building sustainable business practices (City of Guelph, 2020b).

Montréal, Quebec

The 2020 and 2021 economic recovery plans for Montréal include funding support for companies transitioning towards circular business models, collaborations for implementing the CE in the bio-food industry, and the development of a committee on the CE in Montréal that will contribute to a CE roadmap for the city (Ville de Montréal, 2021). The City of Montréal is also a partner with RECYC-QUÉBEC and Fondaction on the first CE investment fund in Canada (Fondaction, 2020; RECYC-QUÉBEC, 2021a)

Northern Canada

Partnerships among communities and private or not-for-profit organizations have driven the development of recycling programs in northern communities. For example, the Tundra Take-Back program was created by the not-for-profit organization Scout Environmental, in conjunction with private partners and the Canadian government to run a skills development program in Nunavut to depollute certain products at the end of the product's life (Oceans North, 2021). The program helps communities handle, manage, and remove pollutants and hazardous materials from large items like vehicles and white goods (Scout Environmental, 2021). In Nunavut, the company Arctic Co-operatives Ltd, in partnership with the Co-Operatives Group Ltd, runs a recycling program to collect cans to be shipped out for processing (Oceans North, 2021).

4.3 Partnerships and NGOs

Canada has several policy groups and NGOs that focus specifically on supporting the transition towards a CE through cross-sectoral collaboration, including:

- The Circular Economy Leadership Coalition, a partnership among businesses, NGOs, and sustainability experts that aims to "provide thought leadership, technical expertise and a collaborative platform for the development of pioneering solutions that eliminate waste at all stages of the life cycle of products and accelerate the transition to a Circular Economy" (CELC, 2020).
- The NZWC, a partnership among governments, businesses, academia, NGOs, and civil society that works to advance waste prevention in Canada. The NZWC is strongly involved in supporting the CE in Canada, including through the development of a Circular Economy Business Toolkit to provide guidance for businesses transitioning towards a CE (NZWC, 2016).
- The Circular Innovation Council (CIC), formerly known as the Recycling Council of Ontario, a non-profit organization originally established in 1978 (CIC, n.d.-a). Historically focused on recycling, the Council aims to promote the CE through education, research, and advocacy, and has undertaken several initiatives to promote circular procurement, including establishing a circular procurement initiative, which includes several free resources for guiding circular procurement practices (CIC, n.d.-a, n.d.-b).

- The Circular Great Lakes program, an initiative of the bi-national Council of the Great Lakes Region (CGLR, 2020). This partnership aims to build collaborative approaches to develop the CE in the region, with an initial focus on reducing marine plastic waste. The Council of the Great Lakes Region has also developed the Ontario Materials Marketplace program in collaboration with the United States Business Council for Sustainable Development, which aims to facilitate the creation of a cross-border materials marketplace in the region through collaborative information sharing and the identification of recycling and reuse opportunities (CGLR, 2020).
- The Circular Opportunity Innovation Launchpad (COIL), launched in 2021, is a network developed by the City of Guelph and partners to provide a platform for testing and scaling circular solutions (City of Guelph, 2021).
- The Pôle Québécois de concertation sur l'économie circulaire, created in 2015 under the facilitation of Institut EDDEC, a multi-stakeholder table of decision-makers and organizations from diverse organizations in Quebec with the goal of facilitating the transition towards the CE in Quebec (Jagou, 2021). The Pôle's definition of the CE has been adopted as the official definition by the Government of Quebec; as of 2021 the Pôle is developing a new strategic plan for its work under Centre d'études et de recherche intersectorielles en économie circulaire (CÉRIÉC) (Jagou, 2021).
- The National Industrial Symbiosis Program is a pilot program launched in Metro Vancouver and Edmonton in 2017 (NISP, 2019). The program was adapted for the Canadian context of multiple environmental regulatory jurisdictions and facilitated industrial symbiosis for businesses in the region. It reported over $6 million in total direct economic benefit from the trials in British Columbia and Alberta and the diversion of more than 250,000 tonnes of waste from landfilling (NISP, 2019).
- The Fonds économie circulaire is an investment fund worth more than $30 million and was developed through a partnership among the investment agency Fondaction, RECYC-QUÉBEC, and the City of Montréal, announced in March 2021 (RECYC-QUÉBEC, 2021a). The fund will support new Quebec businesses that adopt models based on the CE and is the first fund in Canada to focus specifically on financing the CE (Fondaction, 2020).
- Metal Tech Alley is a professional association in southern British Columbia promoting collaborations towards a CE in industrial areas such as metallurgy, digital fabrication, industrial recycling, clean technology, and the internet of things (Metal Tech Alley, n.d.).

4.4 Research Strengths

Academic institutions in Canada are producing research on the CE, although Canada is generally not considered to be a leading producer of CE research at an international level (Raufflet *et al.*, 2019b). Research capacity for the CE is fragmented in Canada among regions, universities, and colleges, and often concerns specific CE strategies or concepts rather than addressing a unified CE. Many Canadian researchers collaborate internationally more than with other Canadian researchers (Raufflet *et al.*, 2019b). Moreover, there is a perception by some academic researchers that governments are not interested in funding CE research (Deloitte, 2019b). Few publications in Canada use the term CE directly (Section 1.3).

However, Canada does have CE research programs that could be leveraged and built upon (SPI, 2020b). Several Canadian universities have developed significant expertise in the CE, including Polytechnique Montréal, Laval University, the University of British Columbia, the University of Waterloo, HEC Montréal, the Université de Montréal, and Dalhousie University (Raufflet *et al.*, 2019b; Jagou, 2021). Indeed, a 2018 bibliometric analysis ranked the University of British Columbia 10th worldwide for CE research (Cui & Zhang, 2018), and another analysis ranked Canada 19th overall in the world (Ruiz-Real *et al.*, 2018). In Quebec, CÉRIÉC, established in 2020 at École de technologie supérieure (ÉTS), brings together a team of researchers from different departments to create a multidisciplinary CE research program (ÉTS, 2020a). Similar research was undertaken previously by the Institut EDDEC at the Université de Montréal, HEC Montréal, and Polytechnique Montréal. In 2021, in partnership with ÉTS and $2.1 million in funding from Desjardins, CÉRIÉC has launched accelerator labs designed to facilitate cross-disciplinary research and innovation for the CE in many different sectors, including agri-food, construction, and plastics (Chiasson, 2021).
The group Canadian Colleges for a Resilient Recovery is a partnership of colleges, polytechnics, institutions, and CEGEPs from across Canada with a commitment to modelling the transition towards a circular, climate resilient, and low-carbon economy; training workers for a "climate resilient economy"; and encouraging research for climate change solutions (Mohawk College, 2020).
The federal government has also initiated a multi-stage funding opportunity for CE-based research through the Imagining Canada's Future Ideas Lab: Canada and the Circular Economy program (SSHRC, 2021).

4.5 Skills Strengths

The CE requires a "diverse and heterogenous labour market with disparate education levels and skill requirements" (Burger *et al.*, 2019). In many sectors, the transition to the CE will require new skills beyond the traditional labour market skills required in the linear economy. For example, in the construction field, skills required for "modular design or the analysis of material compositions" might be prioritized over other traditional skills in a CE (SPI, 2020b). To help Canadians develop the skills needed to meet the demands of a CE and to ensure a just transition that supports all workers, training programs will be important. Rapid upskilling and training will be particularly relevant for current workers, but training and skills development in all sectors and levels of education will be important, including K to 12 education (Section 7.3).

4.5.1 Government Training Programs

Several federal and provincial government programs currently offer financial or logistical supports for workers to pursue additional training. However, these programs are more broadly focused on developing a resilient workforce and do not explicitly mention a transition towards the CE. Nevertheless, these programs can be used by workers and employers looking to encourage skills growth in areas related to the CE. For example, the Future Skills Initiative from Employment and Social Development Canada is focused on understanding future trends for jobs in Canada and the effects of "disruptive changes in the workplace" (SPI, 2020b).

4.5.2 Academic Training Programs

Academic institutions provide important support for skills development and training workers for a transition towards the CE. Specific CE skills programs exist at various academic institutions in Canada. Several universities in Quebec have either incorporated CE concepts into courses or developed programs that specifically focus on training individuals in the CE. The Université de Sherbrooke offers a CE training program within its Master of Environment program, while Polytechnique Montréal offers CE-focused options in undergraduate training programs, as well as CE training paths for professionals (Jagou, 2021). The Institut EDDEC has also developed the first francophone Massive Online Open Course (MOOC) on the CE, in conjunction with the Université de Montréal, Polytechnique Montréal, and HEC Montréal (Jagou, 2021). The course introduces participants to the CE, CE business models, value chains, and CE deployment. The flexibility and freedom of MOOCs make them accessible to participants with diverse backgrounds, and the content evolves and changes as more research on the CE emerges (Jagou, 2021).

Outside of Quebec, other academic institutions are also beginning to develop CE-specific training material and content. For example, McMaster University offers a three-day certificate of completion in the CE professional training program (McMaster University, 2021). The University of Waterloo's School of Environment, Enterprise and Development hosts the Waterloo Industrial Ecology Group, which offers courses on the CE and CE-related concepts like life-cycle analysis (University of Waterloo, n.d.).

4.5.3 Industry-Specific Training

The transition towards a CE and more sustainable development will require a skilled industrial workforce, which Canada has, thanks to its strong natural resources sector. The skills needed to develop renewable energy sources are very similar to existing skills and technical knowledge of those working on non-renewable energy projects (MacArthur *et al.*, 2016). One organization supporting Canadian energy workers in the transition towards work in the renewable energy sector is Iron and Earth, a coalition formed by fossil fuel workers in the Canadian oilsands who are supporting the transition towards renewable energy (Iron and Earth, n.d.-a). Workers in Canada's fossil fuel industry have identified the need for rapid upskilling programs that help workers quickly transfer their technical knowledge from fossil fuel projects to renewable energy projects (MacArthur *et al.*, 2016). Iron and Earth's Renewable Skills Initiative is an example of a rapid upskilling program; the initiative offers tradespeople hands-on training for solar panel installation (Iron and Earth, n.d.-b).

5

Challenges to a CE in Canada

5.1 Geographic Barriers

5.2 Economic Barriers

5.3 Business Barriers

5.4 Data Barriers

5.5 Policy and Regulatory Barriers

5.6 Social and Behavioural Barriers

Chapter Findings

- Advancing a CE requires changing a broad range of systems — including design standards, supply chains, infrastructure, and public policy — that currently support and lock-in linear practices and behaviour.
- Canada's size and population distribution complicate the implementation of material loops at larger scales due to transportation costs and infrastructure requirements. These challenges are heightened in rural or remote areas and in northern Canada, where particularly large infrastructure gaps exist.
- Economic and policy incentives in Canada have contributed to making virgin materials and landfilling less expensive relative to more circular options. The lack of pricing of social and environmental costs, together with a lack of policy harmonization within and across all levels of government, inhibits a widespread transition towards a CE.
- Businesses face greater uncertainty regarding returns on circular investments. This is exacerbated by price-sensitive consumer purchasing and institutional procurement in Canada, which do not account for the total cost of ownership.
- While social acceptance of circular concepts is growing, cultural and behavioural barriers remain. Building confidence in the quality of circular offerings, increasing accessibility of circular practices, and managing the social impacts of a CE to avoid unintended harm will improve buy-in. Improved metrics are needed to capture the social impacts of circularity.

Studies performed by various national and international organizations have identified barriers to the CE, such as low virgin material prices, high upfront investment costs, a lack of harmonized policies or standards, a lack of data, and a lack of awareness (Kirchherr *et al.*, 2017; CELC & GLOBE, 2020). Some challenges are ubiquitous to many countries while others are specific to Canada's geography, jurisdictional structures, and culture. This chapter considers barriers organized along geographic, macroeconomic, business, informational, regulatory, and social dimensions.

An overarching challenge identified by the Panel is *linear lock-in*. This has been defined as "the engrained structures that have anchored themselves around our linear-based growth models" (EMF, 2014). Infrastructure, global trading norms, metrics such as GDP, and many modern social systems are based on linear economic approaches; redesigning these systems to support the CE would result

in a level of cost and social disruption (Campbell & Court, 2014; de Lange *et al.*, 2018; Williams, 2019). A lack of infrastructure and logistics for reverse supply loops contribute to the lock-in of linear supply chains at an international scale (EMF, 2014). Within Canada, cheap virgin materials and energy facilitate linear practices (Deloitte, 2019b; ECCC, 2019b). Nationally and globally, linear systems provide little incentive for circular leadership. In a marketplace focused on the lowest purchase price, and in which shareholders expect short-term profits, there is little reward for businesses to tackle the various barriers associated with adopting circular practices. Thus, there is a need to create economic signals that account for the social and environmental impacts of production.

However, the adoption of policies supporting the CE could be hindered by lobbying by businesses or jurisdictions that currently benefit from unsustainable linear economic models (de Lange *et al.*, 2018; EC, 2020b). While industries can act as powerful innovators of the CE and as cooperative participants in industry regulation, they can also exert power to weaken environmental regulations (Eckert, 2019a, 2019b) (Section 5.5). Countries that are heavily dependent on natural resource exports might reject policies that incentivize resource efficiency, impeding international adoption of the CE (Dellink, 2020; Schröder, 2020). Further, social and institutional norms create reluctance to adopt circular innovations that might have impacts such as job losses (Ranta *et al.*, 2018).

Despite this, challenges for the CE can be addressed through coordinated action on the part of businesses, governments, and other stakeholders; inclusive and collaborative approaches to transition may be useful in engaging stakeholders and obtaining buy-in (Section 8.1). While this chapter will report specific solutions to challenges, many of these solutions are discussed in more depth in Chapter 7.

5.1 Geographic Barriers

The geographic scale over which it is feasible to implement material loops depends on factors such as the quantity of the material, the type of infrastructure needed to recover it, and levels of supply and demand in different areas (Burgon & Wentworth, 2018). Internationally, the geographic distribution of waste/end-of-life products and recycling/remanufacturing capacity create challenges for looped supply chains (EMF, 2014). Canada faces similar challenges due to its large area and heterogeneous population distribution (Section 3.1), complicating CE practices that rely on the recirculation of end-of-life materials. In theory, remote communities in Canada would benefit from local supply loops, which would eliminate the need for costly transportation of external goods. In practice,

however, the Panel finds that lack of infrastructure, climate conditions, and scale of local demand limit the ability of communities to create self-sustaining loops. A network of local, regional, national, and international loops would be necessary to enable a CE, and material loops at larger scales will be difficult to establish within Canada.

Canada's size, low population density, and climate result in higher logistical and infrastructure costs to support material loops in supply chains.

Local or regional loops, where commodities are produced near the point of use, are easier to implement due to lower transportation costs. Materials such as glass can be cycled highly efficiently by local reuse operations (EMF, 2014), but recycling operations over long distances are not economically feasible (Jacoby, 2019). The environmental benefits and economic feasibility of recycling construction and demolition waste similarly depend on transportation distances (reviewed in Ghisellini *et al*., 2018). Refurbishment and remanufacturing loops may also work best at local or regional levels by reducing logistics costs and making use of local skills and capacity (EMF, 2014). Implementing such loops locally also reduces energy expenditures and GHG emissions related to transport. In contrast, for materials such as secondary fibres for paper and cardboard production, low-cost transportation and economics of scale enable supply loops over very large geographic areas (EMF, 2014). Further, some materials may require international supply loops if they require extensive infrastructure to process or if they are only used in small quantities and thus cannot be effectively recirculated locally (Burgon & Wentworth, 2018).

Because of this sensitivity of materials loops to scale, Canada's size and low population density create challenges for circularity (Deloitte, 2019b). Geographic challenges related to transportation arise not only due to low density, but also due to cases where supply and demand are distributed heterogeneously, creating distance between production and use. For example, in Canada's mining industry, there is typically a large distance between a mine and its potential market. The challenges of distance are exacerbated by a lack of transportation infrastructure, particularly in rural and northern communities in Canada (INFC, 2018). Canada's weather conditions also impact maintenance costs for transportation infrastructure, raising the transportation costs of circulating materials over large areas (Deloitte, 2019b). Indeed, in many cases, it is easier to transport goods between the United States and Canada rather than within Canada, with implications discussed in Sections 3.2 and 5.5.

Canada's population distribution, combined with infrastructure gaps in rural and remote areas, creates challenges for advancing the CE in these areas compared to urban centres.

As noted in Section 3.1, Canada's population is distributed across rural areas and urban centres, which are often separated by large distances. Transportation issues can be addressed in part by developing a CE first in areas of higher local density, and by incentivizing eco-industrial parks (Deloitte, 2019b). Indeed, municipal and regional initiatives in Canada, including cross-border partnerships with the United States, are currently advancing the CE at the local level (Sections 4.2.3 and 4.3). Globally, there are good reasons to focus on cities when adopting a CE. Cities currently consume the majority of natural resources and contribute significantly to global waste, and there is potential for these impacts to grow as a result of increased urbanization (UNEP, 2012).[8] Thus, implementing circularity in cities will have a strong environmental impact. This raises the question of whether rural and remote areas would be left out of the CE.

Communities in northern Canada already struggle with the costs of maintaining waste management programs and adopting recycling schemes (Northern Public Affairs, 2016). Waste management practices resulting in part from the low density and harsh climate result in a variety of health and environmental harms in these regions, including contaminated drinking water and threats to Indigenous food sources (Keske *et al.*, 2018). Marine plastics pose further health and environmental risks in the Arctic, including Inuit Nunangat (Oceans North, 2021). The need to dispose of waste from natural resource extraction is an additional burden in the North; while in some cases, by-products such as cleared timber may be recovered from extraction waste, opportunities for by-product commercialization are still limited by distance to markets (Keske *et al.*, 2018).

Waste management infrastructure is generally limited and outdated in northern Canada (Oceans North, 2021). In addition to facilities for processing materials, information and communication technology that provides access to the internet is an important supporting infrastructure for a CE (ECCC, 2020a). Internet access is lacking in many rural and remote communities in Canada (INFC, 2018; CCA, 2021). It has been proposed that because these communities have not developed extensive linear waste management infrastructure, the transition towards circular infrastructure may be able to proceed more smoothly without having to confront sunk costs that could "lock in" linear waste management (ECCC, 2020a). However, the scale at which circular infrastructure needs to be established remains a challenge for the CE.

8 There is a possibility that trends towards urbanization may shift, for example, due to remote work post-COVID-19; however, this is difficult to predict.

The Panel identifies a need for strategic planning that considers the different geographic and economic circumstances across Canada to identify CE opportunities, particularly those that can be implemented on a local or regional scale. For example, some have noted that practices such as community ownership of waste management programs, improved sorting, and facilitating trading of end-of-life materials are well-suited to the realities of remote northern communities in Canada (Keske *et al.*, 2018). CE practices in agri-food, such as composting and nutrient recovery from food waste (SPI, 2021), might be particularly relevant in agricultural-based rural communities and could help rural regions develop sustainable food systems. Some have proposed that 3D printing (Section 7.2.2), combined with internet access, provides an opportunity for small communities to access necessary parts for repair (The Guardian, 2016). The Panel further suggests that practices that increase durability would be beneficial to regions where the transportation of replacement goods is costly. Local-scale loops such as repair operations create economic and social benefits through small businesses or community initiatives (Riisgaard *et al.*, 2016; van der Velden, 2021); however, it will still be necessary to connect communities to the larger national or international loops required to reprocess certain materials (Burgon & Wentworth, 2018).

5.2 Economic Barriers

A variety of economic incentives and constraints create barriers to the adoption of a CE. On the macroeconomic level, the most relevant barriers for Canada are the low costs of disposal, virgin materials, and fossil fuel-derived energy, compared to circular alternatives.

In Canada, low landfilling costs and higher recycling costs incentivize the landfilling of material rather than reducing or recycling waste.

Limited and inconsistent data on Canadian waste management systems make it difficult to determine what is being landfilled and what fees are charged per tonne (Canada's Ecofiscal Commission, 2018). The limitations of this data, as well as the differences in methodology and timeframes observed in international data, made it difficult for the Panel to compare disposal costs in Canada with other countries. Still, landfilling fees in many Canadian jurisdictions do not cover the full costs of disposal, including those associated with building and upgrading disposal infrastructure or those associated with the impacts of waste disposal facilities on the environment and nearby communities (Canada's Ecofiscal Commission, 2018). For example, landfill disposal fees in Toronto were $127 per tonne in 2019, whereas solid waste management services in Toronto estimated the full cost of

landfill disposal at approximately $300 per tonne (City of Toronto, 2019a). The Panel notes that the difference between disposal fees and the full cost of disposal represents a subsidy on waste generation. At the same time, Canada's fees tend to be higher than those in the United States, which results in waste exports to cheaper landfills in the United States (Canada's Ecofiscal Commission, 2018).

Competing with the low costs of disposal, recycling costs in Canada are particularly high due to the cost of transporting materials over large distances between cities and differences in requirements across jurisdictions (ECCC, 2019b). Operational costs relating to decontamination and health risks also increase the costs of recycling and recovering materials and water (Williams, 2019). However, market prices for secondary materials are low and sometimes volatile. A lack of market mechanisms to facilitate materials recovery and recycling is thus a challenge to circularity (Adams *et al.*, 2017; Monahan, 2018).

These factors create incentives to landfill rather than recycle materials or develop innovative waste management strategies (Canada's Ecofiscal Commission, 2018). Indeed, the current system of incentives resulted in the landfilling or incineration of 72.9% of Canada's waste in 2016 (GC, 2018b).[9] Moreover, policies such as landfill bans are under-used in Canada (EPRC, 2017b). For example, though Electronics Product Stewardship Canada has recommended province-wide landfill bans for electronics, they have largely been implemented only at the municipal level, if at all, with electronics banned from all municipal landfills in Newfoundland and Labrador, Nova Scotia, and Prince Edward Island only (EPSC, 2016).

Eliminating this bias in favour of landfilling requires adjusting the value proposition for waste management to include not just the full financial costs of disposal but also external environmental and social costs and benefits (Nahman, 2011). This could be done by increasing costs for disposal (Section 7.1.3). Alternatively, the value of recycling could be increased, for example, creating a market for recycled material through the procurement of goods with recycled content (Section 7.1.5), such that landfilling represents an opportunity cost. A variety of regulatory and social factors affect the value of secondary materials (Sections 5.5 and 5.6) and could be adjusted to support a market favouring recycling. Subsidies for recycling could also address cost differentials, though the Panel notes that government-financed efforts to clean up pollution, including carbon capture, represent subsidies for the industries causing this pollution and thus create a cost advantage for polluting linear practices.

9 This percentage represents both residential and non-residential waste, including municipal recycling programs. It does not capture materials that bypass government or industrial waste management streams entirely, such as materials that are recycled or reused by retailers or, conversely, littering and dumping of waste (GC, 2018b).

Increased landfilling fees do not change the fact that producers of materials are not responsible for end-of-life disposal costs and, as such, have little incentive to reduce waste through circular design (Burgon & Wentworth, 2018). One approach to addressing this problem is to make producers responsible for managing their own products at end of life through EPR (Burgon & Wentworth, 2018). However, the effects of such policies have been less significant than anticipated (OECD, 2016). EPR is discussed further in Sections 5.5 and 7.5. Overall, creating a market that incentivizes circularity requires a variety of policies, which could include circular procurement, disposal bans for certain materials, mandatory recycled content requirements, landfill surcharges, or other financial levers in addition to improved EPR (ECO, 2017) (Chapter 7).

Low costs for virgin materials and energy incentivize the use of new rather than recycled materials and fail to sufficiently incentivize energy efficiency.

Processing recycled materials into a quality product is costly, and the supply of recycled materials from post-consumer waste is sometimes inconsistent (SPI, 2020b). As a result, some companies using recycled or bio-based materials have reported a need to charge more for their products than those using non-circular materials (e.g., petrochemical plastics) (Kirchherr *et al*., 2017). Advances in recycling technology may shift these price balances, though this requires investment and innovation (Section 5.3). For example, it is now possible to produce post-consumer plastics that are competitive in price and quality to virgin plastics (Beattie, 2021). However, the volatility of virgin plastic prices complicates this comparison; while more predictable pricing can be an advantage for recycled materials, intermittent decreases in the cost of virgin materials may threaten recycling efforts (Beattie, 2021).

The relatively low cost of raw materials in Canada creates a particularly large cost advantage for virgin materials (ECCC, 2019b; Delphi Group, 2021). Similarly, there is a relatively weak incentive for many sectors[10] to engage in energy-efficiency initiatives due to the low cost of fossil fuel-based energy in Canada (Deloitte, 2019b; NRCan, 2020a). This comparatively low price of virgin materials and fossil fuels is in part due to abundance (ECCC, 2019b), but also due to policy incentives. Overall, the Smart Prosperity Institute (2020b) found that tax policy in Canada favours primary over secondary materials (see Section 7.1.2 for more on tax policy). This creates an incentive to extract raw materials rather than process recycled materials. Moreover, in 2019–2020, Canada provided at least $600 million in fossil fuel subsidies; the actual amount is likely significantly higher, as this

10 The Panel notes that in some sectors, such as mining, where energy represents a large portion of operating costs, energy efficiency still has a significant impact on profit.

figure does not include subsidies for which public data are unavailable, such as tax-related subsidies (IISD, 2020). Indeed, Canada is the largest provider of fossil fuel subsidies in the G7 per unit of GDP and the second-least transparent about these subsidies, after the United Kingdom (Whitley *et al.*, 2018). These subsidies impair Canada's ability to address climate change and transition to a low-carbon economy (IISD, 2020). In addition, the removal of fossil fuel subsidies is often cited as a key element of the transition towards a CE (Pedicini, 2015). The federal government plans, by 2025, to phase out "inefficient fossil fuel subsidies," such as those that "encourage wasteful consumption" (IISD, 2020). In addition to helping Canada advance the transition towards a CE, this will help the country to meet SDG 12(c) regarding inefficient fossil fuel subsidies.

Economic barriers to the use of circular materials can be overcome by sharing data within supply chains to identify where materials can be traded, ideally for the highest-value product (e.g., making warehouse pallets out of waste from paper packaging). In forestry, for example, experts have recommended digitizing supply chains to allow for their complete integration (ECCC, 2019b). Changes to incentives, such as through tax policy or procurement (Sections 7.1.2 and 7.1.5), are an additional strategy. In addressing energy incentives, it is important to consider that the CE involves both a transition to renewable energy and improvements in energy efficiency (Section 6.7). Increased use of renewable energy does not necessarily reduce the consumption of fossil fuels (York & McGee, 2017). Total energy consumption could increase because of cheap renewable energy, and evidence suggests that in affluent countries, the development of renewables often crowds out nuclear power rather than fossil fuels (York & McGee, 2017). Thus, specific levers may be needed to drive energy efficiency. If Canada overcomes the challenges to circularity resulting from the role of natural resource extraction in its economy, it could become an international leader among resource-exporting countries (Section 6.5).

5.3 Business Barriers

In addition to macroeconomic barriers, businesses encounter a variety of challenges in implementing circular practices, including the high costs of investing in a transition towards the CE, a long transition time, the predominance of linear supply chains, difficulties in innovation and scaling up, and the immaturity of circular business models compared to linear models. These barriers compound the economic factors discussed in Section 5.2 to drive up costs for businesses adopting circular practices — with little return in a marketplace where customers, including procurement offices, are highly price-sensitive (Sections 5.5 and 5.6). Sustainable products and services often compare more favourably on total cost over a life-cycle rather than purchase price (UNEP, 2017). However, calculating the total cost of

ownership is challenging even for organizational buyers (Piscopo *et al.*, 2008). Price sensitivity can be addressed in part through better costing methodologies and more proactive communication from sellers regarding total cost advantages.

Still, environmental and social costs are not well captured by the current structure of incentives and subsidies. Overcoming business barriers to circularity thus requires a systemic re-balancing of incentives in addition to specific supports for collaboration and innovation. In addition to global challenges for circular business, Canada faces specific challenges related to lack of innovation and difficulties for Indigenous communities in accessing capital for circular investments.

High upfront investment costs are a barrier for businesses, particularly SMEs, and for Indigenous communities in Canada.

High costs of investment to implement circular business models are a barrier for industry in many countries (Kirchherr *et al.*, 2017). For example, case studies suggest that a common trait in companies successfully implementing CE business models is investing in in-house refurbishing infrastructure (Atasu *et al.*, 2018); however, such investments in remanufacturing and recycling require significant capital and thus risk (Masi *et al.*, 2018). In addition, it is difficult to accurately estimate the long-term financial benefits of circular practices, which can inhibit businesses from investing in the CE (reviewed in Tura *et al.*, 2019). Overall, businesses are more likely to invest in circular practices that provide a short-term return on investment (e.g., waste reduction, material efficiency) rather than those with a longer return on investment (e.g., product design for reuse, recycling and/or recovery) (Masi *et al.*, 2018). While the need for investment in the CE represents a barrier, it also presents a strong opportunity to improve circular financing and to introduce other marketplace signals, such as procurement, that drive circular investment. These measures are further discussed in Sections 7.1.1 and 7.1.5.

Many of the circular strategies discussed in Section 2.2 have benefits for businesses, such as reducing costs or increasing customer satisfaction. However, the Panel's assessment indicates that due to the cost structures of a linear economy, businesses adopting circular practices during the transition towards a CE will likely experience reduced profits or even losses. This is challenging for publicly owned companies due to shareholder expectations. Lost profits are particularly concerning for SMEs, which run lean and cannot absorb even a temporary cut in profits. SMEs are also inhibited from investing in the CE due to limits on internal capital and difficulties obtaining external funding from government or banks (Rizos *et al.*, 2016). In one survey of SMEs that have successfully implemented circular practices, 50% indicated that a lack of capital was a barrier, and 20% reported difficulty obtaining funding from banks, suggesting these businesses need particular attention in circular financing and investment (Rizos *et al.*, 2016). At the same time, the

availability of alternative financing, such as venture capital or peer-to-peer lending, not only fails to support the CE but, in fact, correlates with a decrease in the adoption of CE business models in SMEs (Ghisetti & Montresor, 2020). Active investment is thus necessary to support the CE. Fortunately, there have been recent advancements in this direction; see Section 7.1.1 for more on circular investments.

Within Canada, Indigenous communities also face particular challenges for circular investments. Federal legislation, Aboriginal Financial Institutions, and other partnerships have improved self-governance and access to capital for First Nations jurisdictions (PPF, 2016). However, legal and institutional barriers still make it difficult for Indigenous governments, businesses, and individuals on many reserves to access traditional financing (Raybould, 2006; PPF, 2016; NAEDB, 2017). Socio-economic realities and infrastructure gaps also make it difficult for these communities to attract private investments (PPF, 2016). Thus, these communities will need new and alternative means to access capital for circular investments (ECCC, 2020a).

Linear supply chains create challenges for businesses seeking to source circular materials or recover their own products at end of life.

In many countries, supply chains are largely structured based on linear economic practices. Circular sourcing requires access to circular feedstock. However, waste recovery systems are not well supported and often rely on old technology or face supply challenges (Kumar *et al.*, 2019). For example, the supply of recovered materials in the U.K. and the EU is insufficient to meet manufacturing demands (Kumar *et al.*, 2019). The Panel believes that materials innovation is necessary to improve access to suitable feedstock. Further along the supply chain, companies distributing products to retailers as opposed to directly to customers lose control over their products (Ritzén & Sandström, 2017) and hence lose access to these products at end of life.

Making changes across a supply chain is complex and difficult (Masi *et al.*, 2018), and even more so when these supply chains are global. As a result, most circular practices are implemented within a firm (e.g., sustainable design, internal environmental management) rather than across the value chain (Masi *et al.*, 2018). However, coordination across the supply chain is important to advancing the CE. For example, because choices made at the design stage have a strong impact on options for creating end-of-life loops, it is necessary for multiple actors in the supply chain to collaborate in the design process (De Angelis *et al.*, 2018). The development of close relationships among materials producers and companies able to use waste or by-products as production inputs (industrial symbiosis) thus represents a key opportunity to advance the CE and will be discussed further in Section 6.1.

Remanufacturing and PaaS offerings also require collaboration with retailers and/or service partners (Mont *et al.*, 2006; as cited in Linder & Williander, 2017). Companies adopting these strategies may need to consider how retailers will profitably participate in PaaS models and how to define retailers' role in logistics related to maintenance (Linder & Williander, 2017). This represents a significant change in the way that retailers operate. The rise of online shopping has not eliminated logistical challenges for retailers. Indeed, retailers are already strained by the reverse logistics of inspecting and reselling online returns (Reagan, 2019). This suggests a need for further capacity development to enable returning and refurbishing products at end of life.

A lack of circular innovation and the insufficient adoption of existing technological solutions impede the CE in Canada.

In waste recovery, processing methods and available technologies have a strong effect on the quality and value of the resulting materials, determining, for example, the length of recovered paper fibres or the extent of chemical contamination (Iacovidou *et al.*, 2017). While construction is an opportune sector for the CE (Section 4.1.4), recovering these materials is particularly technically challenging due to a lack of circular design in existing buildings and the continued evolution of construction methods (Adams *et al.*, 2017). However, a survey of businesses and government officials in the EU did not identify technical barriers among their top concerns, suggesting that the transition towards the CE can be meaningfully advanced without waiting for time-consuming R&D (Kirchherr *et al.*, 2017).

The adoption of existing solutions is also important to advancing the CE. Barriers related to technological commercialization could be addressed by modifications to intellectual property and anti-trust frameworks, as well as better collaboration among researchers and industry (ECCC, 2019b). The high cost of investment leads to slow adoption of technology (de Jesus & Mendonça, 2018), as discussed earlier in this section. Regulations also affect the rate of technology adoption; one study found that higher levels of environmental regulation in European countries correlated with the adoption of innovation aimed at increasing materials efficiency and recycling (Cainelli *et al.*, 2020).

Canadian experts specifically identified a need for cost-effective technologies to support circular product design, manage and treat industrial waste, and upcycle waste material (e.g., 3D printing using tailings from mining operations) (ECCC, 2019b). However, Canada currently lags behind other countries in terms of support for circular R&D. While this could be attributed to the relatively recent introduction of the CE field in Canada (Deloitte, 2019b), manufacturing R&D spending is declining overall in Canada (OECD, 2020b). At the same time, Canada has shown the potential to be a leader in some areas of innovation relevant to the CE, such as

artificial intelligence (AI) (CCA, 2018). Opportunities to address Canada's innovation and commercialization challenges while building on Canada's R&D strengths with respect to the CE are discussed in Sections 6.5 and 7.2.

The linear economy largely prioritizes the lowest purchase price, which encourages planned obsolescence as a competitive strategy.

Planned obsolescence is the rational business model in the linear economy wherein buyers, from individuals to government procurement offices, focus on the lowest price rather than the total cost of ownership (Section 5.5 and 5.6). This model involves designing products to have a short life span, whether sacrificing longevity to produce a low-cost product in response to market demand or creating a need for replacement products to generate sales (Cooper, 2010). This accelerates consumption and depletes materials (Satyro *et al.*, 2018). Planned obsolescence is thus at direct odds with the CE, which aims to reduce the extraction of new materials. Product obsolescence occurs through a variety of mechanisms, whether because of physical loss of function, depleting a consumable such as lighter fluid more rapidly than necessary, or by changes in style or technology (Kessler & Brendel, 2016; Satyro *et al.*, 2018). The latter mechanisms are sometimes described as "perceived obsolescence" and are influenced not only by functionality but also by consumer attitudes and culture (Wieser & Tröger, 2018) (Section 5.6). Regulations also result in obsolescence if they require products or parts to be replaced at certain intervals (Kessler & Brendel, 2016). Businesses can design products with multiple obsolescence points occurring within different time frames, such as products that become technologically outdated before physically failing (Kessler & Brendel, 2016). The existence of proven and profitable business models such as planned obsolescence limits the attractiveness of circular strategies and models.

Practical information regarding circular business models is limited, and piloting these models is challenging.

CE literature identifies widespread challenges in developing and adopting circular business models. A transition to the CE requires the adoption of business models that implement long-term strategies and different mechanisms for creating and capturing value (Ferasso *et al.*, 2020), as described in Section 2.2. Though a variety of methods and tools have been proposed to assist in innovating circular business models, there is currently no consensus in typology for these business models (Pieroni *et al.*, 2019). Different approaches to creating such a typology may focus on stages of the value chain (e.g., circular design), types of material flows (e.g., short and long loops), or business value propositions (e.g., PaaS) (OECD, 2019b). Unfamiliarity with circular business models combined with a lack of

technical expertise can lead to the adoption of linear business practices (Rizos *et al.*, 2016).

While adopting a circular business model is a dynamic process, many publications discussing business model innovation present it as static. This may create a design-implementation gap, particularly considering that most available tools deal with designing rather than implementing circular business models (Pieroni *et al.*, 2019). There has also been little research on transforming traditional business models by incorporating circularity strategies (Ferasso *et al.*, 2020). Part of the challenge related to adopting circular business models involves taking new variables into account, such as the logistics of processing products and materials at end of use (Pieroni *et al.*, 2019). Specific circular business models may also face barriers such as access to spare parts for repair (Hansen & Revellio, 2020), availability of supply (Sections 5.2 and 5.3), or the attractiveness of new models to customers (Section 5.6). Customer interest in circular models differs depending on the nature of the product or service, or whether the customer is an individual, business, or government procurement office.

It is more difficult to run product pilots or stakeholder interview studies for circular business models involving reuse and remanufacture than it is to test linear business models, contributing to uncertainty regarding the profitability of circular models (Linder & Williander, 2017). One difficulty for such pilots is dealing with a longer time frame, as circular models need to estimate not only current demand for a product but also the future value of and demand for a refurbished product. Assessing the sales of a refurbished product increases the time it takes to test the business model and adds additional expense that is at risk if the pilot fails. In one case study involving a bicycle subscription program, the innovating company expected that it would take years to determine the costs of remanufacturing, and thus the overall profitability of the business model (Linder & Williander, 2017).[11] Concerns that sales of remanufactured products will "cannibalize" the market for new products also deter manufacturers from attempting remanufacturing, though this concern could be overcome by optimizing design, pricing, and production (Kwak, 2018). Concerns about loss of value to third-party remanufacturers also discourage the adoption of this model (OECD, 2019b).

The limited adoption of circular business models to date does present significant opportunities for scaling up in a wide range of sectors (OECD, 2019b). However, ease of scaling up depends on the specific business model. Some newer circular business models, such as product-service system models based on digital technologies (e.g., car sharing), have grown market share relatively quickly. On the other hand, mature circular business models, such as waste recycling and

11 The Panel observes that similar challenges in assessing value of and demand for returned assets would also apply to spare parts and to commodities.

product repair, have existed for millennia, and achieving higher rates of market penetration will require significant policy changes. Changes in consumer preferences and available technologies will also affect the uptake of circular business models (OECD, 2019b), and financial risks relating to cost uncertainties slow the process of scaling up (Linder & Williander, 2017).

Research performed over longer time scales and research focused on iteratively improving actions are necessary to mature circular business models and support their implementation (Pieroni *et al.*, 2019). Importantly, the Panel identifies a broad need for better data to inform these business models (Section 5.4). In addition, the Panel identifies the dissemination of practical knowledge, in multiple formats and to various stakeholders, as an important part of the CE transition (Section 7.3). This includes mechanisms for developing and sharing made-in-Canada approaches and business models. In particular, developing circular and sustainable models for natural resource management could position Canada as an international leader in this area (Section 6.5).

5.4 Data Barriers

Decision-making regarding circularity is complicated by a lack of accessible data on material flows, as well as challenges in assessing the circularity of systems and the impacts of specific interventions. Informational challenges are also created by the dynamic and non-linear systems involved in resource recovery efforts (Iacovidou *et al.*, 2017). Challenges relating to information flows, which are exacerbated on an international scale, affect both businesses and policymakers. Clear information on circular practices is also important for investors by allowing them to account for relevant risks and benefits, which sends appropriate price signals to the marketplace (EMF, 2020a). Canadian experts have identified information gaps as among the top five barriers to a CE in Canada (CELC & GLOBE, 2020). Better systems for collecting and sharing data are necessary to advance circularity. Moreover, information gaps may be exacerbated by language barriers in Canada. In the Panel's experience, the existence of both English-language and French-language CE literature in Canada impedes information sharing in both directions, particularly as leading CE research published in Quebec may only be available in French.

Business-to-business information sharing is impeded by a variety of factors.

A lack of information can produce market failures when it comes to the CE (EMF, 2015a). Businesses may be impeded from sharing information related to successful circular practices by confidentiality, concerns regarding commercially sensitive information, general difficulty in communicating expertise, or by unclear

competition laws (Rizos *et al.*, 2016; Burgon & Wentworth, 2018). Currently, most circular business model innovation approaches operate within an organization, likely in part due to complexities introduced by the need to establish inter-organizational trust (Pieroni *et al.*, 2019). Initial investments in socially responsible practices can be costly for some firms, as the relationships that allow these investments to generate financial returns take time to build, and in the meantime the firm's efforts may be seen as less credible (Barnett & Salomon, 2012). Some suggest that in business to business contexts, companies may prefer to discuss the environmental efforts of their suppliers rather than expose their own initial sustainability efforts to critical scrutiny, but in taking this approach these companies forfeit opportunities to engage customers (Malarciuc, 2017). Information sharing can be improved within a supply chain by developing long-term relationships and standardizing information (Tura *et al.*, 2019). The introduction of third parties to oversee or facilitate standardization could also be beneficial to overcoming barriers to information flows (Burgon & Wentworth, 2018).

Existing data collection and circularity metrics are insufficient to support effective policies and financing for circularity.

Data gaps also impede policy development. These gaps are found in many countries and particularly include data related to material and waste flows (OECD, 2020a), as discussed in Sections 2.3.1 and 2.4.1. For example, a lack of quality information on material flows, due in part to data ownership and privacy concerns, makes it difficult to create resource loops in urban systems (reviewed in Williams, 2019). Data gaps and uncertainty also complicate assessments of the impacts of various circularity interventions (Iacovidou *et al.*, 2017). It is difficult to separate the effects of interventions, such as EPR schemes, from other drivers of environmental design. Comparative case studies for such policies would assist in determining best practices (OECD, 2016). Further, international data are often collected using differing methodologies, making them difficult to compare (OECD, 2020a).

Targeted financial support for the CE is particularly impeded by information gaps in assessing the circularity of companies, projects, and products. For example, methodologies for life-cycle assessment are particularly variable (Dewick *et al.*, 2020). Due to such problems with metrics currently in use, more rigorous and standardized circularity metrics are needed. Recent steps forward in this direction include Circulytics from EMF, Circular Transition Indicators from the World Business Council for Sustainable Development, new guidelines from the FinanCE group, and an upcoming set of guidelines from the International Organization for Standardization (ISO). Greater participation from academics, such as those in industrial ecology, may be useful in developing more reliable metrics (Dewick *et al.*, 2020).

Addressing data gaps would require national systems for data collection, including the development of metrics and indicators to assess the effects of policies (OECD, 2020a). While Canada has good quality data on flows of energy, water, and emissions, it does not keep comprehensive data on flows of biomass and minerals (Midsummer Analytics, 2020) (Box 2.2). Canada's statistics on waste generation are lacking compared to the EU and there is a particular need for data on industrial and commercial waste (Monahan, 2018). There is also a need for more targeted data collection on circular business practices; for example, data on product life extension is very limited, dealing only with repair revenues, and data on availability or uptake of models such as PaaS is nonexistent (Midsummer Analytics, 2020). The modernization of Statistics Canada and the Clean Technology Data Strategy provide opportunities to collect and share important data related to the CE, such as tracking material flows and recycling (Deloitte, 2019b). Encouraging or requiring private companies to report certain kinds of data, such as material flows, would also help fill some gaps (ECCC, 2019b).

Regional and municipal data collection on material and waste flows is also important and valuable, for example, in the development of municipal recycling programs (Zeller *et al.*, 2018; ECCC, 2019b). The Panel further notes that regional data initiatives could be used to stimulate regional circular innovation. Some Canadian provinces and territories collect data on the production of materials of regional interest, such as wood products in British Columbia and fossil fuels in Alberta (Midsummer Analytics, 2020). However, Canadian data collection regarding waste diversion is inconsistent between jurisdictions, suggesting a need for standardization to support assessment of waste management policy (Canada's Ecofiscal Commission, 2018). The Panel believes that cooperation across levels of government is necessary to ensure that circularity data can easily be compared across Canada.

There is a widespread lack of data regarding the relationship between circularity and international trade.

Few studies exist on the interaction between international trade and the CE, or on the resultant economic, environmental, and social outcomes (EC, 2020b). There are limited data tracking material flows that are important to circular trade, such as secondary raw materials, second-hand goods, end-of-life products, and waste, due in part to the lack of internationally accepted definitions and classifications for these materials (OECD, 2018). To measure the impact of waste trade on the CE, it will be important to distinguish waste traded for material recovery versus waste traded for energy recovery, as well as the extent to which waste and scrap trade contribute to upcycling and downcycling (OECD, 2018). These efforts may be complicated by illegal trade in waste, which makes it difficult to track material

flows and maximize material recovery (EMF, 2014). While shifts towards a CE on the part of actors, such as the EU, will affect global trade, current indicators are insufficient to capture these effects (Kettunen *et al*., 2019). The development of international standards and the global harmonization of indicators, along with the development of a global database for resource flows, could help to address these challenges (Geng *et al*., 2019) (Section 5.5).

From the Canadian perspective, the costs associated with circular trade are still unknown, as are the supply and demand of waste and resources at the regional, national, and international levels (ECCC, 2019b). Because most of Canada's trade occurs with the United States (Section 3.2), data regarding material flows and waste demand across the Canada–U.S. border will be particularly important to advance circularity in Canada. Some organizations have begun cross-border collaboration on circular practices. For example, the Ontario Materials Marketplace is designed to facilitate data gathering and identify opportunities to recycle and reuse materials within the industrial, commercial, and institutional sectors across North America (Ontario Materials Marketplace, 2021). The Panel believes that such projects represent a promising start to filling circular data gaps.

5.5 Policy and Regulatory Barriers

Policy misalignments across and within levels of governments or among stakeholders can cause conflicting or perverse incentives with respect to resource efficiency and the CE. To advance the CE, a coordinated approach is needed both nationally and internationally (OECD, 2020a). In addition, circular policies and practices must be coordinated not just across different regulatory bodies but across sectors. To the extent that national and international regulations deal with specific sectors, strategies implemented on the local level tend to be siloed rather than facilitating cross-sectoral action, which is necessary for a fully circular ecosystem (Williams, 2019). At all levels, policy development must contend with the challenges related to linear lock-in. The Panel identifies a need for strong long-term commitments from governments to drive the cross-sectoral action needed for a CE transition.

Canada's federal structure adds a particular layer of complexity to harmonization efforts, as these must be coordinated across provincial/territorial levels as well as municipal and national levels, each with its own jurisdictional powers (Section 3.1). Policy coordination may be impeded by the desire of provincial and federal governments to maintain autonomy, which has in the past resulted in provincial opposition to federal environmental regulations (Macdonald, 2020). Ultimately, Canadian experts identified the lack of harmonized frameworks and policies as the top barrier to the CE in Canada (CELC & GLOBE, 2020).

Unclear terms and metrics describing circularity and unclear or misaligned regulations impede a transition towards a CE.

As noted in Section 2.1, the concept and the definition of the CE continue to evolve. Uncertainty regarding the definition of the CE contributes to the use of imprecise criteria and indicators in determining the eligibility of companies for CE-specific support, such as funding opportunities. Even where such programs promote genuine efforts towards sustainability, broadly defined supports could come at the expense of failing to support the companies that will have the greatest effect on increased circularity (Dewick *et al.*, 2020). Defining terms and developing unambiguous metrics for qualities such as durability or ease of disassembly for repair also pose challenges for creating regulations for circular design (Peiró *et al.*, 2020). Thus, the Panel notes that clarity in measuring the CE is important for purposes of circular policy, even if a consensus definition remains elusive.

Unclear or misaligned regulations impede a clear path to a CE. For example, stakeholders in construction have indicated that ambiguous end-of-life regulations for waste were the most significant policy challenge relating to the adoption of the circular practices in their industry (Adams *et al.*, 2017). Regulations regarding waste treatment operations can impose administrative obligations on secondary materials processors, such as paper mills, complicating their operations; definitions of materials as waste or non-waste may also have tax implications that affect recyclers (Eckert, 2019a). Moreover, in some cases, regulatory standards impede reuse. For example, it is sometimes difficult to update old buildings to modern safety and environmental standards (Bullen & Love, 2010). Meanwhile, regulatory standards that indicate quality and safety of circular resources, increase confidence and demand (Williams, 2019). The development of international standards for circular materials has its own set of challenges, which are discussed later in this section.

To achieve better environmental and economic impacts from circular practices, it is valuable for regulations to target shorter loops, such as repair and remanufacture (Peiró *et al.*, 2020), and for waste management policies to incentivize high-quality over low-quality recycling (Milios, 2018). Some suggest, however, that focusing on recycling and landfill diversion at end of life leads to downcycling at the expense of efforts towards reuse (Adams *et al.*, 2017). Different stakeholders (e.g., original manufacturers, third-party repair services, recycling companies) are invested in different loops and design principles, complicating the political task of developing regulations (Peiró *et al.*, 2020).

Current procurement is generally not fit for enabling circularity.

A UN survey found that common barriers to sustainable procurement included a lack of specific expertise and, in North American organizations, competing procurement priorities (UNEP, 2017). Companies have further noted that criteria for public procurement are not well adapted for PaaS models (Orasmaa *et al.*, 2020). Broadly speaking, sustainability concerns are currently not well integrated into the Canadian procurement system, with a recent study determining that only 12% of requests for proposals included sustainability as an independent criterion, and the average weight of this criterion was only 5%, which has little impact on results (Da Ponte *et al.*, 2020). Moreover, only 4% of requests for proposals contained any mention of the total cost of ownership as a consideration (Da Ponte *et al.*, 2020). This finding is concerning given that governments traditionally consider minimizing cost to be a fiduciary responsibility, and assessing cost via purchase price rather than the total cost of ownership tends to disadvantage sustainable offerings (UNEP, 2017; Da Ponte *et al.*, 2020). In addition, none of the Canadian requests for proposals that contained sustainability considerations included accountability mechanisms to ensure compliance (Da Ponte *et al.*, 2020). These findings were relatively consistent across all studied levels of government (federal/provincial/municipal) and procurement categories (Da Ponte *et al.*, 2020). Da Ponte and Kennedy (2021) identify a need for greater national leadership to improve sustainable procurement in Canada. Circular procurement is further discussed in Section 7.1.5.

Privatization can limit the ability of municipalities to advance the CE.

As mentioned in Section 5.1, cities represent promising centres for early adoption of the CE. The Panel believes that municipal governments can accelerate the transition towards the CE through implementing circular strategies tailored to their communities. However, Williams (2019) argues that local implementation of the CE is impeded by increased privatization of municipal utilities, services, and infrastructure, as corporate control over these systems reduces the role of the public in municipal decision-making, leading to shorter-term and market-driven thinking. Kishimoto and Steinfort (2020) note that many municipalities worldwide are now reversing this trend and bringing services and utilities back under public control for economic, social, and environmental reasons. Canada could be considered ahead in this respect, with relatively widespread public ownership of municipal services and infrastructure (Ramsay, 2020).

EPR schemes do not necessarily provide strong incentives for circular design and are subject to implementation challenges.

EPR describes a set of policies aiming to make producers responsible for the costs of managing their products at end of life (OECD, 2016). These policies involve a variety of mechanisms, with the most common being requirements for producers to take back their products at end of life and advanced disposal fees paid upon purchase by either the producer or consumer (OECD, 2016). In Canada, full EPR schemes involve producers directly managing their products at end of life, though partial EPR schemes exist in which management is operated by government but financed by producers (Arnold, 2019). Currently legislated EPR schemes are primarily collective, meaning that all members of industry share responsibility for the management of a type of product (Burgon & Wentworth, 2018).[12] This is typically done through producer responsibility organizations, which manage products on behalf of individual producers in an industry and cover costs by collecting fees from producers and selling recycled materials (Arnold, 2019).

As noted in Section 5.2, by placing the costs of managing end-of-life materials on manufacturers, EPR aims to incentivize design for waste reduction and recycling (OECD, 2016). However, fees may not always produce sufficient incentive for design changes (Arnold, 2019). Indeed, some producers of more easily recyclable products note that when they pay flat fees (i.e., based only on the type of product) into collective schemes, they effectively subsidize the costlier disposal of competitors' products (Hogg *et al.*, 2020); this may disincentivize sustainable design. Internationally, EPR schemes have had some success in increasing recycling but little effect on design (OECD, 2016).

Similarly, even though early EPR was introduced in Canada in the 1980s and has been refined in the decades since, it has produced only limited improvements in sustainable design (Arnold, 2019). This results, in part, from fee structures that are largely based on product category — and weight, for products such as packaging — rather than the product's environmental design features (Lakhan, 2016; EPRC, 2017b). Still, Ontario's EPR scheme for packaging, where fees are based on the recyclability of materials, does not appear to have increased recycling rates (Lakhan, 2016). The national harmonization of EPR would contribute to improving national data collection on these schemes (EPRC, 2017b). However, Canada still represents a small share of the global marketplace (EPRC, 2017b), and such a change may have a limited effect on products designed for global markets, such as mobile phones (OECD, 2016). Coordinating policy through efforts such as the Global Alliance on Circular Economy and Resource Efficiency, in which Canada participates (GACERE, 2021a), could help make EPR policy relevant in the global market.

12 *The Waste Free Ontario Act* started a shift to individual producer responsibility in 2016 (Arnold, 2019). The impacts of this shift remain to be seen.

Coordinating EPR on a national level within Canada while implementing programs at the provincial and territorial level would also be a positive step given the system-wide costs of a lack of harmonization (EPRC, 2017b).

Additional challenges with EPR include anti-competitive behaviour and free riding (OECD, 2016). Canada has been less successful than Europe in establishing competitive producer responsibility organizations, in effect allowing single producer responsibility organizations in Canada to act as monopolies (OECD, 2016; EPRC, 2017b). While such monopolies have some benefits for waste management, the OECD (2016) recommends that they only be allowed when these benefits demonstrably outweigh the costs of reduced competition and that this cost–benefit calculation must be regularly reviewed. Ontario's EPR system is moving towards increased competition, intended to improve innovation and cost efficiency (Moran, 2019). Online sales from outside Canada are a significant source of free riding, as it is difficult for Canadian regulators to ensure that these businesses pay into Canadian producer responsibility organizations (Arnold, 2019). A lack of accountability with respect to performance targets is also a concern (EPRC, 2017b). Quebec has proposed penalties for missing take-back targets but delayed them because of pushback from producer responsibility organizations (Leclerc & Badam, 2019). Despite this, in 2017 Canada collected a similar per capita volume of electronics to what was collected in 2016 by the Netherlands, the U.K. and France (EPSC, 2019).

There is, however, a tendency for EPR to support recycling rather than more efficient circular practices. British Columbia's EPR scheme for packaging has been criticized for overemphasizing recyclability in its fee structure rather than total environmental impact, including reducing the amount of materials (Miller, 2019). Despite explicitly prioritizing reuse and having a high capacity for refurbishing, most e-waste collected through Quebec's EPR scheme is recycled, due largely to the age and condition of the returned material and relatively low demand for used products (Leclerc & Badam, 2019). Finally, current EPR in Canada covers only a small range of products; most provinces have implemented EPR for "Phase 1" materials (packaging, printed materials, mercury-containing products, electronics and electrical equipment, hazardous wastes, and automotive products) but little progress has been made in extending EPR to the next phase, including construction materials, furniture, textiles, and appliances (CCME, 2014; Arnold, 2019). This makes EPR too narrow in scope for CE purposes, which call for EPR to be deployed across a wide array of industries.

Based on this evidence, the Panel concludes that, in practice and to date, EPR has been of limited effectiveness and can produce perverse incentives. Thus, it should not be seen as a key lever for promoting the CE. At the same time, the Panel recognizes the potential of these schemes to contribute to the CE, and methods to

improve their implementation are discussed in Section 7.5. These improvements can be combined with other mechanisms that create strong economic models for reuse and recycling, such as procurement, reducing incentives for extraction, or disincentives for the use of materials with environmental impacts.

Trade barriers and global supply chains complicate the implementation of domestic CE policies, with the Canada–U.S. supply chain playing a significant role for Canada.

The fragmentation of global value chains and the distribution of environmental and social impacts across borders calls for a coordinated international approach to CE policy (OECD, 2020a). Many existing trade barriers will need to be overcome to advance the CE both domestically and globally. These barriers may be intentional or unintentional and are typically linked to import and/or export restrictions on CE-related trade commodities such as waste, secondary raw materials, second-hand goods, and end-of-life products. In some cases, domestic regulations and policies for the CE may have positive environmental, economic, and social outcomes for the country or region in which they are enacted, but act as a trade barrier when standards are not aligned between countries (OECD, 2018; Kettunen *et al.*, 2019). Trade barriers can also impede the adoption of CE-enabling technologies across international borders (OECD, 2020a).

The development of international standards for the CE can help to ensure that countries pursuing higher environmental standards are not at a competitive disadvantage in the global marketplace. For example, if CE-promoting policies such as EPR schemes raise costs for domestic companies relative to companies in countries that are not pursuing the CE, this could result in unintended and counterproductive advantages to countries with lower levels of circularity (Kettunen *et al.*, 2019).

The potential economic impacts of the CE for a country likely depend on the extent to which the extraction and export of natural resources play a role in its economy (Schröder, 2020). Modelling by Meyer *et al.* (2015) and Dellink (2020) suggests that, based on its current exports and imports, Canada should expect that global implementation of material efficiency policies will result in a lower GDP relative to business-as-usual projections, though this does not necessarily indicate an absolute decrease in GDP from present values. The effect in Canada is smaller than in countries that are more heavily dependent on extraction, such as Russia or Brazil (Meyer *et al.*, 2015; Dellink, 2020). Moreover, some models have found more optimistic results (Section 6.3). Canada's below-average levels of services exports are also an economic concern with respect to the global advancement of the CE (Dellink, 2020), though Canada's services exports increased at a faster rate than goods exports between 2010 and 2019 (GAC, 2020b).

The majority (56%) of Canada's imports represent intermediate inputs, such as parts or manufacturing equipment used to produce a good or service for domestic consumption or export (GAC, 2020b). While there are benefits to such internationally integrated supply chains, they can also be vulnerable to shocks, as demonstrated by decreases in trade within the automotive, machinery, and electronics sectors as a result of COVID-19. This was particularly evident in automotive sector trade between Canada and the state of Michigan. Several additional manufacturing sectors, including electronics, paper, plastics, rubber, and other chemicals, are highly vulnerable to global supply chain disruptions due to a combined reliance on intermediate imports and on exports of final products (GAC, 2020b). The high share of intermediate inputs within Canada's imports suggests that international coordination of circular policies and standards will be a particularly important factor for Canada. Coordination with the United States will be highly significant due to the particularly high level of integration of supply chains across the Canada–U.S. border and the importance of trade with the United States to the Canadian economy (Section 3.2).

International waste trade to facilitate the CE faces challenges relating to the categorization of materials, quality standards, and illegal trade.

Definitions and classification of waste, scrap, and secondary raw materials vary across countries, as do distinctions between those categories and end-of-life products (OECD, 2018). The lack of quality standards for recyclable waste can result in the import of low-quality waste, leading to higher recycling costs, downcycling, or landfilling/incineration. This can also create negative perceptions of secondary raw materials and waste trade in general, thereby creating obstacles to widespread implementation of the CE (Kettunen *et al.*, 2019). Classification of end-of-life products as waste presents problems for domestic EPR schemes by making it difficult to recover end-of-life products for refurbishment or remanufacturing after they have crossed international borders (OECD, 2018).

Waste exports have the potential to cause a variety of problems. Exporting waste may contribute to an inaccurate understanding of the impacts of domestic policies for the CE; for example, in the EU, exported recyclable materials are counted as progress towards recycling targets. However, it is uncertain whether that material is really recycled after it is imported and under what conditions (Kettunen *et al.*, 2019). Waste exports (e.g., plastics) may outsource negative impacts to waste-importing countries with lower environmental standards (Section 5.6) and may represent a lost economic opportunity for Canada (IISD, 2019b). The export of waste to jurisdictions with cheaper disposal fees (such as to the U.S.) limits the ability of individual municipalities to incentivize waste reduction through

charging for the full cost of disposal (Canada's Ecofiscal Commission, 2018) (Section 5.2). On the other hand, imposing restrictions on domestic waste exports may inadvertently create a barrier to the CE by limiting the supply of feedstock materials at low prices (OECD, 2018). Illegal trade in waste further complicates data collection and the implementation of EPR schemes (discussed earlier in this section), and often heightens negative impacts on the environment and health (OECD, 2016, 2018).

International regulation has attempted to address problems with waste trade. A 2019 Plastic Wastes amendment to the Basel Convention restricted global trade in plastics waste and increased monitoring of this trade (Nielsen *et al.*, 2020), and a Basel Ban Amendment prevents OECD countries from exporting hazardous waste to non-OECD countries (ENVI, 2021). Canada has still not ratified the Ban Amendment (ENVI, 2021). Moreover, while it has ratified the Plastic Wastes amendment, a bilateral agreement signed shortly prior to these restrictions going into effect allows continued trade in waste plastics between the United States and Canada, even though the United States is not a party to the Basel Convention (Staub, 2020; ENVI, 2021). This has been criticized by some groups as representing a lower environmental standard (Staub, 2020). Given Canada's leadership role in introducing the G7 Ocean Plastics Charter (GC, 2020a), this controversy presents conflicting messages regarding Canada's stance towards international efforts to reduce plastics waste.

Lobbying can be a significant barrier to circular policies, and its impact will likely be strengthened by Canada's economic policy focus on natural resource-based industry.

Lobbying has been identified as a challenge for advancing circular policies and programs (Delphi Group, 2017). Companies may use voluntary environmental measures and lobby for programs such as subsidies for environmentally friendly products to avoid stronger mandatory regulations; this can damage public welfare (Lyon & Maxwell, 2008). In the United States, lobbying by firms standing to lose from climate change regulation has reduced the likelihood of passing environmental regulations related to this issue (Meng & Rode, 2019). The waste management industry has also been known to lobby against circular "zero-waste" initiatives, preferring to optimize landfill or advance incineration, with stark impacts for New Zealand (Hannon & Zaman, 2018). In Canada, the Corporate Mapping Project found that corporations use various forms of power — including lobbying, control of investments, and cultural influence — to impede climate action (Carroll, 2021). Similarly, the Canadian plastics industry is lobbying against efforts to ban single-use plastics and requirements for 50% recycled plastics content (Fawcett-Atkinson, 2021).

The Canadian context includes an economic policy that has, for over a century, centred around natural resource-based industries, from fur and cod to timber and agricultural products to mining and fossil fuels (Watkins, 1963, 2020; Keeling & Sandlos, 2016). The impacts of this policy are somewhat complex. On the one hand, Canada's resources have contributed positively to its growth (Boschini *et al.*, 2013), and Canada has avoided becoming economically dependent on the extraction of its natural resources (Cockx & Francken, 2014). At the same time, some have argued that Canadian business and policy leaders have insufficiently invested in diversification and in the development of added-value industries (Rotstein, 2020; Watkins, 2020; Wolfe, 2020). Ultimately, a shift in economic policy is necessary to encourage Canadian development of innovation-based exports (Wolfe, 2020) or to redirect some of the incentives that, by benefiting primary materials, contribute to linear lock-in. This will be seen as against the interests of some communities or corporations that have historically been accustomed to policy support for extraction. Managing resulting pushback and mitigating the real or perceived negative effects of the CE on these stakeholders is a key challenge to advancing the CE in Canada.

5.6 Social and Behavioural Barriers

Social considerations for the CE, and particularly implications for international development, have received relatively little attention compared to technological and business concerns (Schröder, 2020). Social challenges to the CE come in two main forms: (i) cultural barriers preventing either organizations or individuals from adopting and engaging in circular practices, and (ii) the difficulties and uncertainties associated with managing social impacts resulting from the CE transition, such as labour market shifts or the unequal environmental effects of waste trade. The ability of companies or consumers to adopt a given practice depends on shared understandings and expectations, the necessary skill to execute that practice, and material conditions that enable the practice (Spurling *et al.*, 2013). Gaps in any of these three elements constitute barriers to the adoption of CE practices. Moreover, public acceptance of the CE may be impeded by the anticipation of negative social impacts.

Overall, the development of trust, collaboration, and communications between actors and institutions in different silos is an important part of implementing the CE, as demonstrated by a Stockholm case study (Williams, 2019). The Panel believes that collaboration, despite significant social barriers, can be achieved in part through a positive vision for a circular society and by applying the concept of a just transition (Section 6.5 and Chapter 8).

While company culture can drive circularity, this is frequently impeded by a lack of incentive for leadership, concerns regarding risk, and unclear responsibilities.

Canada has only recently engaged with the CE as a concept, and while some companies have implemented circular practices, understanding of the concept as a whole is very limited (Deloitte, 2019b). This translates into difficulties implementing circular practices. Even where businesses are aware of circular principles, there are a variety of cultural barriers to putting the CE into practice, which are observed in a variety of countries as a result of the expectations and material incentives of the current economic system.

As discussed in Sections 5.2 and 5.4, economic and regulatory incentives create material systems that largely encourage linearity rather than circularity. While some companies have successfully implemented circular strategies (see examples in Section 2.2), the Panel identifies little incentive for circular leadership due to first-mover disadvantages for circular companies operating in a linear economy. For example, due to knowledge spillover, early movers in adopting circular practices will shoulder a greater portion of the costs — such as the cost of testing circular business models (Section 5.3) — while their competitors share the benefits of this innovation (SPI, 2020b). In the Panel's experience, corporate metrics for success such as market share are not suitable for measuring — and thus recognizing the value of — circular practices such as shifts to providing PaaS. Given these conditions, the Panel finds it unsurprising that many businesses are hesitant to engage with the CE.

Implementing the CE requires major changes in business strategies, execution, and product design objectives, as well as greater flexibility in incorporating a variety of circular inputs and different ways of marketing and selling to customers (Accenture Strategy, 2014). However, interviews by Ritzén and Sandström (2017) with individuals at large manufacturing companies indicated a preference for incremental change and a lack of interest in developing new business models, which inhibit the transformational action necessary to implement a CE. Concerns regarding risk are also noted both in large companies and in managers/owners at SMEs (Rizos *et al*., 2016; Ritzén & Sandström, 2017). From the perspective of the businesses, this likely represents an attempt to prudently manage a complex set of risks related to market uncertainty and regulatory changes. Investors and shareholders may also pressure companies to minimize risks and ensure a steady return on investment. The result, however, is that the assessment of risk represents another cultural barrier to the CE.

In addition, companies may experience uncertainty regarding the governance of CE, such as how to assign responsibility for advancing the CE among the sustainability department, upper management, and middle management

(Ritzén & Sandström, 2017). Advancing the CE, in fact, requires coordinated changes across the different levels and departments of a company (Ritzén & Sandström, 2017) and, in the Panel's experience, across lines of business. Moreover, it is often important to have a variety of stakeholders involved in adopting circular practices. For example, a lack of interest and awareness on the part of clients and designers was seen as a significant challenge to adopting CE practices in the construction industry (Adams *et al.*, 2017). Similarly, some circular designers report involving suppliers in the design process (Sumter *et al.*, 2020); this approach is recommended by Éco Entreprises Québec (2021).

Despite these challenges, company culture can be a positive force (Rizos *et al.*, 2016). In SMEs that have successfully implemented a CE, company culture was reported as an enabler by a majority of companies and as a barrier by only 8% of companies. The study authors note that companies successfully implementing a CE may be much more likely to be those with a supportive company culture (Rizos *et al.*, 2016). Some evidence suggests that adopting innovative sustainability practices can provide a competitive advantage, particularly when a company is able to leverage superior knowledge or technology; moreover, an increasing number of sustainability practices are becoming a necessary part of doing business (Ioannou & Serafeim, 2019, 2021). Cultural incentives for companies to adopt circular practices involve changes in social expectations and enabling material conditions. For example, stakeholder pressure, corporate social responsibility, and customer demands can encourage companies to implement more sustainable design principles (OECD, 2016). Low regulatory uncertainty is also an effective driver of the adoption of common sustainability practices (Ioannou & Serafeim, 2021). Circular investment and circular procurement are particularly important in promoting circular practices and are discussed further in Sections 7.1.1 and 7.1.5.

A culture of consumerism in Canada promotes linear consumption and impedes circular behaviour.

Public interest is growing in sustainability and circular practices such as repairing goods (GlobeScan & GreenBiz, 2020; Vadakkepatt *et al.*, 2021). Canadians largely support environmental policies, including many circular measures (Sections 3.4), but are largely unaware of the concept of the CE, possibly because of the lack of a common and well-known definition (Deloitte, 2019b). Lack of understanding of the scope of the CE could be a barrier to adopting circular practices if, for example, Canadians do not perceive practices such as sharing products or choosing services over goods as environmentally beneficial. The Panel notes that further research on domains and practices that Canadians associate with sustainability or circularity may be helpful in this respect. In addition, Canada has a strong culture

of consumption (Section 3.3). This suggests that Canadians may be motivated to engage in the CE but that cultural changes and removal of social and other barriers are necessary to increase household engagement in CE practices.

For many countries, contemporary cultural norms relating to individual consumption may act as a barrier to the CE (Williams, 2019). In the current consumer culture, most people express their identities through consumer goods, and consumption is largely oriented towards private and individual ownership of goods (Holt, 2005). Consumption choices are shaped by the modern environment, reflecting not only individual attitudes but the structure of society and the economy (Zukin & Maguire, 2004). Marketing and social pressure contribute to overconsumption (Sanne, 2005).

Some customer preferences may run contrary to the principles of a CE. For example, customers may believe that circular products are of lower quality (Rizos *et al*., 2016); it is thus necessary to communicate the quantified benefits of these products and services. Notably, low demand for reused and recycled materials stem not just from individual consumers but also from a lack of interest in the commercial sector (e.g., with respect to buildings and construction materials) (Densley *et al*., 2017; Jin *et al*., 2017; Williams, 2019). One study indicated that experience in recycling and reuse increases professionals' opinions of the quality of these materials (Jin *et al*., 2017).

Remanufactured products may have a less appealing appearance, reducing customer demand; this was seen as the second greatest barrier to the CE in a survey of EU and British manufacturing companies after a general lack of consumer awareness (Kumar *et al*., 2019). However, product attractiveness depends not only on the customer but also on the social context. For example, the point at which a user perceives a product to be obsolete depends on factors such as advertising messages and the accessibility of repair options (Wieser, 2016). Changes to technology and function also affect the attractiveness of recirculated products to customers; robust and modular design may reduce perceived obsolescence (Linder & Williander, 2017).

Some socio-demographic variables may also affect the uptake of and engagement in circular practices. Highly educated individuals and those in middle-class neighbourhoods are more likely to offer assets on sharing platforms such as peer-to-peer car rentals (Schor, 2017). Conversely, low-income consumers in the U.S. are more likely to purchase second-hand clothing, which higher-income consumers may see as undesirable (Norum & Norton, 2017). Attitudes towards reuse may be shifting, as second-hand markets for many types of goods are projected to grow faster than markets for new products (reviewed in Hristova, 2019). However, these shifting attitudes may vary for different social groups, as

younger consumers are more likely than older ones to buy second-hand products (Norum & Norton, 2017; GlobeScan & GreenBiz, 2020). Environmental attitudes also vary by political affiliation (Franzen & Vogl, 2013), which could affect interest in circular practices.

Sustainable behaviour also invites moral assessments, which differ based on socio-economic status and can affect engagement in circular practices. When low-income consumers, particularly those on government assistance, buy environmentally sustainable products at a price premium, they face negative social judgments for these choices, whereas high-income consumers are judged positively for the same purchase (Olson *et al.*, 2016). Moreover, when low-income individuals engage in sustainable practices, this is typically judged as resulting from financial need rather than environmentalism and thus less worthy of praise (Kennedy & Horne, 2020). The perception that sustainable purchasing is morally praiseworthy is not entirely positive, as choosing sustainable options can cause individuals to morally justify increased consumption (Wilk, 2014), contributing to a rebound effect.

Changes from consumer ownership to models where consumers access products owned by producers, such as PaaS models (Section 2.2), are an important part of the transition towards a CE (Orasmaa *et al.*, 2020). Product ownership is a current social norm and can provide a sense of satisfaction, which individuals must weigh against the potential convenience of access-based offerings (Cherry & Pidgeon, 2018). Consumer preference for ownership models may, in part, be habitual (Planing, 2015); however, some suggest that these preferences are shifting (Orasmaa *et al.*, 2020). For example, recent data from the United Kingdom show high levels of spending on renting and services, suggesting that product ownership is not necessarily a strong motivator for consumers (Burgon & Wentworth, 2018). The visibility of circular practices such as the use of service-based offerings will be important to establishing new social norms (Planing, 2015). At the same time, practical factors such as price and convenience affect the adoption of these models (Cherry & Pidgeon, 2018).

Material conditions such as affordability and accessibility can prevent the adoption of circular practices.

Price point is a significant factor in demand for circular products. Recycled materials can be more expensive than virgin materials (Section 5.2), and while products with a lower purchase price tend to have a shorter lifespan, customers often have difficulty calculating the total cost of ownership (Section 5.3). Customers are not always willing to invest in circular technology or pay more for circular products (Tura *et al.*, 2019). For example, while 53% of Canadians surveyed

were willing to purchase products made from recycled materials, only 12% were willing to pay a higher price to avoid non-recyclable packaging (Ipsos, 2019).

In some cases, consumers may be willing but financially unable to invest in circular products. A European study found that consumers are willing to pay more for products that are advertised as having a longer lifespan, but consumers from the Czech Republic were less willing to pay higher amounts than consumers from higher-GDP countries (EESC, 2016). Consistent with this, one international survey found that 49% of consumers reported affordability as a barrier to adopting a healthier and more sustainable lifestyle (GlobeScan & GreenBiz, 2020). Moreover, past studies have found that household income affects the amount consumers are willing to pay for environmentally sustainable products (Vecchio & Annunziata, 2015; Chen *et al.*, 2018). Conversely, remanufactured products can often be offered at a lower price point, which can motivate consumers (Hazen *et al.*, 2017).

Lower pricing, however, could result in a circular rebound effect, whereby increases in the efficiency of producing or consuming goods lead to increases in overall consumption, offsetting the environmental benefits of efficiency (Zink & Geyer, 2017). This can happen if products such as refurbished smartphones or similar technology are sold to consumers who would not otherwise have purchased a new product, rather than replacing purchases of new items. In addition, producing products more cheaply can also lead to greater consumption if excess income is spent on more products; thus, offering circular products at lower prices tends to increase consumption (Zink & Geyer, 2017). Increased costs of new products, for example, due to increasing resource costs, can also push consumers to switch to remanufactured products (Hazen *et al.*, 2017). The Panel notes that properly pricing environmental and social externalities would increase the prices of linear products, allowing circular products to compete on price without necessarily causing a rebound effect of increased consumption.

Purchase price is not the only material factor influencing the uptake of circular practices, however. In the context of business-to-business transactions, customers may be interested in remanufactured products if they want to continue using a particular product, especially one that has been discontinued (Pearce, 2009). Some circular offerings have drawbacks for consumers, however. Access-based models can be seen as risky as they generally involve ongoing financial obligations, as opposed to ownership models where the consumer controls assets (Cherry & Pidgeon, 2018). In general, access-based models are more prevalent in business-to-business contexts than business-to-consumer (Cherry & Pidgeon, 2018). The legal complexity surrounding divisions of responsibility in access models (Orasmaa *et al.*, 2020) may cause consumers anxiety, particularly with respect to contractual obligations (Cherry & Pidgeon, 2018). This anxiety, in part,

may explain the differences in the prevalence of these models between the different contexts.

Larger structural conditions also have a significant impact on practices. For example, low-density urban areas with large distances among homes, workplaces, and shopping centres create a need for private car ownership (Sanne, 2002). Further, placing responsibility for environmental behaviour on households burdens consumers and disproportionately burdens women, who are traditionally responsible for household labour and care work (Kennedy & Kmec, 2018). This emphasizes a need for action from governments and businesses to minimize the money or time costs that circular practices impose on consumers; circular products must not only be attractive but practical and accessible. To assist customers in choosing circular options, businesses can provide support and practical information about how to use these offerings and ensure that they are convenient (GlobeScan & GreenBiz, 2020).

Social systems create barriers to individual behavioural change, limiting the ability of consumer engagement to drive a CE.

A CE has the potential to engage individuals not just as consumers but also as citizens. Citizens may resist the location of recycling or reprocessing infrastructure within their neighbourhoods, sometimes without understanding the actual impact of such projects (Williams, 2019). Moreover, the decreased power of local institutions in the face of global interests decreases public trust in those institutions and public engagement with local initiatives supporting a CE (Williams, 2019). The increasing prominence of the consumer role over the citizen role can be observed in Canada. Between 2003 and 2008, the number of Canadians who have participated in boycotts and ethical purchasing decisions increased from 19 to 25%, paired with decreasing engagement in group-oriented forms of political expression such as attending public meetings (from 22 to 19%) (Kennedy & Bateman, 2015).

Despite challenges to consumer engagement with the CE, only 18% of participants in a Canadian CE workshop identified consumer demands among their top barriers, behind the harmonization of government policy and industry standards (CELC & GLOBE, 2020). The Panel believes that the relative ranking of these barriers reflects a need to prioritize systems change ahead of individual behavioural change with respect to a CE in Canada. No single sector can drive the transition — there is a need for consumers and industry to move together and for government to provide a framework that makes circular practices appealing through a variety of levers, including regulation and procurement.

Potential negative social impacts are important to consider and mitigate but are not always well captured by current circularity metrics.

The Panel identified various social impacts of circular technologies and business models. While a CE is expected to have overall positive effects on employment (Section 6.2), negative effects are also possible, such as a reduction in labour due to increased automation/digitization and industrial restructuring (Schröder, 2020), an increase in precarious work or income inequality due to sharing economy platforms (Schor, 2017), or job losses in sectors such as resource extraction (Deloitte, 2019b). The Panel notes that these impacts are likely to fall most heavily on remote areas that rely on resource extraction, are far from markets, and lack the necessary infrastructure to diversify. Moreover, as discussed in Sections 5.1 and 5.3, such a lack of infrastructure and investment opportunities mean that a CE may not be equally accessible to rural, remote, and Indigenous communities. Retraining will be necessary to address labour market shifts; how this could be implemented is discussed in Section 7.3. Finally, sharing and service-based models may not be equally accessible or beneficial to all and could allow companies, for example, to increasingly monitor their customers (Pitkänen *et al.*, 2020).

It is important to acknowledge and consider that technological advances, including the CE, do not equally benefit all people in society, and it is necessary to "address the social impact on those who lose out" (ECCC, 2019b). Unfortunately, despite the importance of the social dimension to the CE, these impacts are difficult to measure (Pitkänen *et al.*, 2020). Circularity metrics such as material flow analysis, life-cycle assessment, and environmentally extended input-output analysis often overlook social impacts and obscure trade-offs such as the environmental and health impacts of waste exports (Iacovidou *et al.*, 2017). These authors suggest using a multi-dimensional framework assessing social, environmental, economic, and technical values, selecting metrics that are suitable to the scenario. The UN Environmental Program (2009) has also released guidelines for social life-cycle assessment, noting that further research is needed in this area. Further considerations for managing the social impacts of a CE are discussed in Section 6.4.

There is a danger that a Canadian CE will have negative effects internationally, effectively outsourcing social and environmental impacts.

Domestic CE policies can have unintended and adverse environmental and social impacts in other countries (Kettunen *et al.*, 2019). For example, investments in domestic remanufacturing capacity may have positive effects on local economic output and employment while reducing economic growth and employment in countries that export primary manufactured products (EMF, 2014). There is also

a potential for circular financing to marginalize companies and projects in developing countries, which may not have the resources to meet administrative and data requirements from investors in high-income countries (Dewick *et al*., 2020).

Waste trade is a notable example of outsourcing environmental impacts. This trade has economic benefits for developed countries but has also resulted in environmental costs in developing countries (Liu *et al*., 2018). Evidence shows that international trade flows for recyclable waste are determined in large part by differences in the level of environmental protections between countries, with flows being directed to countries with lower environmental standards (typically developing countries) (OECD, 2018; Kettunen *et al*., 2019). The Ban and Plastic Waste amendments to the Basel Convention (Section 5.5) attempt to address this problem, and some groups argue that Canada's actions with respect to these amendments exacerbate the problems caused by waste exports to developing countries (Dyer, 2020).

Some countries have acted to stem inflows of waste using import restrictions. In 2018, China banned the import of certain types of plastic waste, and several other countries have enacted or announced plans to ban plastic waste imports, including India, Thailand, Vietnam, and Malaysia (Kettunen *et al*., 2019). Notably, these four countries collectively received almost 24% of Canada's plastic waste exports in 2018, compared to less than 5% in 2015 (CIMT, 2021a). These import bans have had a significant impact on both global waste trade flows and Canada's waste exports, provoking what has been described as a "crisis" for the industry in Canada (Lewis & Hayes, 2019). Moreover, these bans may result in the redirection of global waste flows to countries that are even less prepared to deal with them, thereby undermining the CE by increasing pollution, landfilling, and incineration. However, these bans may also spur actions to reduce waste in waste-exporting countries and regions, as they have in the EU, which has modified its CE strategy in response to the ban (Kettunen *et al*., 2019).

Considering the global implications of advancing the CE in Canada could both help to prevent negative externalities and encourage the development of CE-related opportunities with Canada's trading partners. Indeed, without addressing this larger perspective, Canada may fail to achieve the benefits of a CE, both domestically and internationally.

6

Opportunities for a CE in Canada

6.1 Economic Opportunities for Businesses

6.2 Labour Market Opportunities

6.3 Opportunities for Economic Growth

6.4 Opportunities for a More Socio-Economically Equitable Society

6.5 Opportunities for Canada's Natural Resources Sector

6.6 Opportunities to Meet Existing Policy Goals

6.7 Opportunities Relating to Energy

6.8 COVID-19 Recovery and Increasing Resilience

Chapter Findings

- A CE provides opportunities for businesses to reduce costs associated with waste and emissions, offer new products and services, increase brand value, develop closer relationships with customers, and respond to expectations from investors and stakeholders.
- A CE has the potential to have overall net positive or neutral effects on employment in Canada, increase economic growth and GDP per capita, generate more value from Canada's natural resources sector, and address some of the socio-economic inequalities produced by the linear economy.
- A CE will help Canada to achieve its policy goals — including meeting GHG emissions reduction targets and SDGs — while also supporting a "build forward better" strategy as part of Canada's recovery from the COVID-19 pandemic.

A circular economy provides opportunities for Canada to become more economically successful, socially equitable, environmentally sustainable, and resilient. In addition to increasing national economic growth and GDP per capita, businesses will have opportunities to reduce the environmental impacts of their operations and value chain, as well as their associated costs, while developing new revenue streams and gaining market share. A transition towards a CE will also impact labour markets in Canada, with modelling suggesting a potential net gain in jobs. These opportunities can be maximized through a multi-stakeholder process that applies just transition principles such as the development of education and skills training programs, equal distribution of benefits, poverty reduction, and diverse employment. In addition, a CE could help Canada to achieve its commitments to the Paris Agreement and SDGs; make progress on energy efficiency, renewable energy, and energy recovery; and increase resilience through "building forward better" in the post-COVID recovery.

Importantly, not only does the CE present Canada with the opportunities described in this chapter, but moreover, there are opportunity costs associated with inaction in advancing the transition towards a CE. Globally, the current trends in production and consumption are environmentally unsustainable. The business-as-usual scenario (Section 2.4.2) shows that with no increase in circularity, Canada's waste and demand for raw materials will significantly increase. Moreover, if Canada does not transition to more circular practices, its firms risk falling behind in global market share, competitiveness, and innovation (Section 7.4). Thus, Canada will have to weigh the costs of the transition against the significant costs of inaction.

6.1 Economic Opportunities for Businesses

Adopting circular strategies and practices can provide economic benefits for businesses.

A transition towards a CE provides opportunities for businesses to adopt circular strategies and would create demand for new business services, such as collection and reverse logistics for end-of-life products, remarketing and sales platforms for reused products, and parts and components remanufacturing and product refurbishment (EMF, 2015c).

Adopting circular strategies not only allows firms to reduce the negative environmental impacts of their operations (Tura *et al.*, 2019), it also provides opportunities for businesses to create value and gain market share. The World Economic Forum has suggested that circular business models will gain a competitive advantage over linear models in the coming years because they create more value per unit of resource input (WEF, 2014). Circular business strategies allow firms to reduce the amount of raw material and the energy used in production processes, thereby increasing cost savings (Urbinati *et al.*, 2017; Tura *et al.*, 2019). Furthermore, adopting circular business practices may increase businesses' resilience to existing and proposed government sustainability policies that impose a cost on emissions and waste, as well as regulatory and tax measures that encourage sustainable business practices (Cairns *et al.*, 2018; OECD, 2019b). Adopting circular approaches can also help businesses attract financing by meeting the growing environmental, social, and governance expectations of investors (Cairns *et al.*, 2018; EMF, 2020a), as well as addressing the environmental values held by employees (Lyon & Maxwell, 2008). Furthermore, as customer preferences shift towards products that have a lower environmental footprint, adopting circular business practices can increase a company's reputation and brand value (Cairns *et al.*, 2018; Tura *et al.*, 2019).

Various circular strategies offer specific benefits for businesses.

Secondary Materials

Incorporating recovered materials into production processes in place of virgin materials allows firms to mitigate supply chain risks related to price volatility and supply uncertainty of raw materials (EMF, 2015c; Cairns *et al.*, 2018). A transition towards a CE also provides new opportunities for resource recovery business models in which firms recover secondary materials and components from waste (Cairns *et al.*, 2018; OECD, 2019b). These approaches require both a market for secondary materials and the availability of a sufficient volume of waste feedstock.

Design for Circularity

Circular design practices promoting modularity and reuse provide opportunities for longer-term relationships with customers (Cairns *et al.*, 2018). They provide producers with information about the performance of their products and how customers use them, which can spur further design insights (Cairns *et al.*, 2018). Furthermore, circular design practices that extend the life of a product — such as designing for durability, reuse, repair, and refurbishment/remanufacturing — provide new opportunities for businesses. Manufacturers may be able to charge higher prices for more durable products (but see Section 5.6); sales and remarketing platforms for second-hand products can charge a percentage of sales on such products; repair services can promote customer loyalty for manufacturers and provide new business opportunities for third-party repair firms; and refurbished or remanufactured products can generate higher profits for sellers due to material costs savings (OECD, 2019b).

Product-as-a-Service (PaaS)

Shifting from product-based to service-based models can create new revenue streams for businesses while improving customer loyalty and market share (Cairns *et al.*, 2018). Shifting from a product to a service allows businesses to retain a greater degree of control over their products, including end-of-life recycling or remanufacturing, and gives them the opportunity to adapt products to better meet customer needs, leading to better customer retention (Fischer & Achterberg, 2016; Aboulamer, 2018). This can result in less cyclical, more stable cash flows, which increase the overall value of a firm (Aboulamer, 2018). Moreover, every additional use-cycle of a product in a PaaS business model increases profit margins and reduces additional costs (Fischer & Achterberg, 2016).

Reverse Supply Chains

To take advantage of the opportunities offered by a transition towards a CE, firms will need to revise their existing linear supply chains through the addition of reverse supply loops that include activities such as reverse logistics, evaluation of the condition of collected products, and capacity for reuse, remanufacturing, and recycling (Urbinati *et al.*, 2017). The successful adoption of these new practices will require firms to "adopt a systemic approach in order to understand where the value is created in the supply chain and the role in the value creation of the entire network of suppliers, manufacturers, retailers and customers" (Urbinati *et al.*, 2017). Furthermore, creating formal collaborations and partnerships throughout a supply chain enables sharing of risks, revenue, and asset ownership; such integration can provide competitive advantages by incentivizing optimal asset management (Fischer & Achterberg, 2016).

Industrial Symbiosis

Industrial symbiosis is a relationship among firms in a close geographical area aimed at increasing competitive advantage through the exchange of materials, energy, water, and by-products (Chertow, 2000). Such relationships provide opportunities for circular business model strategies in which waste produced by one firm is used as production input by another firm (Bocken *et al.*, 2016; NISP, 2019; Raufflet *et al.*, 2019a). Eco-industrial parks (Section 4.1.9) provide an opportunity to establish these relationships to support the CE (Raufflet *et al.*, 2019a), and Canada could facilitate the development of eco-industrial parks and industrial symbiosis via financial incentives (Deloitte, 2019b). Industrial symbiosis initiatives can also be supported via inventories of waste and resource needs (ECCC, 2019b), and by the introduction of a common platform for information sharing and communication among industrial parks (Zhu *et al.*, 2014). Existing industrial parks can be encouraged to participate in the CE through policies supporting the development of technologies for the recycling and reuse of materials and energy (Raufflet *et al.*, 2019a), particularly technologies linking organizations through by-product exchanges (Zhu *et al.*, 2014).

6.2 Labour Market Opportunities

A CE will likely have an overall positive or neutral impact on employment in Canada.

The transition towards a CE is likely to disrupt the labour market in Canada, with some sectors gaining and some sectors losing. While the nature and extent of the impacts will vary by region and sector, multiple studies are predicting that a transition towards a CE is likely to have net positive effects on employment (Horbach *et al.*, 2015; Wijkman & Skånberg, 2015; Aguilar-Hernandez *et al.*, 2020; Laubinger *et al.*, 2020). Based on a literature survey, Laubinger *et al.* (2020) reported net gains in employment ranging from 0 to 2%. Similarly, a meta-analysis of different potential CE modelling scenarios found that "ambitious" CE scenarios predict a median increase in net employment of 1.6% between 2020 and 2030 (relative to business-as-usual scenarios), whereas "moderate" CE scenarios had only negligible impacts on employment (Aguilar-Hernandez *et al.*, 2020). However, the Panel notes that these predicted net gains are largely within the normal fluctuation range of labour markets, and thus the CE should be understood as having a net positive or neutral impact on employment and job creation in Canada.

Despite these positive overall projections, it is important to note that some CE approaches, such as an increase in the sharing economy, may eliminate more jobs than they create (Cairns *et al.*, 2018). Furthermore, certain sectors may face job losses due to reduced demand for raw materials (e.g., mining) or due to increased use of technologies, including digitization and automation, that can help meet CE goals (e.g., to increase resource productivity, optimize production, reduce waste) but also decreases the need for workers (Schröder, 2020). Remote areas that rely on resource extraction (Petigara, 2012), and which face challenges with infrastructure (Section 5.1) may also be more likely to experience job losses resulting from the transition towards a CE. To ensure a just transition, the potential negative impacts of a shift towards a CE on employment will need to be considered when developing CE policies (Section 6.4).

Finally, although a transition towards a CE is expected to create jobs, this could present a challenge to Canada, where labour shortages are becoming more of an issue. In 2018, a survey by the Business Development Bank of Canada identified growing labour shortages in sectors such as manufacturing, retail trade, and construction (Cocolakis-Wormstall, 2018). In a 2021 survey, following the

disruption to the labour market caused by COVID-19, the Bank of Canada found that many firms reported an increase in the intensity of labour shortages, and labour-related constraints in recruiting skilled or specialized labour in fields such as skilled trades, information technology, and sales professionals (BoC, 2021). Thus, it will be essential for governments to ensure the Canadian workforce is prepared for a transition towards a CE, potentially through education and skills training (and retraining) programs (Section 7.3).

A CE may decrease jobs in Canada's extractive sectors and increase jobs in the renewable resources and waste sectors.

In general, it is expected that a transition towards a CE is likely to reduce demand for workers in material-intensive sectors such as resource extraction and processing, and increase jobs in labour-intensive industries such as recycling, repair, and remanufacturing (Cambridge Econometrics *et al*., 2018; Laubinger *et al*., 2020). Globally, in 2011, four material-intensive sectors — construction, food products, primary metals and non-metallic minerals, and power generation and distribution — accounted for nearly 90% of global material use while employing only 15% of the global workforce. This suggests that job losses resulting from a transition towards a CE are likely to be relatively modest and are likely to be replaced with jobs created in other sectors (Laubinger *et al*., 2020). However, countries in which material-intensive sectors such as resource extraction and processing play a major role in the economy are likely to experience greater effects on the labour market (Laubinger *et al*., 2020).

In 2019, jobs in the Canadian natural resources sector represented about 3.4% of the employed workforce (StatCan, 2021a), while the *environmental and clean technology* (ECT) sector represented about 1.8% (StatCan, 2020a).[13] Notably, jobs in the natural resources sector tend to have higher average wages than jobs in the ECT sector, although both are higher than the Canadian average. In 2019, the average wage in the ECT sector was $75,816 (StatCan, 2021b), compared to $96,280 in the natural resources sector (StatCan, 2021a). The average salary in the Canadian economy in 2019 was $56,783 (StatCan, 2021a, 2021b). However, salaries vary widely within both sectors, by job type and by geographical region, as well as by demographic factors such as gender and immigration status (StatCan, 2021a, 2021b).

13 "Environmental and clean technology is defined as any process, product or service that reduces environmental impacts through any of the following three strategies: environmental protection activities that prevent, reduce or eliminate pollution or any other degradation of the environment; resource management activities that result in the more efficient use of natural resources, thus safeguarding against their depletion; or the use of goods that have been adapted to be significantly less energy or resource intensive than the industry standard" (StatCan, 2020a).

An analysis by the International Labour Organization (2018) found that a CE is likely to create the greatest job growth in the renewable resource and waste sectors; the industries with the highest expected growth rates include the reprocessing of metals, wood materials, and solar panels. Notably, Canada is well positioned to achieve job growth in the reprocessing of secondary metals (IISD, 2018a), and Canada produces 14 of the 19 metals required for solar panels (ISED, 2018). By contrast, the industries set to experience the greatest job losses include metal and mineral mining, and fossil fuel extraction and processing (ILO, 2018), which also employ a significant number of people in Canada (NRCan, 2019b). However, because raw materials will be needed to meet the growing demand for renewable energy (Section 2.4.2), the labour market for metals in Canada may be more affected by global demand than domestic demand.

While there is currently a lack of studies examining the impact of a CE on the labour market in Canada, some preliminary research does exist. For example, a 2014 study found that increasing the waste diversion rate in Ontario from 23 to 60% would create nearly 13,000 full-time jobs in the province (Knowles & Gill, 2014). Research has also found that waste diversion programs in Ontario can create ten times more jobs than waste disposal, and that seven jobs are created per every 1,000 tonnes of waste diverted (MECC, 2017). Nationally, the demand for jobs associated with the reduction and diversion of waste could benefit from the Canada-wide targets for waste reduction set by the CCME in 2018: a reduction of per capita waste of 30% by 2030 and 50% by 2040 (CCME, 2018b).

The current growth in demand in Canada's ECT jobs will be amplified by circular approaches.

Canada's ECT sector accounts for approximately 3% of Canada's GDP and includes world-leading firms. As noted above, the ECT sector employed about 1.8% of Canada's employed workforce in 2019 (StatCan, 2020a). The global transition to a more resource-efficient economy may result in job growth in the clean technology sector due to increased demand for more environmentally sustainable solutions in industry and more resource-efficient goods and services (Thirgood *et al*., 2017). However, a 2019 survey of clean technology employers in Canada found that there may be a shortage of available labour in the sector, with some employers struggling to fill jobs (ECO Canada, 2020). The survey emphasized the need for cross-sectoral collaboration among industry, government, and academia to ensure a sufficient supply of qualified workers to meet the growing labour demands of the sector (ECO Canada, 2020).

6.3 Opportunities for Economic Growth

The CE can have a positive impact on economic growth and GDP, and provides opportunities for new ways of conceiving of well-being.

Analyses of the CE in EU countries have found that several CE-related indicators — including environmental tax revenues, the recycling rate of municipal waste, resource productivity, circular material use, and trade in recyclable raw materials — positively correlated to increased economic growth, measured in terms of GDP per capita (Busu & Trica, 2019; Hysa *et al.*, 2020). The respective studies differed slightly regarding which variables had the most significant impact on GDP per capita, but both found the recycling rate of municipal waste to be highly significant. In addition, Hysa *et al.* (2020) found that the level of environmental tax revenue had a significant impact and Busu and Trica (2019) found resource productivity to have a significant impact. Furthermore, modelling and analysis by the International Resource Panel (2019) have identified a CE-like sustainability scenario in which GDP per capita is projected to almost double by 2060 in high-income countries that are net exporters of natural resources (Section 6.4).

However, it is important to note that measuring the impact of the CE in terms of GDP may not be ideal (Section 2.3). While GDP is perhaps the most frequently cited and influential economic indicator currently in use, and is often taken as a measure of overall economic health and general well-being, it fails to capture many negative externalities, such as environmental degradation due to economic growth (IISD, 2018b). Indeed, the growth of the global material footprint and GHG emissions are strongly correlated with growth in GDP (Strand *et al.*, 2021). Thus, although the CE seems likely to positively affect GDP, the transition towards a CE also provides a potentially more important opportunity to adopt alternative conceptions of national wealth that take other relevant factors into account. For example, the International Institute for Sustainable Development has suggested that Canada should assess *comprehensive wealth* — a measure of sustainable well-being that takes into account natural, human, and social capital — as a complement to GDP (IISD, 2018b). Furthermore, the European Environmental Agency has suggested that the limits of the CE's ability to decouple resource consumption from economic growth may require adopting alternatives to traditional conceptions of economic growth, such as degrowth, post-growth, green growth, and doughnut economics (Strand *et al.*, 2021). The Panel's model could be used to explore the implications of changes in GDP values on material flows.

6.4 Opportunities for a More Socio-Economically Equitable Society

A transition towards a CE could improve socio-economic equity if a just transition framework is applied.

The transition towards a CE provides an opportunity for Canada to address some of the socio-economic inequalities associated with the linear economy. While a transition towards a CE does not guarantee a more equitable society, it provides an opportunity to achieve broad societal benefits such as poverty reduction, employment, and human well-being. For example, a European study found that implementation of a particular circular framework could significantly lower household costs for housing, transportation, and food, while providing additional benefits such as reducing traffic congestion and producing healthy food locally through urban farming (EMF, 2015a).

In order to succeed, the transition towards a CE needs to equitably distribute its benefits (and risks) throughout society. The concept of a just transition has begun to be widely applied in national and international approaches to climate change and the low-carbon energy transition, such as in the Paris Agreement (Schröder, 2020). When applied to the CE, a just transition approach "can identify opportunities that reduce waste and stimulate product innovation, while at the same time contributing positively to sustainable human development." Policies to implement such a transition will need to consider the potential negative social impacts of the transition towards a CE (e.g., job losses) on vulnerable sectors, regions, communities, and individuals, and include appropriate protections. For example, policies to incentivize job creation in industries such as repair, recycling, and remanufacturing could help to offset job losses in sectors that may be negatively affected by the transition towards a CE (Schröder, 2020). However, new jobs created by such policies may not be located in the same regions in which old jobs are lost (Conway, n.d.). Other support mechanisms include skills training and early retirement plans (Conway, n.d.).

Governments can support a CE by creating just transition funds to provide economic assistance to communities and industries that are negatively affected by the transition towards a CE and to help scale up CE transitions in communities (Schröder, 2020). For example, the EU has proposed the creation of a €7.5 billion fund as part of its proposed Just Transition Mechanism, which provides support to regions to ameliorate the negative socio-economic impacts of the transition to a sustainable and climate-neutral economy (EC, 2020a). Whereas the fund will primarily provide grants, the mechanism includes an InvestEU scheme to attract private investment and a public sector loan facility with the European Investment Bank to support increased public sector investment (EC, 2020a).

Inclusive, collaborative processes can help to ensure a just transition.

Multi-stakeholder collaboration and inclusive planning processes will be needed in order to ensure that the transition towards a CE is just. Such processes can help to identify vulnerable sectors, regions, and communities, and create social support for the transition towards a CE (Schröder, 2020). Identifying the industries and regions most likely to experience major changes allows for early dialogues that can help to prepare for the transition. Participatory roadmapping (Section 8.1) helps to identify social and economic impacts and develop ways to collaborate both domestically and internationally (Schröder, 2020). Consultation and collaboration have been prominent in Quebec's approach to advancing the CE; for example, the multisectoral roundtable Pôle québécois de concertation sur l'économie circulaire, formed in 2015 to advance the implementation of a CE, is composed of stakeholders from provincial and local governments, non-profit organizations, industry associations, the financial services sector, academia, and civil society (Jagou, 2021).

A just transition calls for countries to live within their equitable share of planetary boundaries and resources.

Importantly, a just transition towards a CE encompasses more than support for workers and communities that are impacted by the transition. Insofar as the CE seeks to limit material consumption to within planetary boundaries (Section 2.1), a just transition also requires a more equitable division of planetary resources. A global transition towards a CE could itself help to address existing inequities. Modelling by the International Resource Panel (2019) has found that policies promoting increased resource efficiency and sustainable production and consumption would result in a more equitable distribution of income and resource use across countries due to larger rates of economic growth in low- and middle-income countries (11%) compared to high-income countries (4%). It also found absolute reductions in domestic material consumption in high-income countries compared to slower growth rates in low- and medium-income countries. As noted in Section 3.3, Canadian material and energy consumption per capita are currently among the highest in the world.

Frameworks for translating planetary boundaries into national or regional policy targets have been developed. For example, Häyhä *et al.* (2016) offer a framework that includes three dimensions — (i) a biophysical dimension that focuses on the impacts of human-environment interaction at different geographical scales, (ii) a socio-economic dimension that focuses on the impacts of production and consumption patterns on the environment, and (iii) an ethical dimension that focuses on issues of equity and justice — and identifies analytical tools to assess and operationalize these dimensions.

6.5 Opportunities for Canada's Natural Resources Sector

Sustainable production and consumption practices benefit Canada's natural resources sector.

Although a relative reduction in demand for primary natural resources is generally expected to occur with the transition towards a CE (OECD, 2018; Kettunen *et al.*, 2019), evidence suggests that implementing policies that promote increased resource efficiency and sustainable production and consumption provide economic, environmental, and social benefits for countries such as Canada. Modelling and analysis by the International Resource Panel (2019) identified a sustainability scenario that could achieve relative decoupling of resource use from economic growth (i.e., resource use increasing at a slower rate than economic activity) and absolute decoupling of environmental impacts from economic growth (environmental impacts decline while economic activity grows). This scenario projects that in high-income countries that are net exporters of natural resources, GDP per capita would almost double by 2060, with a significant decrease in per capita resource use (IRP, 2019). Moreover, this scenario does not include the full spectrum of CE policies, which could deliver even larger relative reductions in resource use (IRP, 2019).

However, the Panel notes that this scenario may be incompatible with the aims of a CE, which seeks an overall reduction in resource use, not simply a slower rate of increase. While the International Resource Panel's scenario shows absolute reductions in domestic material consumption in high-income countries such as Canada, material consumption would still increase globally, and resource extraction would increase both globally and in Canada. Although the scenario asserts that resource extraction can continue to rise in absolute terms while environmental impacts decline, this may fail as an approach to limiting consumption and production to within planetary boundaries, as per the definition of a CE (Section 2.1). It cannot be presumed that a growth model relying on ever-increasing resource use, as in the International Resource Panel's scenario, is environmentally or economically sustainable. Nevertheless, increased materials demand due to an increasing global population and improved standards of living may be unavoidable (see next Section).

A global CE would still require Canada's natural resource exports.

Even if the CE is implemented around the globe, there will still be an increasing demand for primary raw materials. Trends such as growing population and increased wealth, as well as increased digitalization and the transition to a low-carbon economy, will increase demand for raw materials in low-, middle-, and high-income countries (Kettunen *et al.*, 2019). Many countries transitioning

towards a CE will still require additions to their net stock of natural resources to meet consumption demands. In the EU, waste generation is far smaller than consumption for most commodities, meaning that even at 100% recycling rates of waste, there would still be a high demand for raw materials (Fellner *et al*., 2017). Indeed, even under the International Resource Panel's sustainability scenario, global resource extraction would still increase by 55%, from 92 billion tonnes in 2017 to 143 billion tonnes in 2060 (compared to 190 billion tonnes under the business-as-usual scenario) (IRP, 2019). However, the types of raw materials extracted would change under the sustainable scenario, with the greatest decreases in the extraction of fossil fuels and metal ores compared to historical trends (IRP, 2019). Notably however, this scenario does not consider the likely need for increased metal extraction for the clean energy transition.

As noted in Section 4.1.1, clean energy technologies are expected to significantly increase demand for certain minerals and metals in the coming decades, which recycling and reuse of metal and minerals will be unable to meet without a corresponding increase in raw material extraction (Hund *et al*., 2020). The Panel's model predicts that a transition to net-zero GHG emissions in Canada (Section 2.4.2) would result in a significant increase in the extraction of metal ores, representing an opportunity to continue growing Canada's mining and metals sector due to the relative abundance in Canada of metals and minerals that are required to produce renewable energy infrastructure (ISED, 2018) (Box 6.1). However, it will also be important to consider the potential environmental impacts of increased mining, including processing, transportation, use, and disposal of these materials. Further evaluations will be needed to assess if increased resource extraction is compatible with the definition of a CE (see above) and whether this extraction may exceed Canada's equitable share of planetary boundaries (Section 6.4).

Box 6.1 Aluminum, Clean Energy, and Canada

Aluminum is a key metal for the transition to clean energy; with its demand predicted to significantly increase over the coming decades (Hund *et al.*, 2020). Although Canada is the world's third-largest producer of aluminum (NRCan, 2019b), Canada imports all the bauxite ore it uses to produce aluminum (NRCan, 2021).

Because it is nearly infinitely recyclable, aluminum has been identified as a good candidate among metals to help advance a transition towards a CE (NRCan, 2021). Aluminum recycling in Canada would reduce dependence on bauxite and in turn reduce raw material requirements. Further incentives for aluminum recycling could stem from much lower GHG emissions associated with recycling compared to creating virgin aluminum (Nuss & Eckelman, 2014). Although recent investments have been made to develop zero-emissions technologies for bauxite processing (NRCan, 2019b), the high demand for primary aluminum is expected to have the highest GHG emissions among any of the minerals that are vital for clean energy technology (Hund *et al.*, 2020). This also provides opportunities for Canada to become a leader in aluminum production, as the aluminum produced domestically has the lowest carbon footprint among other large producers (NRCan, 2021).

However, even if recycling rates for end-of-life aluminum reached 100% by 2050, that would supply only 60% of the total demand required to meet the clean energy needs for a scenario in which global temperature increases are limited to 2°C (Hund *et al.*, 2020). Therefore, primary aluminum production will still be required to meet demand.

Opportunities may arise for Canada to become a leader in CE innovation among resource-exporting countries.

Despite the projections of continued increases in resource extraction, a CE is expected to produce a relative reduction in demand (compared to business-as-usual) for primary raw materials. As a result, a global shift towards a CE has the potential to adversely affect low- and middle-income countries that are economically reliant on natural resource exports to higher-income countries (Kettunen *et al.*, 2019; Schröder, 2020). While this could have positive environmental impacts in these low- and middle-income countries (due to a reduction in the environmental impacts of resource extraction), it would likely have negative economic impacts, potentially reducing the ability of such countries to meet several of their SDGs (Kettunen *et al.*, 2019). As a result, these countries may

require support from the international community to compensate for the reduction in exports and assist them in transitioning towards the CE (Geng *et al.*, 2019; Schröder, 2020). Canada could play an important role in assisting these countries in developing governance and financial innovations, given Canada's status as one of the "pioneers of eco-innovation among raw materials exporters" (Geng *et al.*, 2019). Such assistance could help these countries take advantage of opportunities identified by Kettunen *et al.* (2019) to grow their domestic markets for raw materials and facilitate the domestic development of higher-value downstream processing. This would also provide opportunities for Canada to become an international leader in exporting natural resource knowledge for a CE. Indeed, Canada has expertise in implementing sustainability practices in natural resources extraction (Deloitte, 2019b).

6.6 Opportunities to Meet Existing Policy Goals

A CE can help Canada meet GHG emissions reduction targets.

Transitioning towards a CE could help Canada achieve its goal of reducing anthropogenic GHG emissions and achieve its commitments under the 2016 Paris Agreement and the 2016 Pan-Canadian Framework on Climate Change and Clean Growth. Canada committed to reducing its GHG emissions by 30% below 2005 levels by 2030 under the Paris Agreement; however, projections published by the Government of Canada in December 2019 showed that the impact of the Pan-Canadian Framework would result in the reduction of emissions to only 19% below 2005 levels by 2030 (GC, 2020c). While current international commitments under the Paris Agreement will only achieve about half the progress necessary to limit the global temperature increase to 1.5°C by 2030, implementation of CE strategies that reduced global GHG emissions related to material use by 20 to 30% could reduce that gap by half (Ecofys & Circle Economy, n.d.). Similarly, an analysis of the CE in five European countries found that material efficiency policies could reduce carbon emissions by up to 10% and that energy efficiency and renewable energy policies could reduce carbon emissions by 30% and 50%, respectively. Moreover, implementing the three policy strategies together could result in emissions reductions of 70% (Wijkman & Skånberg, 2015). Such policies might be particularly important in economies with carbon-intensive energy sources (Cairns *et al.*, 2018).

Studies in the Canadian context have demonstrated that recycling and waste management strategies have already reduced GHG emissions in Canada and that additional measures, such as diverting organic waste from landfills, could help to further reduce emissions while also creating valuable products such as compost and biomethane (Cairns *et al*., 2018). A study that modelled the application of certain CE strategies in three industrial sectors in Quebec (iron/steel, cement/concrete, and aluminum) predicts direct reductions in emissions of CO_2 equivalent by 7.4 million tonnes (roughly equivalent to 10% of the province's GHG emissions), and indirect reductions of 9.7 million tonnes (Saunier *et al*., 2021). In 2020, the Government of Canada recommitted to meeting or exceeding the 2030 targets through various investments, including public transportation, enhancing carbon sequestration, and conducting a national infrastructure assessment to prioritize planning for a net-zero future. Once implemented, these measures could reduce projected emissions by an additional 85 million tonnes, or more than 30% below 2005 levels (GC, 2020c).

Transition towards a CE will contribute to meeting SDGs.

Several countries and jurisdictions — including the EU, the Netherlands, and Scotland — have explicitly indicated that they view actions on the CE as a way to meet their commitments to implement SDGs (Gov. of the NL, 2016; SG, 2016; EC, 2020b). Not only can the CE help to achieve SDGs, but working to achieve them also helps to promote the uptake of CE practices (Schroeder *et al*., 2018). Additional research may be required to determine the most relevant synergies between the CE and SDGs in the Canadian context. Schroeder *et al*. (2018) found that circular practices and business models directly contribute to meeting 21 of the 169 SDG targets and indirectly contribute to 28 other targets. For 35 targets, there was little or no relation to CE practices. Velenturf and Purnell (2021) also provide estimates of the contribution of the CE to SDGs (Figure 6.1). SDG 17 (Partnerships for the Goals) is also important to advance the global adoption of CE practices through cooperation and partnerships (Schroeder *et al*., 2018). Indeed, advancing the transition towards a CE will require multisectoral and international collaboration (Sections 7.4 and 8.2).

Source: Velenturf & Purnell (2021)

Figure 6.1 Relationship Between CE and SDG targets

The CE may contribute to 16 out of the 17 SDGs set by the UN. Combining literature reviews and expert judgment, Velenturf and Purnell (2021) estimated the fraction of targets under each goal that would be strongly (red) and partially (orange) enabled by the implementation of CE measures. Globally, the CE has the potential to contribute the most to SDG 7 (affordable and clean energy), SDG 6 (clean water and sanitation), and SDG 12 (responsible consumption and production). The authors note that these estimates are global and will vary among countries.

It is unclear whether the CE could help Canada achieve its biodiversity goals.

In 2015, Canada adopted 19 national targets for biodiversity known as the 2020 Biodiversity Goals and Targets for Canada, which were developed jointly by federal, provincial, and territorial governments, Indigenous organizations and governments, and other stakeholders (ECCC, 2019c). These targets are intended to help meet Canada's international commitments as a party to the UN Strategic Plan for Biodiversity 2011–2020, also referred to as the Aichi Biodiversity Targets. To date, Canada's progress in achieving its national targets has been mixed (ECCC, 2019c); for example, Canada failed to achieve Target 1, conserving only 12.5% of the country's lands and freshwater by the end of 2020, as opposed to the target of 17% (Conservation 2020, n.d.).

A transition towards a CE in Canada could potentially help reduce biodiversity loss due to a reduction in resource extraction and processing, which is responsible for over 90% of global biodiversity loss and water stress (IRP, 2019). In addition, the EMF (2015b) suggests that the CE could help to address biodiversity loss by

increasing resilience in living systems. However, Buchmann-Duck and Beazley (2020) have argued that there is little scientific evidence demonstrating the benefits of CE for biodiversity. Similarly, CE was found to have a limited impact on biodiversity-related SDGs, such as SDG 14 (Life Below Water) and SDG 15 (Life on Land) (Velenturf & Purnell, 2021). Furthermore, certain circular strategies may risk unintentionally exacerbating biodiversity loss, particularly if they are not explicitly designed to be commensurate with biodiversity goals (Buchmann-Duck & Beazley, 2020). For example, policies promoting growth in the bioeconomy and bioenergy can have negative impacts on biodiversity (Eyvindson *et al.*, 2018; Di Fulvio *et al.*, 2019), as can the land-use requirements of the renewable energy infrastructure needed to power the CE (Buchmann-Duck & Beazley, 2020). Such issues raise the need for further research on the relationship between CE and biodiversity to identify potential benefits and harms (Buchmann-Duck & Beazley, 2020).

6.7 Opportunities Relating to Energy

Sustainable energy and energy efficiency have implications for material demand.

The CE offers an opportunity for Canada to transition to cleaner, more renewable forms of energy. However, the Panel notes that there may be an increase in material resources required to support this transition. As noted above, clean energy infrastructure is expected to increase demand for certain metals, and the energy-efficiency measures described below could increase the demand for certain construction materials, such as non-metallic minerals or biomass. Thus, it will be important to consider the trade-offs between different CE strategies (i.e., energy efficiency versus material efficiency).

Increasing energy efficiency may be important to a CE strategy for Canada.

Circular approaches seek to increase both material efficiency and energy efficiency. In Canada, the low cost of energy has presented a challenge to improving energy efficiency (Section 5.2), and Canada is one of the most energy-intensive economies in the world (Section 3.3). Thus, increasing energy efficiency could be a key component of Canada's CE strategy, given the significant potential for improvement in this area (Deloitte, 2019b). There are opportunities to realize energy reductions in several sectors with the right incentives, including buildings (-28%), transport (-25%), oil and gas extraction (-21%), and industry (-12%) (IEA, 2018). A focus on energy efficiency in Canada's CE strategy could also help to reduce emissions and increase employment. As noted above, Wijkman and

Skånberg (2015) found that a CE approach that included a 25% increase in energy efficiency was likely to cut carbon emissions by approximately 30% and have significant positive effects on employment. Similarly, a 2018 analysis found that implementing energy-efficiency measures could significantly boost employment and GDP while reducing GHG emissions (CEC/EC, 2018).

Efforts to improve energy efficiency can provide new opportunities for the construction sector to retrofit old buildings and implement other types of energy-efficiency improvements (Wijkman & Skånberg, 2015). Such upgrades are included in the energy efficiency measures proposed by Clean Energy Canada and Efficiency Canada (2018). In addition, there are opportunities to increase energy efficiency in Canada through circular strategies such as wood-based building designs that are more energy efficient than traditional buildings (Kellam *et al.*, 2020) (Section 4.1.4). The federal government has taken some recent steps to improve energy efficiency in the Pan-Canadian Framework on Clean Growth and Climate Change, such as developing new building codes that promote energy efficiency (with the goal of net-zero building codes in all provinces and territories by 2030), as well as retrofitting existing buildings, developing new energy-efficiency standards for appliances and equipment, and improving industrial energy efficiency (DEC, 2018). Other policies that could help to improve energy efficiency include "white certificates", which certify a reduction of energy consumption and which can be traded on the market (Wijkman & Skånberg, 2015; Di Santo *et al.*, 2016). Opportunities also exist for energy companies to compensate for the reduced demand resulting from increased efficiency by pivoting to providing energy-efficiency services (Wijkman & Skånberg, 2015).

A 2017 analysis found that the implementation of CE practices could reduce global industrial energy use associated with the production of goods and services by 6 to 11% (Cooper *et al.*, 2017). This is slightly more than the energy savings predicted to accrue from global industrial energy efficiency (5 to 8%) (IEA, 2007). Most of these energy savings are embodied in goods and services, whether these act as inputs to other industries or meet final consumer demands (Cooper *et al.*, 2017). Notably, because of international trade, the reduction in energy use that results from applying these CE approaches will often occur outside of the region in which those strategies are implemented (Cooper *et al.*, 2017).

It will also be important to ensure that improvements in energy efficiency do not result in a rebound effect (Sections 2.2 and 5.6), wherein increased energy efficiency leads to an increase in energy consumption due to an overall reduction in energy costs. However, research suggests that a rebound effect is unlikely to reverse the gains of increased energy efficiency (Gillingham *et al.*, 2015).

A CE provides opportunities for Canada to increase its share of renewable energy sources.

One of the key principles of a CE is transitioning away from non-renewable sources of energy such as fossil fuels and towards renewable energy sources (EMF, 2015b). Canada's reliance on non-renewable energy (Section 3.3) tethers the country to a linear economic model, despite existing and potential improvements to energy efficiency (Deloitte, 2019b). However, there are significant opportunities for Canada to increase its production of renewable energy, drawing on sources such as wind, moving waters, biomass, solar, and geothermal. The Canada Energy Regulator has estimated that demand for renewable energy sources could grow by 45% between 2019 and 2050 if actions to reduce GHG emissions in energy systems in Canada and around the world continue according to recent historical trends (CER, 2020). Experts have also suggested that the transition towards a CE in Canada could be accelerated by supporting renewable energy-based district heating systems (Deloitte, 2019b; Kellam *et al.*, 2020).

Some waste-to-energy practices play a role in a CE.

There are also opportunities for Canada to increase its use of waste-to-energy. A case study analysis found that energy recovered from waste (via incineration and anaerobic digestion) can provide approximately 50% of the energy required to power an integrated waste management system in an EU city of 790,000 citizens over a 12-year period while still meeting all EU material recovery targets (Tomić & Schneider, 2018). Moreover, waste-to-energy was found to increase the sustainability of recycled materials via a decrease in the use of primary energy sources in recycling processes (Tomić & Schneider, 2018). However, the role of waste-to-energy as part of a CE is unclear (Section 2.2) and decision-making would benefit from life-cycle analysis assessment to weigh the negative impacts versus the purported benefits (EC, 2017a).

6.8 COVID-19 Recovery and Increasing Resilience

COVID-19 recovery provides an opportunity to move away from a linear economic model.

The COVID-19 pandemic has highlighted some of the limits and challenges of the traditional linear economy (Dufourmont *et al.*, 2020; EMF, 2020b). For example, it has demonstrated some of the risks of global supply chains and the value of local supply chains (EMF, 2020b). Furthermore, the COVID-19 pandemic may have exacerbated waste problems in the short term, particularly in the plastics sector. The use of disposable, single-use plastic products and packaging has increased

dramatically, and the significant reduction in oil prices has made virgin plastics even cheaper relative to recycled materials (ECCC, 2020a). In addition, the pandemic has set back progress on some aspects of the CE due to its negative effects on shared-use business models. For example, the pandemic has had a negative impact on the shared mobility industry, which decreased in 2020 due to lockdowns and concerns about social distancing and the virus (Audenhove *et al.*, 2020; movmi, 2020).

However, a transition towards a CE provides an opportunity to "build forward better" (Galvez, 2020), creating a more sustainable and equitable economy. Policies for the pandemic recovery that are based on CE principles not only help to ensure a resilient economic recovery but also achieve environmental and social policy objectives in both the short and long terms (EMF, 2020b). Indeed, research by the European Central Bank, the World Bank, and the OECD found that countries with stronger environmental protections tend to recover faster from economic recessions than countries with lower levels of environmental protection (Schnabel, 2020). Unlike many other countries, Canada has taken some steps to include sustainability measures in its stimulus package (GIM, 2021), providing a foundation for further progress. Recommendations for a sustainable and equitable COVID-19 recovery that include a focus on a CE have been produced by a member of the Senate of Canada (Galvez, 2020). Some jurisdictions that had already committed to transitioning towards a CE have used COVID-19 as an opportunity to reinforce that commitment; for example, the EU has indicated that the CE will be an important part of their COVID-19 recovery plan (Sinkevičius, 2020).

Incorporating CE principles into COVID-19 recovery increases resiliency.

The transition towards a CE also provides opportunities to increase social, environmental, and economic *resiliency*, i.e., "the ability of a system to recover from a shock, such as an economic crisis or a natural disaster" (Dufourmont *et al.*, 2020). CE strategies that help to increase resiliency at the organizational and societal levels include increasing resource efficiency, reducing the use of virgin materials in favour of secondary recycled materials, increasing the use of shared resources, decentralizing decision-making and governance, developing a workforce with transferable skills, encouraging a culture of lifelong learning, and promoting sustainable culture and institutions. For example, reducing the use of virgin materials in production processes in favour of recycled secondary materials increases the resiliency of a system by diversifying the feedstock of production

inputs and mitigates risks related to price volatility and supply uncertainty of raw materials. Indeed, the resiliency of a system will increase along with the number of feedback loops across the value chain, including repair, reuse, refurbishment, remanufacturing, and recycling (Dufourmont *et al.*, 2020). However, under certain conditions, some CE approaches could also reduce the resiliency of systems. For example, reducing resource use and waste creates more efficient production systems and reduces dependency on global supply chains but may also leave a system more vulnerable to supply chain interruptions and less redundancy to deal with unforeseen events. Thus, the transition towards a CE will need to strike a balance between efficiency and redundancy (Dufourmont *et al.*, 2020).

In Quebec, the Synergie Québec industrial symbiosis program led by CTTÉI (Section 4.3) is an important tool for increased resiliency due to the implementation of circular strategies. It has also been critical in helping to quickly develop supply chains for pandemic-essential products such as disinfectants (CTTÉI, 2020).

Circular strategies for COVID-19 recovery will require long-term thinking and sector-specific support.

Implementing a CE as a part of COVID-19 recovery will require focusing on long-term goals, not merely immediate-term stimulus (EMF, 2020b). Short-term spending on sustainable infrastructure investments can turn the COVID-19 pandemic into an opportunity for long-term improvements in environmental sustainability as well as community equity and resilience (CCUNESCO, 2020). The EMF (2020b) has identified CE investment opportunities that can help to enable a sustainable and resilient COVID-19 recovery in sectors such as construction, mobility systems, plastic packaging, fashion, and food. Many of these focus on infrastructure that enables recycling, refurbishment, remanufacturing, repair, and reuse in these sectors. Moreover, government support for local repair, refurbishments, and remanufacturing capacity supports the transition towards a CE and develops local supply chains while simultaneously enhancing local economic development (EMF, 2020b).

7

Levers for Change Towards a CE

7.1 Economic Instruments and Policies

7.2 Innovation

7.3 Public Awareness, Education, and Skills Training

7.4 Trade and International Relations

7.5 Extended Producer Responsibility Programs

Chapter Findings

- The transition towards a CE will require significant financial investments. In addition to private investment, public financial incentives — such as tax policies, disposal fees, transfer payments, and procurement — are needed to support and enhance circular supply and business models.
- New technologies, improved product design, eco-labelling, and the development of CE standards and certifications are key to enabling the transition towards a CE.
- Awareness campaigns, educational curricula that incorporate CE principles, and skills training or retraining for workers will help the public engage with the CE.
- Trade is an essential consideration in supporting a transition towards a CE both domestically and globally, given current globalized systems of production and consumption. As a relatively small player in many global value chains, Canada's CE approach would benefit from coordination with international initiatives.
- EPR programs are a widely used policy lever that can theoretically help to advance a CE. However, existing EPR programs in Canada are often narrow, fragmented, and underdeveloped, leading to limited effectiveness in practice.

This chapter identifies and describes some of the levers that can help to advance the transition towards a CE in Canada. These levers include economic instruments such as: (i) public and private sector finance, tax policy, and circular procurement; (ii) innovation in a wide variety of areas, including technology, production processes and business models, design and labelling, and standards and certifications; (iii) increasing public awareness of the CE, as well as education and skills training to support the transition; and (iv) trade policy and international relations. Importantly, policies will need to be developed in an integrated manner that aims for coherence, given the systemic and interconnected nature of the transition towards a CE (EMF, 2021). In Canada, such integration calls for all levels of government to collaborate.

7.1 Economic Instruments and Policies

Economic instruments and policies are among the most important levers that governments have to advance the CE. These include direct investments in CE projects and activities, financial regulation, tax incentives, pricing externalities through mechanisms such as disposal fees, transfer payments, and public procurement. More research may be needed to assess the relative contribution of these economic levers. Significant private sector investments will also be required to advance the CE. Currently however, most financial services are designed for the economic growth of a linear economy (UNEP FI, 2020).

7.1.1 Investing in a CE

Growing interest in financing the CE provides opportunities for impact investing and to address environmental, social, and governance issues.

Environmental, social, and governance (ESG) issues have become major considerations in the financial services sector. Investments in a CE provide an opportunity for financial institutions to address those issues (EMF, 2020a) and a means to implement voluntary industry frameworks that promote ESG principles, such as the UN-supported Principles for Responsible Investment and Principles for Responsible Banking (UNEP FI, 2020). The CE may also provide opportunities for impact investors; moreover, it has been suggested that the CE can unite ESG and impact investing, as investments in closed-loop business models more accurately reflect ESG-related risks and opportunities while also producing positive environmental impacts (Freedman, 2017).[14] At present, however, awareness and consideration of the CE among impact investors may be relatively limited. A recent survey of impact investors found that fewer than 6% of respondents targeted CE themes, although more than 40% targeted responsible consumption and production (GIIN, 2019). Furthermore, it will also be important for investors to consider just transition principles (Section 6.4) in financing the move towards a CE to ensure that the benefits and risks of the transition are equitably distributed (Schröder, 2020). Just transition investment principles applied to a CE could potentially be adapted from similar principles developed in the context of climate change (Schröder, 2020).

14 ESG investing attempts to incorporate environmental, social, and governance factors into investment decision-making for the purpose of accurately pricing all relevant financial risks and opportunities. By contrast, impact investing explicitly attempts to produce positive environmental and social impacts through investments while also generating a return (Freedman, 2017).

Private finance is needed to support companies and industries transitioning to a CE.

A variety of actors in private finance, including investors, banks, and other financial services firms, are needed to scale up the CE market and support companies and industries in the transition towards a CE (EMF, 2020a). Private equity and venture capital firms can invest in scaling up innovation for the CE; banks can offer new products and services to assist businesses in transitioning to circular practices; investors can direct capital towards circular companies; and financial markets can more accurately price the risks associated with the linear economy (EMF, 2020a).

CE-related activities in the financial services sector have increased dramatically over the last several years. For example, around the world, the number of public equity funds investing in the CE grew from one in 2018 to ten by mid-2020, and they include some of the world's largest financial asset managers (EMF, 2020a). Similarly, the number of corporate bonds with a CE focus grew from zero in 2018 to ten by mid-2020, with a value of over US$10 billion and leading investment banks are involved. Early-stage and growth-stage investing in CE companies has also accelerated, with the number of private market funds with a CE focus — including venture capital, private equity, and private debt funds — growing from three in 2016 to thirty in mid-2020. There has also been a significant rise in bank lending, project finance, and insurance for CE-related activities, as well as a rise in private and blended finance instruments to fund infrastructure for the CE (EMF, 2020a). Interest in the CE is also increasing among institutional investors (CCFG, n.d.). For example, PGGM, the second-largest pension fund in the Netherlands, has incorporated CE principles in its investment strategies (Burckart & Butterworth, 2017).

Financial institutions in Canada have also begun to show interest in the CE. In 2014, TD Bank donated $1 million for the creation of the Institut EDDEC at the Université de Montréal (Jagou, 2021). In 2021, the investment fund Fondaction, in collaboration with RECYC-QUÉBEC and the City of Montréal, announced a $30-million investment fund for the CE to support sectors that proved to be critical during the COVID-19 pandemic (RECYC-QUÉBEC, 2021a). In 2020, Desjardins announced a $2.1-million contribution to the ÉTS for the development of an ecosystem of sectoral acceleration laboratories for the CE (ÉTS, 2020b; Jagou, 2021).

Public sector investments and government regulation of the financial sector have an essential role to play in the transition towards a CE.

It is unlikely that voluntary initiatives on the part of private financial institutions will be sufficient to enable the transition towards a CE without government intervention (Dewick *et al.*, 2020). In addition to providing direct public investment in CE projects, infrastructure, and innovation, governments also help to attract private capital to invest in CE projects and companies. They can reform policies and regulatory frameworks to drive the transition in the private sector (EMF, 2020a) and reduce or remove barriers to private investment in the CE (SPI, 2020b). The transition towards a CE may also be accelerated through government interventions to integrate circularity considerations in financial regulation, risk assessment, and modelling, as well as through less conventional measures such as green quantitative easing (EMF, 2020a).

In addition to providing public investments through grants and loans, governments can attract private capital for the CE by making circular business models more attractive to investors through tax credits for capital investments, funding models based on risk-pooling, and green bonds (SPI, 2020b). The development of regulatory frameworks for the financial sector is also an important lever to advance the transition towards a CE, including monitoring of market practices, investments, and lending that set long-term incentives for circularity (Dewick *et al.*, 2020; EMF, 2020a). For example, financial regulators and central banks could require that CE be considered as part of the identification of financial risks in scenario analyses (EMF, 2020a). Governments could increase transparency for investors by imposing requirements for mandatory disclosure of CE practices and "linear risks," among other actions, such as regulating standardized definitions and metrics for CE activities (Dewick *et al.*, 2020; EMF, 2020a). These types of measures would help to prevent the "greenwashing" of circular finance products and help investors to more accurately price CE-related risks and benefits (Dewick *et al.*, 2020).

In addition, governments have an important role to play in directly funding CE companies and projects, providing financial support for businesses and initiatives that are unable to attract private investors (Kirchherr *et al.*, 2017) and investing in circular activities, infrastructure, and innovation (EMF, 2020a). One prominent example in Canada comes from RECYC-QUÉBEC, which has provided financial support to a wide variety of CE projects and companies (RECYC-QUÉBEC, 2021a). There are currently no financial support programs at the federal level in Canada that explicitly support innovation for the CE. Rather, such programs currently focus on carbon reduction and net-zero targets and are thus currently missing the opportunity to take advantage of the contributions of the CE to meet these goals (SPI, 2020b).

Governments can also help to reduce economic uncertainty for businesses and investors by de-risking the transition process (ECCC, 2019b). For example, governments could backstop private sector recycling programs to ensure that certain types of materials are recycled even if shifts in material commodity prices mean that doing so is not profitable. Governments could provide support for circular R&D (Section 7.2) by de-risking the commercialization stages of innovation (SPI, 2020b). Public finance also plays a crucial role in investing in infrastructure to support the transition towards a CE (EMF, 2020a). Indeed, a lack of CE-supporting infrastructure is a challenge for implementing circular approaches in Canada, particularly in rural or remote parts of the country (Section 5.1). To spur the development of CE-friendly infrastructure, federal, territorial, and provincial governments could include criteria around waste reduction and recycling in their decision-making processes when providing funding for capital investments and operating costs for municipal environmental infrastructure (e.g., water treatment and waste management) (Monahan, 2018).

Central banks can also support the transition towards a CE by developing and participating in platforms such as the Network for Greening the Financial System, a network of central banks and financial supervisors that collaborate and share best practices on the environment and climate risk management in the financial system (NGFS, n.d.), and the Financial Stability Board's Task Force on Climate-Related Financial Disclosures, which gives recommendations to increase market transparency and stability through more effective disclosure requirements (TCFD, 2017).

Blended finance and public–private partnerships are useful for funding infrastructure, innovation, and riskier CE projects that are in the public interest.

Blended public–private financing can help to attract investment for riskier or more challenging CE projects and infrastructure, in addition to supporting longer-term innovation (EMF, 2020a). One example of blended finance for the CE is the European Investment Bank's funding for medium- to high-risk CE projects through initiatives such as the European Fund for Strategic Investments and InnovFin, with opportunities to combine this funding with EU grants (EIB, n.d.). In Canada, the newly formed Canada Infrastructure Bank (CIB) could potentially play a similar role by funding and attracting private capital to CE-enabling infrastructure projects that are in the public interest. Indeed, green infrastructure is already one of the CIBs priority areas (CIB, n.d.), and a CE-specific focus could be added as an additional priority area. Canada also has several existing initiatives supporting innovation in the clean technology sector that could be adapted to include a greater focus on facilitating the development of technology-based

circular strategies. For example, Sustainable Development Technology Canada (SDTC) provides financial support for the development and demonstration of clean technology projects. As of 2020, SDTC had provided nearly $1.3 billion in funding to 447 projects and leveraged an additional $3.2 billion in public and private sector investment (SDTC, 2021). In Quebec, RECYC-QUÉBEC's partnership with Fondaction and the City of Montréal (RECYC-QUÉBEC, 2021a) is an example of multi-sectoral collaboration that aims to finance the CE.

7.1.2 Tax Policy

Tax policies that target pollution and consumption of non-renewable resources advance the transition towards a CE.

Shifting taxes away from taxing labour (which includes personal income tax, payroll taxes, and social security contributions) and towards taxing pollution and consumption of non-renewable resources can accelerate the transition towards a CE (Stahel, 2013; Wijkman & Skånberg, 2015; ACCA, 2018). The OECD, International Monetary Fund, World Bank, European Commission, and International Labour Organization have all endorsed shifting taxes away from labour and towards the consumption and use of resources (ACCA, 2018; SPI, 2020b).

Currently, taxes on labour are the largest source of tax revenue in most industrialized countries (Wijkman & Skånberg, 2015; ACCA, 2018). Across OECD countries, over 52% of tax revenue comes from labour (ACCA, 2018). Environmental taxes in Canada accounted for only 3.6% of total tax revenue in 2019, compared to an average of 5% across the OECD (CYC, n.d.). Indeed, environmental taxation is relatively rare in Canada, with the exception of the recent national carbon pricing system (Monahan, 2018; SPI, 2020b). Canada has the third-lowest environmental pricing revenue in the OECD, at 1.1% of GDP in 2014 (OECD, 2017). Furthermore, existing tax incentives in Canada have generally favoured the use of primary materials over secondary ones (SPI, 2020b), further disadvantaging circular business models and practices.

Shifting away from taxing labour supports a transition towards a CE because a CE is more labour intensive than the linear economy due to its prioritization of maintenance, repair, upgrading, remanufacturing, and recycling. By contrast, the traditional linear economic focus on resource extraction and manufacturing is less labour intensive, and often relies on automation and robotics (Wijkman & Skånberg, 2015). Shifting away from taxing labour also helps to boost job creation and employment, including jobs related to local renewable natural resources (Stahel, 2013). It may also help to provide "meaningful employment opportunities

for 'silver workers', people beyond the traditional age of retirement," due to the knowledge needed to repair older infrastructure and equipment (Stahel, 2013), thereby potentially helping to support a just transition towards a CE for workers for whom reskilling is not practical.

Taxing non-renewable resource consumption provides financial incentives to minimize the use of resources, reduce waste, and promote water and energy savings, thereby increasing the competitive advantage of firms that adopt circular business practices (Stahel, 2013). Taxes on the consumption of non-renewable resources could be structured similarly to a value-added tax (Stahel, 2013). Goods made with secondary materials could be exempt from a value-added tax (as it will have already been paid once), thereby incentivizing uptake of products with recycled or repurposed content (Wijkman & Skånberg, 2015). This type of tax policy can also be used to incentivize repair, reuse, and recycling. For example, Sweden has reduced the rate of their value-added tax from 25 to 12% for repairs to a range of products, as well as allowing income tax deductions for the labour costs of appliance repair (Sorrell, 2016), and the EU has indicated support for similar measures in its 2020 CE Action Plan (EC, 2020c).

Economic modelling has found that shifting 13% of the EU's labour taxes to natural resources and consumption over a five-year period could increase GDP by 2% and reduce carbon emissions by 8.2%, while increasing employment and reducing natural resource use (Groothuis, 2016). Shifting taxes away from labour and towards the consumption of non-renewable resources also leads to higher material efficiency, as it provides a financial incentive for the remanufacturing of worn components instead of manufacturing new ones from virgin materials (Stahel, 2013). Moreover, shifting taxes in this way could also help to address the current situation wherein manufacturers often pay less for virgin materials than recycled equivalents by reducing the high costs of labour associated with sorting materials for recycling while simultaneously increasing the cost of primary materials (Stahel, 2013).

7.1.3 Disposal Fees

Fees on waste disposal provide financial incentives to adopt circular practices.

Canada's low disposal fees present a challenge to the implementation of the CE (Section 5.2). Current fees in many Canadian jurisdictions do not cover the full costs of disposal, effectively creating a subsidy on waste generation. Indeed, the OECD (2017) has suggested that there is a need to increase Canada's low landfill

fees to reduce its high levels of per capita waste and stimulate reuse. Levying taxes or fees on the disposal of waste (both landfill and incineration) would help to advance the CE by providing financial incentives for waste prevention and waste recovery (SPI, 2020b). Such fees can also include variable pricing for different materials, such as those that are hazardous, bulky, or recyclable (Canada's Ecofiscal Commission, 2018) to reduce the current disparity between Canada's low disposal costs and high recycling costs (ECCC, 2019b). Higher disposal fees have been found to positively correlate with circular practices in international jurisdictions, such as reduced landfilling rates in European countries (EPRS, 2017).

Many municipalities in Canada have begun to adopt pay-as-you-throw programs that charge households for the amount of waste that they produce (Monahan, 2018; SPI, 2020b); however, most households in Canada lack financial incentives for reducing waste (Kelleher *et al.*, 2005). In the commercial sector (e.g., large buildings, institutions, industry), landfill fees are often based on weight or type of waste, but in most cases, the fee does not reflect the full costs of disposal (SPI, 2020b). Some provincial governments have begun to address this issue. For example, British Columbia "requires all regional districts to charge fees that reflect the full cost of the service" (Canada's Ecofiscal Commission, 2018), and Quebec is increasing disposal fees for organic waste (MELCC, 2020).

7.1.4 Transfer Payments

Another tool that could potentially be used by the federal government to advance the CE in Canada is transfer payments to provinces and/or municipalities that are conditional on undertaking certain CE activities or achieving certain CE outcomes. For example, the gas tax agreements negotiated in 2005–2006 among the federal government and the provinces/territories provided funding in sustainable infrastructure but imposed eligibility limits on the types of projects and expenses, mandated the development of community sustainability plans, and provided accountability measures (Boyd *et al.*, 2016). Such arrangements effectively helped to advance federal policy objectives in areas that were beyond the federal government's direct legislative reach and have been suggested as a mechanism to incentivize low-carbon infrastructure (Boyd *et al.*, 2016).

7.1.5 Circular Procurement

Public procurement is an important tool to advance the transition towards a CE.

Public procurement has been identified as one of the key policy interventions needed to support the transition towards a CE, as it creates demand for circular products and services with the goal of supporting and enhancing circular supply and circular business models (Wijkman & Skånberg, 2015; Jones *et al.*, 2018), and provides strong market signals to suppliers (UNEP, 2017). *Circular procurement* is "the process by which public authorities purchase works, goods or services that seek to contribute to closed energy and material loops within supply chains, whilst minimising, and in the best case avoiding, negative environmental impacts and waste creation across their whole life-cycle" (EC, 2017b). Similar to the waste disposal hierarchy of the three R's (reduce, reuse, recycle), circular procurement decisions can be prioritized based on four R's (reduce, reuse, recycle, and recover) (EC, 2017b).

Some countries, regions, and cities in the EU have included circular procurement as a key element of their CE transition strategies (EC, 2017b). In Canada, the city of Toronto developed a circular procurement implementation plan and framework in 2018 to "leverage the City of Toronto's purchasing power to drive waste reduction, economic growth, and social prosperity" (City of Toronto, 2018). Pilot projects began in 2018 and were expected to continue until 2020; at the beginning of the process circularity metrics were identified and were subsequently tracked throughout the pilot (City of Toronto, 2018). Target areas included "textiles and uniforms, food and catering services, office equipment, and information technology," which were identified based on their potential to reduce waste, and circular procurement best practices from international jurisdictions (City of Toronto, 2019b). The federal government has also identified public procurement as a tool to advance the transition towards a CE as part of its greening government strategy (GC, 2020c), and has included reducing waste and supporting reuse and recycling as considerations in the federal policy on Green Procurement (GC, 2018a). In addition, the Circular Innovation Council has launched an initiative to advance circular procurement in Canada that provides guidance and best practices, case studies and CE-friendly business models, a showcase of vendors and suppliers, and a platform for buyers to connect and share ideas and resources, as well as workshops for both the public and private sector (RCO, 2021; CIC, n.d.-c).

Incorporating circular practices and principles into infrastructure procurement can also help to significantly advance the CE because of the large volume of raw material and waste in the construction sector (Section 4.1.4). Circularity requirements could be incorporated into infrastructure funding agreements between the federal and provincial/territorial governments, similar to Infrastructure Canada's 2018 bilateral funding agreements with the provinces and territories, which subjects certain projects to a climate impact assessment (INFC, 2020a). Indeed, because investments in infrastructure often involve federal, provincial/territorial, and municipal governments, circular procurement for infrastructure may be a particularly powerful lever to advance the CE in Canada. Circular procurement practices have been used in several international jurisdictions for infrastructure and construction projects (see, e.g., Alhola *et al.*, 2018; Climate-KIC, 2019; BBI, 2020). These often include criteria relating to competence in design and site management practices that minimize construction and demolition waste, as well as requirements for the use of materials with recycled or reused content, such as concrete (Alhola *et al.*, 2018). Various organizations have identified promising practices (e.g., BBI, 2020) and challenges (e.g., Climate-KIC, 2019) related to circular procurement for infrastructure projects. Case studies on pilot projects from the Netherlands have found that circular procurement practices have "a major positive impact on cost, time and reliability when procuring construction materials" (Rijkswaterstaat, n.d.). Circular procurement for infrastructure arises in several stages, and can involve design, construction, purchasing products and equipment, deploying energy services, and more (MECC, 2017; as cited in Climate-KIC, 2019).

Best practices for circular procurement are already widely available.

The European Commission's guidelines for circular procurement target system, supplier, and product levels (Box 7.1). These guidelines also promote best practices to incorporate circular procurement in the public sector, such as starting with small pilot projects, focusing on "low-hanging fruit," and engaging in conversations with suppliers to set technical specifications (EC, 2017b). Best practices for sustainable procurement are further described in the Sustainable Public Procurement (SPP) Regions *Circular Procurement Best Practices Report*, which highlights three important modifications to current procurement practices to promote circularity: "(i) focus on service instead of products; (ii) focus on the product's design, use phase, and end of life; and (iii) focus on market dialogue" (Jones *et al.*, 2018). The inclusion of qualification-based procurement policies and processes to identify the best-qualified engineering firms may also help to facilitate life-cycle costing and produce more resilient infrastructure that better serves the public good (Engineers Canada, n.d.).

Box 7.1 Circular Procurement Models

System Level. The contractual methods a purchasing organization can use to ensure circularity:

- product–service system
- public–private partnership
- cooperation with other organizations on sharing and reuse
- rent/lease
- supplier take-back systems, including reuse, recycling, refurbishment, and remanufacturing

Supplier Level. How suppliers can build circularity into their products and processes to meet circular procurement criteria:

- supplier take-back system
- design for disassembly
- reparability of standard products
- external reuse/sale of products
- internal reuse of products

Product Level. The products that suppliers procure further down the supply chain:

- materials in the product can be identified
- products can be disassembled after use
- recyclable materials
- resource efficiency and total cost of ownership
- recycled materials

(EC, 2017b)

The inclusion of sustainability provisions in Canadian procurement is currently lacking.

To advance the transition towards a CE in Canada, governments at all levels could explicitly include independent criteria related to circularity in procurement requests for proposals. This would also require accountability mechanisms to ensure compliance. Canada's current approach to sustainable procurement offers some lessons in this regard. Sustainable procurement has become a priority across public institutions (MCSP, 2019) and is an important policy lever due to its ability to use existing purchasing power to support policy objectives and its relatively low cost (Da Ponte *et al.*, 2020). In Canada, government procurement accounted for 13.3% of national GDP in 2017 (OECD, 2019a), demonstrating the scale at which public procurement can affect environmental and social initiatives. However, the inclusion of sustainability as independent criteria in current procurement practices is relatively rare and lacks accountability mechanisms to ensure compliance (Da Ponte *et al.*, 2020) (Section 5.5).

The Quebec-based Espace de concertation sur les pratiques d'approvisionnement responsable (ECPAR) measures the progress of Canadian organizations in sustainable procurement across five categories (vision, policy and governance, stakeholder mobilization, operationalization, and assessment) (ECPAR, 2020). The 2020 report assessed 142 organizations, including businesses, government departments and organizations, municipalities, non-profits, and education network organizations. Overall, the report collectively ranked these organizations at two out of five, finding that, on average, they demonstrated a promising initial commitment to sustainable procurement but with significant room for improvement. Notably, the report found that sustainable procurement practices related to the CE were relatively uncommon across these organizations, with only 25% implementing practices that incorporate circular systems (ECPAR, 2020).

7.2 Innovation

Innovation is key to enabling the transition towards a CE in Canada. This includes the development and use of new technology; innovations in manufacturing processes, business models, and product design; and the development of new standards and certifications for circularity. Indeed, a CE may provide Canada with an opportunity to overcome some of the long-standing deficits in its innovation ecosystem (Section 5.3).

7.2.1 R&D for the CE

Canada currently lags other countries in terms of support for circular R&D (Section 5.3). Indeed, as a share of GDP, Canada's gross domestic expenditures on R&D (GERD) are significantly below the OECD average, as are private sector expenditures in R&D by business (BERD) (ISED, 2019). However, expenditures on R&D by universities (HERD) are consistently above the OECD average (ISED, 2019), and it may be possible to leverage Canada's relatively high public spending on R&D in higher education to advance the uptake of circular practices by private businesses, despite Canada's low level of private sector R&D investment. An analysis of EU countries by Garrido-Prada *et al.* (2021) found that increased investment in public R&D on environmental and energy issues in a country are positively correlated with an increased likelihood of SMEs implementing CE activities in that country. The authors argue that this effect is due to the generation of new, publicly available knowledge that allows SMEs to develop the capabilities needed to implement circular practices.

R&D to advance the CE could be facilitated by tax credits, targeted government funding, and partnerships among academia and industry (EMF, 2015b, 2021). One example of collaboration is Denmark's Rethink Resources, "a partnership between universities, technology centres, manufacturing companies, and the Danish Ministry of Environment [that] aims to support resource efficiency" through R&D focusing on product design, manufacturing processes, closed-loop practices, product life extension, and circular business models (EMF, 2015b). Canada's Resources for the Future Economic Strategy Table has recommended that Canada develop cross-sectoral innovation networks, led by industry and facilitated by the federal government, to accelerate the CE in specific resources sectors (ISED, 2018).

Ongoing R&D will be needed to continually advance the transition towards a CE (Deloitte, 2019b). However, in the view of the Panel, an excessive focus on the early stages of innovation can create barriers to the transition by delaying action. Indeed, a survey of businesses and government officials in the EU suggests that the transition towards the CE can be meaningfully advanced without waiting for time-consuming R&D (Kirchherr *et al.*, 2017) (Section 5.3). As such, it will be equally important to focus on the later stages of innovation, involving commercialization, diffusion, and uptake.

7.2.2 CE-enabling Technologies

While CE-related concepts have been discussed for decades, the recent development of new technologies provides new opportunities to implement the CE (Accenture Strategy, 2014). These technologies enable the circular design and logistics necessary to execute circular loops such as repair and sharing. Major new CE-enabling technologies include connected assets or the Internet of Things, artificial intelligence (AI), and 3D printing (EMF, 2019a). Advances in recycling, materials sciences, and modular design also improve businesses' ability to recover materials and adopt circular approaches (Accenture Strategy, 2014). Enabling technologies may be particularly important for the transition towards a CE to help overcome challenges related to Canada's large geographical size and the difficulty of implementing circular approaches in remote parts of the country. However, this will require addressing existing technological deficits in these areas, such as a lack of high-speed internet access (Section 5.1). Furthermore, Canada has strengths in some areas of innovation relevant to the CE, such as AI (e.g., CCA, 2018).

Intelligent assets such as Internet of Things technology can facilitate circular practices.

Connectivity facilitating remote monitoring and machine-to-machine communication allows components or systems to be automatically managed, reducing costs and the need for centralized infrastructure (Accenture Strategy, 2014). In particular, predictive maintenance can extend a product's lifespan (EMF, 2016). Connectivity allows for the effective optimization of transportation fleets and delivery routes (EMF, 2016), mitigating some of the challenges associated with Canada's dispersed population. Connectivity can also be used to inform customers of their options for returning products at end of life (Accenture Strategy, 2014) and provides companies with an improved assessment of the value of these returned assets with respect to options for reuse, refurbishment, or remanufacturing (EMF, 2016). Intelligent assets could also help to advance the CE by enabling the tracking and monitoring of natural capital (EMF, 2016), and be used to facilitate shared-use business models. However, these technologies will not be able to help advance the CE in rural and remote communities in Canada that lack connectivity to the internet. For more on connectivity in rural and remote communities see CCA (2021).

AI can accelerate circular design, PaaS, and waste sorting.

Canada has significant research capacity in the field of AI (CCA, 2018), a technology that presents an opportunity to advance the CE by enabling innovation in three ways (EMF, 2019a):

- creating new circular products, components, and materials through rapid prototyping and testing with machine learning-assisted design;
- applying AI in combination with real-time data to manage inventories and predict pricing, demand, and maintenance requirements, facilitating PaaS business models; and
- improving the ability to sort waste and disassemble products, which facilitates enhanced recycling and remanufacturing.

The use of AI to support circularity and unlock potential economic value has been demonstrated in agriculture and consumer electronics (EMF, 2019a). For example, the use of AI to design out food waste has the potential to generate up to US$127 billion a year in 2030, and similar benefits may be achieved in a wide variety of sectors (EMF, 2019a). However, to implement AI for the CE, the relevant data upon which it operates must be accessible, high-quality, and transparent, and privacy must be respected. This will require oversight as well as collaboration among stakeholders, including governments and NGOs (EMF, 2019a).

3D printing may help to increase resource efficiency and circular design.

Additive manufacturing, which includes 3D printing, has significant implications for resource efficiency and circular design. It supports the upcycling of plastic waste (Mejia *et al*., 2020) and facilitates repair through the on-demand production of replacement parts (Terzioglu, 2018). 3D printing also supports the CE by allowing local manufacturing of products from locally recycled materials (Garmulewicz *et al*., 2018). 3D printing could be beneficial for communities in rural and remote regions by providing easier access to products and replacement parts, and reducing the time and cost of shipping (The Guardian, 2016). In addition, the single-process nature of additive manufacturing simplifies the measurement of energy consumption in the manufacturing process (which is helpful for the life-cycle assessment of products), and minimizing costs in additive manufacturing is also likely to minimize energy consumption (Baumers *et al*., 2013). 3D printing could also help to enable design for circularity and create new opportunities for innovation and entrepreneurship in the CE (Despeisse *et al*., 2016). However, 3D printing also has the potential for some negative environmental impacts, such as the use of toxic materials for printing, and thus requires proper policies or standards to prevent these outcomes (Unruh, 2018).

7.2.3 Design and Labelling for Circularity

Eco-design requirements help to improve circularity.

Eco-design is "the process…of integrating environmental considerations into product design and development with [the] aim of reducing environmental impacts of products through the life cycle" (Charter, 2018). Eco-design aims to make products more durable and long-lasting; reduce energy, resources, and waste in their production process; and make them easier to reuse, repair, refurbish, remanufacture, or recycle (Charter, 2018; Deloitte, 2019b). Because the vast majority of a product's environmental impact is determined at the design stage, eco-design principles are essential to advancing the transition towards a CE (Charter, 2018). Table 7.1 lists some eco-design approaches that help to improve the circularity of products.

Governments can use regulatory requirements and standards to help advance the uptake of eco-design in the private sector (Teigeiro *et al.*, 2018). To be effective, such requirements need to take a life-cycle approach that includes the reuse phase; end-of-life collection systems; and design for disassembly, reparability, reusability, and recyclability (ECCC, 2020b). Eco-design requirements can also include minimums for recycled content in products and packaging (ECCC, 2020a). In Quebec, the provincial government has set a commitment to use eco-design requirements to incentivize a minimum of 15% recycled content in plastic packaging by 2024, as well as ensuring that 80% of plastic packaging and containers are recyclable under current systems (Gov. of QC, 2019). In 2005, the European Commission adopted a set of eco-design requirements for energy-related products, and the EU's 2020 Circular Economy Action Plan signalled its intent to extend the requirements to a broader range of products (EC, 2009, 2020c). Eco-design also has benefits for businesses (Section 6.1): it has been shown to have a positive or neutral effect on profits (Teigeiro *et al.*, 2018), and can potentially improve both customer satisfaction and loyalty and help companies create PaaS business models (Deloitte, 2019b).

Table 7.1 Design Options to Improve Product Circularity

Design Focus Area	Options for Design Improvement
Design for Material Sourcing	• Reduce weight and volume of product • Increase use of recycled materials to replace virgin materials • Increase use of renewable materials • Increase incorporation of used components • Use materials with lower embodied energy and/or water • Sourcing from certified suppliers*
Design for Manufacture	• Reduce energy consumption • Reduce water consumption • Reduce process waste • Use internally recovered or recycled materials from process waste • Reduce emissions to air, water, and soil during manufacturing • Reduce the number of parts • Use standardized elements*
Design for Transportation and Distribution	• Minimize product size and weight • Optimize shape and volume for maximum packaging density • Optimize transport and distribution in relation to fuel use and emissions • Optimize packaging to comply with regulations • Reduce embodied energy and water in packaging • Increase use of recycled materials in packaging • Increase use of recyclable materials in packaging* • Eliminate hazardous substances in packaging
Design for Use (including installation, maintenance, and repair)	• Reduce energy in use • Reduce water in use • Increase access to spare parts • Maximize ease of maintenance • Maximize ease of reuse and disassembly • Minimize time required for disassembly* • Avoid design aspects detrimental to reuse • Reduce energy used in disassembly • Reduce water used in disassembly • Reduce emissions to air, water, and soil • Maximize ease of materials recycling
Design for End of Life	• Avoid design aspects detrimental to materials recycling • Reduce amount of residual waste generated • Reduce energy used in materials recycling • Reduce water used in materials recycling • Design to facilitate parts harvesting*

Adapted with permission from Charter (2018)

Entries marked with an asterisk (*) are additions by the Expert Panel

Labelling requirements empower consumers to choose circular products.

Product labelling helps consumers to identify products that contribute to the CE and to understand end-of-life procedures for products. However, the impact of labels on consumers' preference for more circular products may be limited. Research suggests that although consumers often prefer products with eco-certified labels over uncertified products, the impact of eco-labelling is highly variable and depends upon factors related to "the individual consumer, the product, the labelling framework, and the context in which the label is applied" (Boyer *et al.*, 2020). Studies have shown that consumers are typically willing to pay more for products with low or moderate levels of circular content but that this willingness decreases as the proportion of recirculated content increases (Boyer *et al.*, 2020). Similarly, other studies have shown that consumers are inclined to pay less for remanufactured products than for new ones, but that this reverses when consumers are informed of the environmental impacts of new versus remanufactured products, due to a lower willingness to pay for new products (Michaud & Llerena, 2011).

Furthermore, in the view of the Panel, the use of labelling to incentivize individual consumers to purchase circular products is far less effective than a systems-level approach that seeks to ensure that all products available to consumers are designed for circularity. Nevertheless, labelling requirements provide useful information about the proper end-of-life treatment of products, which is essential in reverse loops for proper handling of toxic substances, facilitating sorting of materials, and avoiding contamination of recycling streams (EMF, 2013). Moreover, labelling helps support EPR schemes (Section 7.5) by raising public awareness and providing information to consumers about end-of-life treatment of products (OECD, 2016).

CE labelling has been adopted in several jurisdictions. For example, the EU has made some progress on labelling to support the CE through its Ecolabel initiative; however, these approaches have been limited in their effectiveness due to the fact that they are voluntary rather than mandatory (EC, 2020c). In Canada, labelling requirements are set out in the *Consumer Packaging and Labelling Act* (GC, 2019) and enforced by the Competition Bureau of Canada (Competition Bureau Canada, 2021). In 2008, the Canadian Standards Association, in partnership with the Competition Bureau, published compliance guidelines for environmental claims for industry and advertisers (CSA, 2008).

7.2.4 Standards and Certifications

The development and use of standards and certifications helps businesses implement circular approaches and strategies (Parida *et al.*, 2019) and complement government policy and legislation by operationalizing the underlying scope, principles, and mechanisms of CE for organizations (Pauliuk, 2018). Standards may be issued by governments, industrial associations, or NGOs, and support a transition towards a CE by providing assurance of quality or compliance with certain criteria, thereby facilitating transactions between various stakeholders (Teigeiro *et al.*, 2018). Furthermore, standards provide a common understanding of the definition, terminology, and scope of the CE and thus increase the ability of different parties to communicate and collaborate when implementing circular practices and developing CE initiatives (Chen *et al.*, 2020). In the view of the Panel, standards and certifications can also be helpful in supporting circular procurement (Section 7.1.5) by helping purchasing organizations (such as governments) ensure that products and services meet circularity criteria. However, the Panel notes that a lack of standards or certifications should not be seen as a barrier to circular procurement, and neither purchasing organizations, nor vendors, nor suppliers should wait for the development of such standards before incorporating circular principles and practices.

Several CE standards exist, and more are under development.

The first standard for implementing CE principles in organizations was published in 2017 by the British Standards Institute (BSI). This voluntary standard, the Framework for Implementing the Principles of the Circular Economy in Organizations (BSI 8001), is applicable to businesses around the world, regardless of size, location, or sector, and is meant as a guide (i.e., not suitable for use for certification) (BSI, n.d.). The standard focuses on CE implementation through process, product, service, or business model innovation (BSI, n.d.) and also includes a transition framework that organizations can use when moving towards a CE (Chen *et al.*, 2020).

The French standards development organization Association française de normalisation (AFNOR) also developed its own voluntary CE standard in 2018, called Circular Economy Project Management System – Requirements and Guidelines (XP X30-901). This standard covers seven areas of action for a CE: sustainable procurement, eco-design, industrial symbiosis, functional economy, responsible consumption, extension of service life, and end of life, and is a tool that project managers can use to plan, implement, evaluate, and improve CE initiatives (AFNOR, 2018). Furthermore, the AFNOR standard is being used as the seed

document to develop four ISO standards on the CE: a framework and principles for implementation (ISO/WD 59004), guidelines on business models and value chains (ISO/WD 59010), a framework for measuring circularity (ISO/WD 59020), and a performance-based approach via an analysis of case studies (ISO/WD 59031) (Naden, 2019; ISO, n.d.-a). In addition, an ISO standard published in 2017 (ISO 20400) provides guidance on sustainable procurement (ISO, n.d.-b), which can help to inform circular procurement practices (Section 7.1.5).

Another widely used standard and certification program for CE products is the Cradle-to-Cradle Certified Product Standard (C2C, 2016). The standard assesses products using five categories — (i) material health, (ii) material reutilization, (iii) renewable energy and carbon management, (iv) water stewardship, and (v) social fairness — and products must be re-certified every two years (C2C, 2016). Other CE-related certifications include the Towards Zero Waste certificate, launched in 2015 by the Spanish Association for Standardization and Certification (Prieto Sandoval *et al*., 2018), and TCO Certified, which provides sustainability certification for information technology products that incorporate CE principles (TCO, n.d.).

7.3 Public Awareness, Education, and Skills Training

Education, public awareness, and skills training will be needed to support the transition towards a CE and promote uptake of CE practices and products among both consumers and producers. Governments, industry, academia, and civil society will all play a role. Investments in education, training, and employment services will be necessary to prepare the labour force for the types of jobs necessary to support the CE (Wijkman & Skånberg, 2015). Governments could establish partnerships with businesses and civil society to raise awareness and increase familiarity with the CE (Cairns *et al*., 2018). Industry associations or regional economic development organizations could provide training and education on CE technologies and business strategies (Deloitte, 2019b). The creation of CE roadmaps also provides opportunities to raise awareness of the CE by including the public and civil society in the development process (Section 8.1).

Public awareness and support for the CE will be necessary to advance the transition.

Evidence suggests that consumer awareness and willingness alone are insufficient to enable the transition towards a CE; rather, the transition requires a significant and widespread shift in consumer behaviour (Planing, 2015). Indeed, cultural norms around individual consumption may present a challenge to the transition towards a CE, as may consumer preferences and lack of citizen awareness (Section 5.6). It has been suggested that a communication strategy to

raise public awareness and uptake of a CE should "aim to foster a sense of ownership regarding the impact of consumer behaviour and should clarify not only what this ownership entails in terms of individual responsibility but also what it offers in terms of benefits" (Hartley *et al.*, 2020). However, in the view of the Panel, it is important that the transition towards a CE be focused on system-level change rather than downloading responsibility onto individual consumers. Moreover, at present, there is limited knowledge about what the CE will require of consumers, and thus additional research in this area is needed.

Incorporating the CE into the educational curricula promotes knowledge and skills development for the next generation.

Incorporating information about the CE into educational curricula at both the K–12 and postsecondary levels can help to raise public awareness of the CE and provide students with the high-level skills — such as creativity and systems thinking — necessary to fill future CE jobs (EMF, 2015b). In Finland, efforts to integrate the CE into educational curricula from primary to university levels have proved successful (Deloitte, 2019b). The Finnish Innovation Fund Sitra has also developed teaching materials for the CE in collaboration with educational institutions and teaching organizations; many of these materials can be adapted for use in other countries (Sitra, 2019b). An evaluation of the impact of Finland's CE educational strategy found that the efforts were largely successful, with the main challenge being a lack of CE knowledge on the part of educators. Feedback on the strategy also highlighted the need for better coordination between levels of education (Silvennoinen & Pajunen, 2019). In Canada, provinces are responsible for training and education, which could include developing tailored CE-focused curricula (Deloitte, 2019b).

At the level of higher education, research in material sciences, biosciences, economics, and public policy is an important lever to building a CE (EMF, 2015b). With some notable exceptions (Section 4.4), there are few research programs in Canada focused on the CE (SPI, 2020b). In Canada, the CE research landscape could be improved by integrating CE into existing research funding programs, allocating a Canada Research Chair for the CE, and by facilitating access to international CE projects such as through the EU's Horizon 2020 or LIFE program (Raufflet *et al.*, 2019b).

Skills training will be needed to develop a labour force for CE jobs.

The transition towards a CE will create new jobs as well as transform or eliminate existing jobs across multiple sectors, thus requiring skills training for new workers and retraining for displaced workers (Schröder, 2020). In general, a transition towards a CE is expected to require an upskilling of the overall workforce, although

skills demand for the CE will vary across regions and sectors. Policymakers will need to consider such variations when developing training programs (Circle Economy, 2020a). Because CE jobs are quite diverse in terms of the requirements for skills, education, and experience, understanding the unique labour demands of different aspects of the CE is essential to ensuring that the future supply of labour is matched with future demand (Burger *et al.*, 2019). Industry- or sector-specific training programs may therefore be needed to develop specific CE skills and knowledge, in sectors such as construction, remanufacturing, and food (EMF, 2015b). Collaboration among industry, unions, and public authorities may help in the design of training programs (Circle Economy, 2020a) as well as contribute to a just transition towards a CE (Section 6.4).

Jobs in a CE will likely require a mix of traditional and new skills. Furthermore, "soft skills" such as those in service and those facilitating cross-sectoral collaboration will be equally important to "hard skills" such as repair and technical skills like programming (Circle Economy, 2020a). The CE will also require skills in business innovation, as well as those that can help financial institutions develop products that meet the unique needs of the CE (SPI, 2020b). Burger *et al.* (2019) distinguish "core CE activities" in sectors such as renewable energy, repair, reuse of materials, and the sharing economy, from CE "enabling activities" such as management, design, and information and communication technology, noting that the former activities are generally less skill-intensive and typically require skills oriented towards technology and manual tasks, while the latter typically require complex cognitive skills and higher levels of education. Overall, however, "the CE requires more complex problem-solving skills, resource management skills, system skills, and technical skills compared to the rest of the economy" (Burger *et al.*, 2019).

Because of the general lack of awareness around the CE and its current exclusion from educational curricula, important CE skills are not being taught or developed (Circle Economy, 2020a). Developing the skills necessary to meet the labour market demands of the CE will require a combination of academic education and practical training across a variety of fields. Skills development through on-the-job training is particularly important for "core" CE jobs (Burger *et al.*, 2019). Both formal and informal learning will be required, and policies like skills passports for informal learning could be explored as a means to facilitate the transition (Circle Economy, 2020a). There are several existing initiatives in Canada aimed at developing the skills for a CE (Section 4.5).

7.4 Trade and International Relations

Trade has an essential role to play in supporting a transition towards a CE both domestically and globally, given the geographic dispersion of waste, resources, and processing capacity. Furthermore, due to globalized systems of production and consumption, it will be necessary to integrate circular business practices into global value chains to achieve their widespread adoption (EC, 2020b).

Demands from Canada's international trading partners are shifting, both for environmental and economic reasons. If Canada does not transition to more circular practices, it risks falling behind in global market share, competitiveness, and innovation. However, early adoption of CE practices would not only prevent Canada from falling behind, but would also provide opportunities for the country to become a global leader in the CE and capture greater value from its resources (Cairns *et al.*, 2018; Kellam *et al.*, 2020). A CE may also present an opportunity to diversify trading relationships with countries currently not engaged in trade with Canada but that are seeking more sustainable trading partners. The main areas of Canada's international trade that would likely be impacted by the transition towards a CE include natural resource, waste, and service exports.

Trade in waste for recycling (Section 3.2) could help to facilitate the CE at a global scale by directing such materials to countries with advantages in sorting and processing capacity (OECD, 2018). Not only is the recovery of secondary raw materials from waste a potentially valuable opportunity for such countries, but waste-importing countries are also often manufacturing hubs, thereby providing opportunities for reuse of the recycled materials (Kettunen *et al.*, 2019). However, a lack of harmonized standards and cross-border tracking for waste and recyclable materials present challenges to using waste trade as a lever to facilitate a CE (Sections 5.4 and 5.5). In the view of the Panel, successful trade in waste for a CE requires policies and regulations strict enough to ensure that exported materials are actually recycled rather than landfilled after leaving Canada but not so strict that useful materials cannot be imported or exported. Such policies could incentivize companies to buy and sell waste with Canada. Alternatively, a transition towards a CE could lead to innovation in the business and technology of waste management; indeed, future trade in the waste sector may be more focused on waste management technology than on waste itself, thus presenting opportunities for Canadian clean technology firms (de Lange *et al.*, 2018).

Trade agreements help to advance the CE both domestically and globally.

Trade agreements promote consistency in CE policies across international jurisdictions, reinforce and normalize CE policies, reduce trade volatility, and increase economic integration across countries (de Lange *et al.*, 2018). Trade agreements may support a CE directly by promoting trade in goods and materials that meet specified circularity requirements or indirectly by requiring each party to commit to domestic reductions in waste and use of primary materials (Kettunen *et al.*, 2019). The inclusion of sector-specific CE provisions and regulatory actions in trade agreements may also provide opportunities to advance the widespread adoption of CE business practices in certain industries and for certain value chains, and it may lead to more concrete action than do high-level environmental principles (Kettunen *et al.*, 2019).

However, the use of trade agreements to implement the CE has its limits; for example, countries typically do not include provisions to trade agreements that do not reflect their pre-existing national policies, priorities, and agendas. Thus, trade agreements are unlikely to include provisions related to the CE unless all parties are already committed to domestic sustainability and waste reduction agendas (de Lange *et al.*, 2018). In addition, trade agreements typically aim to reduce transaction costs and thus do not necessarily lead to higher standards. The CE could potentially be addressed in non-trade treaties instead or a combination of a trade agreement and non-trade treaties (de Lange *et al.*, 2018). Finally, although the inclusion of CE provisions in trade agreements is a positive step in principle, the actual implementation and enforcement of those provisions in practice are more complicated (Kettunen *et al.*, 2019).

Canada can take advantage of, and contribute to, a global transition towards a CE.

The development of common international standards can facilitate CE trade (de Lange *et al.*, 2018), and Canada could advance the CE globally by promoting such standards. CE trade agreements could introduce provisions affecting procurement requirements at the federal, provincial/territorial, or municipal levels (de Lange *et al.*, 2018). While it has been suggested that unilaterally imposing circular procurement requirements could violate existing trade rules (e.g., Kellam *et al.*, 2020), other analyses suggest that the only barrier would be prohibitions related to origin-based discrimination (e.g., "buying local") (IISD, 2019a).

Furthermore, because Canada is a relatively small player in many global value chains, it will be difficult for Canadian firms to drive a transition towards a CE. Thus, it will be important for Canada to advance circularity through international efforts (ECCC, 2019b). Multilateral frameworks and international trade

negotiations could help to advance the CE by better identifying the materials and required processing capacity in different regions, helping to promote demand for secondary raw materials and second-hand goods, and removing unnecessary regulatory barriers to CE trade (OECD, 2018). Moreover, the international community will need to develop mechanisms to resolve disputes, enforce regulations, and implement sanctions related to CE trade. Voluntary reporting initiatives may be a useful first step (Geng *et al.*, 2019).

The Global Alliance on Circular Economy and Resource Efficiency (GACERE) was launched in 2021, and is comprised of Canada, the EU, and 11 other countries, along with the UN's Environment Programme and Industrial Development Organization, the EMF, the Platform for Accelerating the Circular Economy, and the World Circular Economy Forum (GACERE, 2021a, 2021b). GACERE is the first alliance of governments and other stakeholders at the global level that works to advance a global just transition towards a CE. Its activities to advance the transition will include advocacy; reviewing domestic policies and fiscal and regulatory frameworks; identifying barriers, governance gaps, and research needs; facilitating sectoral, bilateral, and regional partnerships; and general sharing of best practices (GACERE, 2021b).

7.5 EPR Programs

Extended producer responsibility (EPR) has been identified as a useful policy lever to advance the CE in Canada (EPRC, 2017b; Teigeiro *et al.*, 2018; CELC & GLOBE, 2020; SPI, 2020b). Broadly speaking, EPR schemes advance the CE by providing: (i) an approach that includes all stages of a product's life-cycle, from design to reuse and recycling; (ii) an "attractive political narrative" that links environmental goals to economic and social conditions, and (iii) a source of revenue that can improve the economic sustainability of recycling systems (OECD, 2016). Well-designed EPR schemes can provide incentives to improve product design, manufacturing processes, and waste reduction (Arnold, 2019). Moreover, EPR schemes can improve the quality and quantity of material recovery, thereby creating a steady supply of recovered materials to support reverse supply chains and more stable feedstock (SPI, 2019). Furthermore, there is evidence that, in at least some countries, EPR has helped to shift the costs of waste management from governments and the public to producers, as well as reducing landfilling and increasing rates of recycling (OECD, 2016). On the other hand, the overall impact of EPR on improved eco-design appears relatively minor (OECD, 2016), which may result from challenges with implementation of EPR schemes (Section 5.5).

EPR is widely used in Canada, but implementation is fragmented and narrow.

EPR is already a widely used tool for waste management in Canada, with over 200 provincial and territorial programs to collect, manage, and recover resources from waste, with varying degrees of producer responsibility (Arnold, 2019). Indeed, nearly all provinces have some form of EPR programs, with the exception of Alberta, which has several product stewardship programs instead of EPR (Arnold, 2019). In addition, many provinces and territories are revising their existing EPR programs, often in accordance with the Canada-wide Action Plan on Extended Producer Responsibility (Arnold, 2019), which was developed by the CCME and aims to establish a harmonized approach to EPR programs across the country (CCME, 2009). However, progress on interprovincial harmonization has been limited, with most provinces implementing distinct programs covering different materials without cross-jurisdictional integration or standardization in terms of definitions, reporting requirements, or governance structures (Arnold, 2019).

While nationally coordinated EPR policies could help to reduce costs, improve environmental performance, provide better incentives for circular product design, and improve economies of scale of waste management (Arnold, 2019), there are several challenges around developing coordinated, harmonized EPR policies in Canada today (Section 5.5). Indeed, in the view of the Panel, while EPR can be a useful component of a transition towards a CE, its current implementation in Canada is relatively narrow (i.e., covering only a limited range of materials and products), fragmented, and underdeveloped, leading to limited effectiveness in practice and in some cases perverse incentives. Moreover, other levers, such as tax incentives, disposal fees, and — in particular — circular procurement, may be more important for facilitating the transition towards a CE.

There are several ways to improve EPR systems to make them more useful as a lever to advance a CE.

Systems in which individual producers are responsible for their own products provide stronger incentives than collective EPR schemes (Burgon & Wentworth, 2018). Indeed, research on EPR systems in Canada has found that the strength of incentives to improve environmental performance is tied to the degree to which producers are legally responsible for compliance (Arnold, 2019). In theory, environmental outcomes are improved when producers must internalize the costs of managing their products at end of life instead of passing them along by way of consumer fees; however, Canada's limited experience with full EPR policies has generally not produced such benefits (Arnold, 2019). Nevertheless, Ontario has begun to shift the burden of responsibility away from a model of shared responsibility among municipalities and producers, and towards full producer

responsibility (Section 4.2.2). Furthermore, producer fees that are variable by weight, recyclability, or similar design features can improve incentives for individual producers to implement circular design within a collective producer responsibility scheme; this comes at an administrative cost. Fees that cover the full cost of waste management also create a stronger incentive (OECD, 2016).

Accountability and enforcement are key to improving the environmental effectiveness of EPR programs (OECD, 2016; Arnold, 2019). However, many EPR policies in Canada currently lack enforcement or accountability mechanisms, relying instead on symbolic or aspirational targets (EPRC, 2017b). Strong monitoring and reporting mechanisms are needed to ensure compliance as well as to evaluate the effectiveness of the programs (OECD, 2016). Increased enforcement and peer pressure can help to ensure compliance and avoid free riders.

8

Advancing the Transition Towards a CE in Canada

8.1 CE Roadmaps and Strategies
8.2 The Role of Different Actors
8.3 Governance of a CE
8.4 Implementation Approaches

Chapter Findings

- Developing CE roadmaps and strategies at the national or sub-national level, as well as for particular sectors or materials, is key to facilitating a transition towards a CE.
- The transition towards a CE in Canada will require the coordinated efforts of a wide variety of actors, including governments at all levels, businesses, NGOs, and civil society.
- Cross-sectoral partnerships and collaboration, as well as new governance structures, will be required to implement the CE. Progress can be made through both top-down and bottom-up approaches, as well as by focusing on "small wins" that can accumulate into systemic change.

Transitioning towards a CE "will require an enormous structural and cultural shift to address the currently unsustainable linear model – on the scale of the industrial revolution" (ECCC, 2020a). A systems approach is best suited to address change at this scale. Although Canada is still in the early stages of such a transition, several existing areas of success can be built upon to accelerate it (Chapter 4).

8.1 CE Roadmaps and Strategies

A successful transition towards a CE in Canada will depend on clearly identifying the (i) objectives and priorities of the CE transition, (ii) tangible steps necessary to achieve those objectives, and (iii) roles and responsibilities of different actors in implementing those steps.

Roadmaps and strategies at the national, sub-national, and sectoral levels enable the transition towards a CE.

One of the key roles of national governments in supporting the transition towards a CE is the development and adoption of a national CE strategy or roadmap, in close collaboration with sub-national governments and other stakeholders. A national CE strategy has been recommended by experts (Deloitte, 2019a; ECCC, 2019b), and Canada could learn from other jurisdictions that have implemented strategies in the form of roadmaps or action plans, such as the EU, Finland, Scotland, the Netherlands, France, and Japan. Within Canada, several existing initiatives could inform the development of a national CE roadmap, including the Canada-wide Strategy on Zero Plastic Waste, the Canadian Minerals and Metals

Plan, the Forest Bioeconomy Framework for Canada, and the Greening Government Strategy (SPI, 2020b).

The development of provincial/territorial CE roadmaps that align with federal policy has been suggested as a useful lever to facilitate the transition towards a CE (ECCC, 2019b). However, in the view of the Panel, sub-national progress on the CE need not wait for federal leadership. Many areas of the CE are partially or wholly under provincial/territorial jurisdiction (Section 8.2), and there are economic and environmental costs and increased risks associated with inaction while waiting for policy guidance from the federal government. At the same time however, the absence of federal leadership could result in a variety of fragmented approaches, with little cross-jurisdictional harmonization. Currently, no provincial/territorial CE roadmaps or comprehensive strategies have been developed in Canada. Nonetheless, some provinces have adopted strategies that incorporate elements of the CE, such as Quebec's Stratégie gouvernementale de développement durable (Teigeiro *et al*., 2018; Korai & Whitmore, 2021).

At the municipal level, cities such as Amsterdam, London, and Paris have also developed CE roadmaps (EMF, 2019b), which could help inform the development of municipal CE roadmaps in Canada (Deloitte, 2019b). Indeed, some Canadian cities have begun to develop strategies to implement some limited aspects of the CE (Section 4.2.3). In addition, the Circular Cities and Regions Initiative provides guidance and information to municipalities to assist in the development of local CE roadmaps (CCRI, 2021).

It has been suggested that roadmaps for specific commodities (e.g., plastics) or goods and services could be helpful in filling knowledge gaps (ECCC, 2019b). Such roadmaps may provide an initial step towards broader national or sub-national roadmaps by providing a foundation of information and experience. For example, the Canadian Academy of Engineering has begun the process of developing a national roadmap which aims to reduce GHG emissions by 80% in all new and existing buildings and related infrastructure (CAE, 2019). In addition, the Smart Prosperity Institute has begun to produce resources to build sector-based CE roadmaps for seven priority sectors in Canada (SPI, 2020c). Sector-specific CE roadmaps could also highlight the ways in which the implementation of circular practices help to achieve Canada's carbon neutrality goals (Section 6.6). Carbon neutrality roadmaps for selected sectors have been developed by Finland (MEAE, 2021), Sweden (FS, n.d.), and the U.K. (Gov. of UK, 2015), which could be replicated in Canada as part of a CE strategy.

Roadmaps identify priorities, objectives, and actions for the CE transition.

CE roadmaps typically define national (or sub-national) objectives and priorities, promote an overarching vision of the CE, and outline concrete goals and tangible actions to facilitate the transition (Järvinen & Sinervo, 2020). Successful roadmaps typically identify opportunities in specific priority sectors or industries, provide guidance, identify best practices at both the micro and macro levels, and list ongoing and planned future CE pilot projects, which often receive financial support from multiple levels of government (Deloitte, 2019b; Järvinen & Sinervo, 2020). The roadmapping process also provides an invaluable opportunity to engage a wide variety of stakeholders to identify opportunities for cross-sectoral collaborations (Deloitte, 2019b; Järvinen & Sinervo, 2020).

Effective roadmaps take into account country-specific perspectives and identify relevant opportunities and challenges (Deloitte, 2019b; Järvinen & Sinervo, 2020). For example, because of its importance to the Canadian economy, a CE roadmap for Canada would likely need to prioritize sustainability actions in the natural resources sector (Deloitte, 2019b) and address energy and water use (Section 3.3). In addition, plastics could be a priority in a Canadian CE roadmap due to their impacts on multiple social areas (ECCC, 2019b).

Multi-stakeholder collaboration is essential to developing a CE roadmap.

Given Canada's jurisdictional complexity (Section 3.1), the development of a national CE roadmap would require the involvement of all levels of government. Looking to other countries that have dealt with jurisdictional complexity in their roadmaps (e.g., Finland) could be helpful for Canada (Deloitte, 2019b) (Box 8.1). In addition, collaboration with stakeholders in the roadmap development process is key to the success of the endeavour, as they are the drivers of change (Järvinen & Sinervo, 2020). Such stakeholders include both the private sector and academia (Deloitte, 2019b), as well as investors and the financial sector, as these actors will help drive the transition towards a CE (Section 7.1.1). Moreover, international experience in developing roadmaps shows that the use of public consultation in the development of the strategy can increase buy-in and relevance to stakeholders (Deloitte, 2019b). A development process that is inclusive of a wide range of stakeholder groups can also help to facilitate a just transition towards a CE (Section 6.4).

Box 8.1 Sitra's Nine-Step Process for Developing a National CE Roadmap

Following the development of two CE roadmaps (Sitra, 2016, 2019a), the Finnish Innovation Fund Sitra published a detailed, step-by-step guide to developing national CE roadmaps.

1. **Groundwork and preconditions:** plan the process, secure the necessary resources (e.g., funding, staff), define the roles and accountability of participants.
2. **Stakeholders and participation:** identify key stakeholders; form steering committees and identify working groups; ensure opportunities for communication, engagement, and participation.
3. **The situational picture:** develop a detailed overview of the state of the CE in the country, collect and analyze information, interview stakeholders.
4. **Vision and goals:** develop a vision for the roadmap, define strategic long-term (and measurable) goals, develop metrics to measure impact.
5. **Focus areas:** identify and define roadmap focus areas, define goals for each focus area, develop specific indicators for each focus area goal, identify and begin to plan tangible actions to achieve goals.
6. **Planning the actions:** plan the actions to achieve roadmap goals, identify organizations/individuals responsible for each action.
7. **Compile and publish:** create a first draft of the roadmap, gather input and feedback from stakeholders, finalize and publish the roadmap, actively promote the roadmap.
8. **Execution and implementation:** define a management model with clear responsibility and accountability, actively involve stakeholders in implementation, identify new funding models for additional actions.
9. **Evaluation and revision:** evaluate ongoing projects; explore supplementary actions; specify a timeline for evaluation, updates, and revisions; develop plans to avoid disruption.

(Järvinen & Sinervo, 2020)

8.2 The Role of Different Actors

The transition towards a CE in Canada will require the coordinated efforts of a wide variety of actors — including governments, businesses, and civil society — to overcome siloed approaches across and within different sectors and industries. Improved access to information, data, and knowledge facilitates partnerships and collaboration (ECCC, 2020a). Indigenous perspectives and leadership will be important in the Canadian context (Section 3.4).

Governments at all levels must coordinate their policies to advance a CE in Canada.

Governments at all levels have a leadership role to play in the advancement of a CE in Canada. While policy, regulatory, and financial levers vary by level of government, various aspects of the CE may be relevant to multiple government departments or may fall under the partial jurisdiction of multiple levels of government. For example, responsibility for waste reduction and waste management has federal, provincial/territorial, and municipal dimensions (Monahan, 2018). Thus, coordination and collaboration across different levels of government and across different departments within each level of government will be essential to the success of CE initiatives (EMF, 2021).

> *A cross-government, inter-ministerial process can help mainstream circular economy principles into different policy portfolios, helping to deliver a transition in which the policy signals from different areas align. Through such coordination, policy strategies with a sectoral focus (such as plastics, textiles, electronics, the built environment, food and agriculture, and broader industrial policy) can align with cross-departmental policy measures (such as public procurement), or cross-governance tier policy measures (such as spatial planning policies). This integration extends to international policies as much as national and sub-national policies.*
>
> EMF, 2021

Such processes —which include working groups with members selected from different ministries and levels of government — facilitate collaboration, knowledge sharing, and de-siloing (WBCSD, 2019). Structures to enable collaboration on the CE among levels of government could be modelled on existing bodies such as the CCME or the Regulatory Reconciliation and Cooperation Table. Such bodies prioritize federal–provincial and interprovincial cooperation to effectively address areas of overlapping jurisdictional authority and harmonize regulatory schemes across jurisdictions. Similarly, bodies to enable government collaboration with industry to advance a CE could be modelled on Canada's Economic Strategy Tables. Inter-ministerial bodies to advance the CE have already been formed at the provincial

level in Canada; in 2017, Quebec created the Groupe interministériel en économie circulaire, made up of 13 ministries and provincially-owned companies, with the goal of coordinating actions more effectively in the province (Jagou, 2021).

Governments can also facilitate the transition towards a CE by designing and implementing CE policies in a manner that is responsive to the needs of businesses. For example, it may be useful to implement CE policies in gradual phases with ongoing engagement with businesses to understand the challenges created by these policies; roadmaps could include built-in mechanisms for policy review and revision (WBCSD, 2019). Governments can also provide non-financial support to businesses, such as technical support, advice, training, and best practices (SPI, 2020b). The Netherlands' Green Deals program provides an example of how governments can help businesses address some of the challenges that they face in transitioning towards a CE. Under the program, government ministries support businesses, industry organizations, and NGOs that propose sustainable business practices. This support includes advice on regulatory issues, administration, and securing financing, as well as potentially amending regulations or developing new policies to address challenges that arise (EMF, 2017c).

Federal Government

The federal government has a leadership role to play in advancing the transition towards a CE in Canada. In addition to using its policy and regulatory levers to advance a CE (Chapter 7), an important role of the federal government would be to lead the process of developing a national CE strategy or roadmap (Section 8.1). The federal government could support the development of CE projects and initiatives at sub-national levels, by providing guidelines, incentives, and funding (ECCC, 2019b); and facilitate a coordinated, collaborative approach across different levels of government and sectors. Canada's federal approach could be informed by the EU's, which is similar to Canada in some relevant respects: jurisdictional authority is dispersed across multiple levels of government, and there is significant regional variation in opportunities and challenges related to the CE (Deloitte, 2019b). The EU develops broad, high-level policies and frameworks that member states can adapt to their specific economic and social needs (EC, 2015; Deloitte, 2019b), and provides funding for various CE initiatives and projects within member states (EC, 2019). The federal government in Canada could similarly set high-level policies and frameworks that provinces and municipalities could adapt to their specific needs, as well as funding CE initiatives and projects (Deloitte, 2019b).

Further to national leadership, the federal government has the ability to collaborate on the CE at the international level. Because Canada is a relatively small player in many global value chains, it would be difficult for Canadian firms to drive a transition towards a CE on their own. Thus, it would be important for Canada to advance circularity through international efforts (ECCC, 2019b) (see Section 7.4 for the role of trade and trade agreements in the CE).

Provincial Governments

Provincial governments have been at the forefront of the early adoption of CE policies and programs in Canada (Section 4.2.2), in part because of their jurisdictional responsibilities. For example, provinces have jurisdiction over natural resources (NRCan, 2017b; Stikeman Elliot LLP, 2018) and waste management (Giroux, 2014), as well as education and skills training (Deloitte, 2019b; ECCC, 2019b) (Section 7.3). Furthermore, provinces grant jurisdictional authority to local/municipal governments (Brideau & Brosseau, 2019) and are able to activate a standard at scale; for example, in Ontario, all localities with more than 5,000 residents are required to establish a blue box program (Gov. of ON, 2007). Furthermore, provinces also have an important role to play in spurring action on national initiatives, such as the National Construction Code and National Energy Code.

Municipal Governments

Actions by municipal governments and cities are essential to CE implementation. Cities are centres of production and consumption, and the "cultural values, norms, social practices, and lifestyles of those inhabiting the city will influence the reuse, recycling and recovery of resources" (Williams, 2019). City governments may also be better situated to assess and respond to the concerns and needs of citizens and more likely to have to manage the negative consequences of the linear economy (EMF, 2019b).

Experts suggest that developing circular strategies for cities helps test these strategies in preparation for implementing them on larger scales (Deloitte, 2019b). Growth of the CE in cities establishes new industries (e.g., repair, reuse) and facilitates the growth of technologies that support CE strategies (e.g., digital platforms for a sharing economy) (Deloitte, 2019b). Municipalities are also uniquely positioned to engage local stakeholders and have jurisdictional authority over land use and public procurement, which can be used to advance a CE (EMF, 2019b). For example, municipalities can advance the transition towards a CE by supporting the development of local eco-industrial parks (Raufflet *et al.*, 2019a)

(Section 4.1.9). The development of municipal CE roadmaps can help cities advance the transition towards a CE by setting strategic goals, coordinating the development of CE policies within municipal governments, and engaging local stakeholders (Section 8.1).

Municipalities can also influence "the choice, design, use, and flow of materials" through a city (EMF, 2019b). One popular concept for assessing urban resources flows is urban metabolism, which studies how local materials and energy flows are affected by municipal features such as spatial organization, infrastructure, land use, economic activities, and transportation, using tools such as material flow analysis (reviewed by Raufflet *et al*., 2019a). Urban metabolism tools can help to develop CE strategies for cities by identifying opportunities and potential interventions to advance circularity (EMF, 2019b).

Many of the countries currently leading in the CE have implemented programs to provide direct funding and/or non-financial support to municipalities to enable their transition towards a CE. These include the Netherland's City Deals agreements (Gov. of the NL, 2016); Scotland's Zero Waste Towns/Circular Cities and Regions initiatives (ZWS, 2018); Japan's Eco Town Initiative (Gov. of Japan, 2018); and France's Positive Energy Regions for Green Growth, Zero Waste, Zero Wastage Regions, and Breathable Cities in Five Years (Gov. of France, 2016). A similar program for Canada could be modelled on Canada's Smart City Challenge (Deloitte, 2019b; ECCC, 2019b), which has already awarded funding to multiple communities, including the City of Guelph which is developing a CE for food (INFC, 2019). In addition, the Canadian Circular Cities and Regions Initiative is a pilot project that aims to provide non-financial support, advice, and guidance to cities to develop CE strategies (Section 4.2.3).

Businesses can advance the transition towards a CE by adopting circular strategies and developing partnerships within and across supply chains and sectors.

Advancing the transition towards a CE will require significant revisions to existing business practices, manufacturing processes, and product design (Accenture Strategy, 2014). Currently, business understanding of the CE is somewhat limited in Canada (Deloitte, 2019b). Businesses can help to advance the transition towards a CE by adopting circular strategies such as reducing resource consumption through eco-design and process optimization, intensifying product use through sharing and PaaS business models, extending the lifespan of products and their components through repair and remanufacturing, and recovering material and energy from waste (Section 2.2).

Adopting circular business practices requires coordination across all levels and departments of a company (Ritzén & Sandström, 2017). Establishing

company-wide commitments to the CE helps businesses to advance the transition. Such commitments provide strong signals to policymakers, company staff, suppliers, and other companies in the value chain about the company's dedication to circularity, thereby unlocking new business opportunities (WBCSD, 2019). Businesses can also support the transition towards a CE by taking action at the inter-firm level, such as developing partnerships and collaborations across supply chains and sectors. Such partnerships help businesses to align CE strategies within supply chains and help policymakers better understand where support is needed to advance the CE (WBCSD, 2019). Moreover, firms can advance the CE by engaging in industrial symbiosis through participation in eco-industrial parks (Section 4.1.9).

Civil society plays an important role in advancing the transition towards a CE.

Both NGOs and the public have important roles to play in advancing the transition towards a CE. NGOs can advance circularity in Canada by contributing research, facilitating partnerships and collaboration among stakeholders, providing guidance and best practices, sharing information, and engaging in advocacy. In industrialized countries, support for the CE has been driven in large part by environmentally and socially oriented NGOs (CIRAIG, 2015). As noted in Section 2.1, the EMF played a key role in defining and conceptualizing the CE globally. Canada currently has several NGOs working to advance the CE, such as the Smart Prosperity Institute and CÉRIÉC (Section 4.3).

The Dutch NGO Fern has developed recommendations to help NGOs engage with forestry-related CE policies in the EU's Circular Economy Action Plan. While the recommendations are specifically tailored to the EU policy context and forestry sector, general themes include developing formal positions on specific policies; informing the development of appropriate methodologies for monitoring frameworks and indicators; taking a holistic approach to highlight adjacent issues that may be less scrutinized; and engaging with working groups and stakeholder initiatives for the purpose of informing the development of policy and standards (Fern, 2017). In addition, NGOs may be well-suited to help facilitate the development of CE roadmaps for particular sectors or materials. In Canada, the Smart Prosperity Institute has undertaken some work in this area for seven sectors (SPI, 2020c), and the Pembina Institute has helped to develop a regulatory roadmap for net-zero buildings in British Columbia (Frappé-Sénéclauze *et al.*, 2017).

The attitudes and behaviours of the public, both as consumers and as citizens, play a key role in advancing a CE. Transitioning towards a CE will require large-scale behavioural change in consumer practices and social actions; however, public opinion and opposition to policy and regulation in practice could impede

participation within the community (Section 5.6). Some argue that the transition towards a CE is unlikely to address the culture of overconsumption due to the lack of emphasis on how and why consumers use particular products and services and generate waste (e.g., Mylan *et al.*, 2016), which is driven not only by individual attitudes but in large part by the structure of society and the economy (Zukin & Maguire, 2004). Indeed, the Panel notes that engagement in the economy involves a broad social context and suggests that in order to address the culture of overconsumption one should reject the idea that consumption is based on individual characteristics. Instead, it is important to take a systems-level view that identifies the social conditions that incentivize overconsumption. There is an assumption that when individuals engage with environmental issues, it is in their capacity as consumers and that individual behaviour is responsible for addressing climate challenges. Indeed, households increasingly express their policy preferences in the marketplace through boycotts and buycotts (Section 5.6). However, this assumption has obscured the extent to which policy decisions structure options and maintain unsustainable institutions (Shove, 2010). In the view of the Panel, education and awareness are not the antecedents to behaviour in civil society and are not the only opportunities or solutions to the CE transition.

8.3 Governance of a CE

Many CE projects and initiatives span the public and private sectors, with significant involvement on the part of both government and business. Thus, the governance models of such projects are an important consideration. The success of a recent CE food project in Italy was attributed in part to a collaborative model of governance in which different actors and stakeholders were united by a shared goal of circularity (Fassio & Minotti, 2019). In this context, CE governance was defined as:

> *a political–social management system that includes multiple levels of power: local, national, and international governments, citizens and NGOs, academia, and private businesses. Everyone takes part, everyone contributes, everyone benefits: a "governance for transition" that facilitates and guarantees the integration and circularity necessary for the paradigm shift.*
>
> Fassio & Minotti, 2019

Successful CE governance requires "vertical" coordination across different levels of government (e.g., municipal–provincial or provincial–federal); "horizontal" coordination within and across governments at the same level (i.e., intra-departmental coordination within a government, as well as coordination among

different municipal governments or different provincial/territorial governments); and cross-sectoral coordination among stakeholders, including government, industry, and civil society (Obersteg *et al*., 2019). An analysis of CE governance challenges in six urban regions in Europe found that: (i) a lack of vertical collaboration across different levels of government often resulted in a disconnect between local or regional CE initiatives and higher-level government policies; (ii) a lack of horizontal coordination between municipalities led to missed opportunities to pursue a CE at a larger regional scale; and (iii) a lack of cross-sectoral coordination often led to decreased public sector support for CE initiatives promoted by civil society (Obersteg *et al*., 2019).

The governance of Guelph's circular food system may provide instructive examples of governance structures for a CE (OFF, n.d.-a). The initiative is coordinated by a Smart Cities Office, which provides project management, administration, and oversight, as well as coordination of the governance system, communication and engagement, and technology and data strategies. The Smart Cities Office is provided by Wellington County and supported by city of Guelph staff, allowing the initiative to draw on existing financial, legal, communications, and project management resources and processes from the city. Strategic direction and oversight of the initiative are provided by the City/County Advisory Board of Management, under the authority of Guelph City Council. At the project implementation level, responsibility for development lies with three workstream tables, each of which is responsible for one of the three goals of the program: increasing access to nutritious foods, creating new circular businesses and collaborations, and utilizing food waste as a resource (OFF, n.d.-b). These workstream tables are composed of program collaborators from government, industry, and academia, and report to a Community Steering Table that "provides advice regarding resource coordination, community and stakeholder engagement, and outreach" (OFF, n.d.-a).

Although the literature on governance models for a CE is relatively limited, circular governance could apply insights regarding sustainable governance, described by Filho *et al*. (2016) as governance systems in which the principles of sustainable development are integrated into the management model of the public or private sectors. Sustainable governance depends on the political, social, and economic context, and is highly dependent on local knowledge (Kovács & Varjú, 2009). This points to a need for the greater involvement of civil society and local governance to promote the adoption of sustainability norms in institutional frameworks (Bosselmann *et al*., 2008). Sustainable governance also requires "clear rules and identification of responsibilities, making stakeholders in sustainability governance more responsible and accountable for their actions" (Filho *et al*., 2016).

8.4 Implementation Approaches

Cross-sectoral collaboration and partnerships are essential to advancing a CE.

Partnerships and collaboration, particularly across sectors, can break down existing silos (WBCSD, 2019). Advancing the transition towards a CE will require a collective effort among governments, researchers, financial institutions, businesses, and consumers (SPI, 2020b). Cross-sectoral collaboration takes various forms, including "public-private agreements, R&D clusters, and voluntary industry initiatives" (SPI, 2020b), and can be facilitated through the development of formal networks and platforms for knowledge and information among stakeholders in different sectors and industries (WBCSD, 2019). The process of developing CE roadmaps also creates opportunities for stakeholders to coordinate and align CE strategies and policies both across and within sectors, as well as to share knowledge, information, and best practices (Section 8.1). Sharing of knowledge and information, in turn, helps to create effective CE policies (WBCSD, 2019).

Several examples of cross-sectoral partnerships already exist in Canada, including the Circular Economy Leadership Coalition and the National Zero Waste Council, as well as the Great Lakes Circular Economy Partnership (Section 4.3). In addition, the Pôle québécois de concertation sur l'économie circulaire has developed a web-based collaboration platform, Québec Circulaire (Québec Circulaire, 2019). Examples in other jurisdictions include Denmark's Rethink Resources, the National Industrial Symbiosis Program in the U.K., and the Institut national de l'économie circulaire in France. Examples of international or multi-national partnerships include the European Circular Economy Stakeholder Platform, the Platform for Accelerating the Circular Economy (PACE), the Circular Economy Accelerator, Factor10, the EMF, the National Industrial Symbiosis Programme (international), and the Circular Economy Club.

CE implementation requires both top-down and bottom-up action.

A CE can be implemented in either a top-down or bottom-up manner. China's approach to the CE is illustrative of top-down implementation, in which the CE is presented as a national political goal for socio-economic transformation, and development and implementation are controlled from above (CIRAIG, 2015; Ghisellini *et al.*, 2016). In contrast, the EU and Japan have adopted largely bottom-up approaches to the CE, with objectives related to the environment and waste management policies (Ghisellini *et al.*, 2016). In bottom-up implementation, the CE is promoted mainly by environmentally and socially oriented NGOs and civil society (CIRAIG, 2015; Ghisellini *et al.*, 2016).

Lieder and Rashid (2016) argue that a successful CE implementation strategy requires a combination of top-down and bottom-up approaches, with the goal of reconciling the differing motivations of the public and private sectors. Whereas the public sector is primarily focused on the environmental benefits of a CE and the social benefits of economic activity, the primary focus of private sector actors is the economic benefits of the CE for individual businesses. Thus, Lieder and Rashid (2016) argue that implementation of a CE requires an approach that avoids the prioritization of economic growth at the expense of the environment, and vice versa. Indeed, in the view of the Panel, under a CE, the dichotomy between the environment and the economy is a false one, as the CE is specifically aimed at creating economic value by improving environmental outcomes. In a hybrid top-down/bottom-up approach, the public sector implements top-down measures (such as legislation and policy, developing support infrastructure, and raising social awareness), while the private sector implements bottom-up measures (including collaborative business models, product design for circularity, developing closed-loops supply chains, and utilizing information and communications technology for product life-cycle management) (Lieder & Rashid, 2016).

A CE in Canada could benefit from adopting "small wins."

Termeer and Metze (2019) have argued for a "small wins" approach to implementing the transformative change needed to advance a CE. Small wins are "concrete, completed, in-depth changes [that] can accumulate into transformative change through various non-linear propelling mechanisms" (Weick, 1984; as cited in Termeer & Metze, 2019; Weick & Quinn, 1999). This approach involves identifying and recognizing the value of small wins and implementing different types of mechanisms through which accumulated small wins can develop into transformative change. In this way, small wins are distinct from quick wins or low-hanging fruit and are instead associated with in-depth and systemic change. Small wins also connect social change with technological change, generally falling into one of three types of CE transitions identified by the Dutch Environmental Planning Agency (PBL, 2016): "radically new technology enabled by adjusted social practices (e.g. bioplastics); socio-institutional change making use of existing technologies (e.g. packaging-free shops); or radical socio-institutional change facilitated by new enabling technology (e.g. sharing economy)" (as cited in Termeer & Metze, 2019).

The accumulation of small wins can lead to a virtuous cycle of bottom-up initiatives through mechanisms that typically have one of three kinds of amplifying effects: upscaling, in which small changes increase in size and number; broadening, in which the consequences and effects of small changes begin to affect other areas; and deepening, in which the effect of a small change

intensifies (Termeer & Metze, 2019). Through these mechanisms, small wins can accumulate into large-scale changes in regulatory, bureaucratic, financial, and technological institutions (Termeer & Metze, 2019).

The "small wins" framework has several advantages over large-scale, system-wide interventions, which tend to be difficult and more prone to institutional linear lock-in. For example, continuous, small-scale interventions are less prone to be postponed or face premature termination and may be less threatening to established actors and less likely to cause paralysis and frustration compared to large-scale changes (Termeer & Metze, 2019). In addition, small wins can identify both resources and barriers that were hitherto unknown; provide feedback on the effectiveness of different CE strategies and their broader, systemic impacts; and encourage reflection and revision of previous views and beliefs (Termeer & Metze, 2019). Furthermore, because small wins are typically located at the company or local level, they allow for a variety of different approaches.

9

Conclusion and Panel Reflections

9.1 Answering the Charge
9.2 Panel Final Reflections

This report answers the charge from ECCC on the potential for a CE in Canada. The CE is a concept that is increasingly recognized as being of critical importance to maintaining an environmentally sustainable economic system — and one that Canada's peer countries are increasingly pursuing. In answering the charge, the Panel considered a wide range of evidence across multiple disciplines and jurisdictions. As the concept remains underdeveloped in Canada, existing information on the CE in Canada was a limiting factor to addressing the charge, mitigated only in part by inferences from evidence in other countries. In addition, much remains to be learned about the relative effectiveness of CE measures as they are being adopted. Answers to each of the questions are summarized below, followed by the Panel's final reflections on considerations for CE implementation.

9.1 Answering the Charge

What are the potential opportunities and challenges for a CE in Canada?

A CE provides an opportunity for Canada to become more economically successful, environmentally sustainable, and socially equitable. However, realizing these benefits for Canada requires addressing challenges including: low virgin material prices and waste disposal costs; the need for public and private investments; a lack of harmonized policies and standards within and between governments; and a lack of knowledge, capability, or participation on the part of governments, companies, and consumers. Further challenges, such as low population density, are unique to Canada's economy or geography. Thus, while Canada can learn from others' initiatives, a Canadian CE would need to be tailored to its context and challenges, including its status as a natural resource-rich country.

What are the key components and approaches of a CE?

The CE is a proposed alternative to the traditional linear economic model (take-make-use-waste) that seeks to address economic, environmental, and social issues related to material consumption and use via a reduction in primary material extraction. It aims to redesign value chains in ways that promote environmental sustainability and social equity by maximizing the amount of value obtained from materials, infrastructure, equipment, and goods. Ultimately, the CE strives to bring human environmental footprints within planetary boundaries. Three underlying principles form the basis of the CE: "design out waste and pollution, keep products and materials in use, [and] regenerate natural systems" (EMF, 2017a). While there is no universally accepted definition of the CE, the Panel has chosen to use the following working definition as the basis for framing the CE throughout the report:

> a systemic approach to production and consumption for living within planetary boundaries that conserves material resources, reduces energy and water use, and generates less waste and pollution.

Circular strategies and practices are implemented through loops of various scales at one or more points in the value chain. Circular business strategies include reducing resource consumption through circular design and process optimization, intensifying product use through PaaS and sharing business models, extending the lifespan of products and their components through repair and remanufacturing, recycling materials when other strategies are not possible, and, as a last resort, recovering energy from waste.

The measurement of circularity is essential to assessing the impact of CE practices and strategies. CE approaches can be measured using different metrics; at the most general level, circularity is often quantified using the related indicators of the circularity gap and circularity rate. However, there are many indicators to measure different dimensions of circularity. Canada does not currently track material flows in a comprehensive fashion as the EU does. These data are important for measuring the circularity of the Canadian economy, for priority-setting based on the estimates of the effects of various measures on circularity, for estimating the implications of changes such as a move to net-zero emissions for the circularity of the Canadian economy, and for comparing Canada's transition towards a CE with progress in other countries.

What are the potential economic, environmental, and social impacts of a CE in Canada?

Economic Impacts

- **GDP:** The macroeconomic effects of the CE on GDP are unclear, in part because of the limitations of GDP as a metric. Research in the EU suggests that CE practices are positively correlated with increased economic growth, defined in terms of GDP per capita. Some models suggest that efficiency policies for materials could increase Canada's GDP while reducing resource use, while other projections indicate that global material efficiency would reduce Canada's GDP. Although the macroeconomic effects of a CE are uncertain, the linear economy is highly likely to cause economic disruption due to resource depletion. Assessing the macroeconomic impacts of the CE calls for an approach to measuring wealth that is more comprehensive than GDP.
- **Jobs:** Although the transition towards a CE is likely to cause shifts in the labour market in Canada, research suggests that the overall effects on employment would likely be net positive or neutral. It is expected that a transition towards a CE is likely to reduce demand for workers in material-intensive sectors such as resource extraction and processing while increasing jobs in labour-intensive industries such as services, repair, remanufacturing, and enhanced recycling. Job losses resulting from a transition towards a CE are likely to be relatively modest and are likely to be replaced with jobs created in other sectors. Job losses in resource extraction resulting from materials efficiency may also be offset by increasing demand in the natural resource sector, particularly for metals.
- **Natural Resources Sector:** Although the transition towards a CE is expected to reduce demand for primary natural resources relative to demand under a traditional linear economy, there will still be an increasing absolute demand for primary raw materials. In particular, clean energy technology — including solar panels, wind turbines, and batteries — is expected to significantly increase demand for certain metals in the coming decades, and this demand contributes to the urgent need for materials efficiency.

Environmental Impacts

- **Reduced Extraction of Natural Resources:** Natural resource extraction is responsible for a variety of environmental impacts, including land degradation, pollution, and loss of biodiversity. Material efficiency through the CE would minimize the impacts needed to obtain the same value from these materials.
- **Reduced Waste:** Through a combination of material efficiency and treating end-of-life materials as valuable commodities, the CE reduces disposal, preventing landfilling and other forms of pollution resulting from waste such as contamination of drinking water.
- **Reduced GHG Emissions:** A transition towards a CE is likely to help Canada achieve its goal of reducing GHG emissions and its commitments under the 2016 Paris Agreement and the 2016 Pan-Canadian Framework on Climate Change and Clean Growth to reduce GHG emissions by 30% below 2005 levels by 2030.
- **Clean Energy:** A CE provides an opportunity for Canada to reduce overall energy use, increase energy efficiency in key sectors, and increase the proportion of renewable sources in Canada's primary energy supply, drawing on sources such as wind, moving waters, biomass, solar, and geothermal, and reducing the country's dependence on fossil fuels.
- **Biodiversity:** The impacts of a CE on biodiversity are uncertain; while some suggest that a CE could reduce biodiversity loss due to reducing environmental impacts of resource extraction and processing, others argue that circularity does not necessarily improve biodiversity and that certain circular strategies may unintentionally exacerbate biodiversity loss.

Social Impacts

- **Socio-Economic Equity:** The transition towards a CE provides an opportunity for Canada to rectify some of the socio-economic inequities produced by the linear economy. However, because increased equity is not an intrinsic result of a CE, increased circularity should be implemented with careful attention to social impacts. Policies will need to consider potential negative social impacts of the transition towards a CE (e.g., poor working conditions, job losses) on vulnerable sectors, regions, communities, and individuals and provide appropriate protections. Including all stakeholders in the process of planning for a CE, such as the development of a roadmap, can help to identify vulnerable industries and ensure a just transition. An inclusive decision-making process would also create social support for the transition towards a CE by engaging citizens and stakeholders in finding circular solutions. Education and training contribute to a just transition by engaging citizens and preparing them for the CE labour market.

Other Potential Impacts

- **COVID-19 Recovery:** Recovery from the COVID-19 pandemic provides an opportunity to integrate CE principles to create a more sustainable and equitable economy. The pandemic has highlighted many of the limits and challenges of the traditional linear economy, such as the risks of global supply chains. Policies for pandemic recovery that are based on CE principles will not only help to ensure a resilient economy but also achieve environmental and social policy objectives in both the short and long terms.

Drawing from relevant international examples and Canadian data, what are the early opportunities (economic, environmental, and social) for advancing a CE in Canada?

Canada has already begun to develop and implement a CE, albeit to a limited degree. Action on circularity exists at the federal, provincial/territorial, and municipal levels. Canada's jurisdictional structure has allowed for sub-national experimentation with local circular strategies that do not require a pan-Canadian consensus. Building on these existing successes will be vital to the transition towards a CE in Canada. However, while decentralized approaches are useful in the initial stages of the transition, a coordinated national approach will be needed to meaningfully advance a CE in Canada.

A key role for the federal government seeking to support the transition towards a CE would be to develop a national strategy or roadmap. Because the roadmap process involves identifying which organizations or individuals are responsible for each component action, involving multiple stakeholders in roadmap development is essential to creating buy-in and accountability. Other policy, regulatory, and financial levers that governments in Canada can use to advance a CE include incorporating circular principles into public procurement criteria; offering economic incentives such as tax measures; investing in CE-supporting infrastructure; funding programs, projects, research, and innovation; offering opportunites for new skills training and education; developing standards and guidelines; engaging in data collection and developing indicators to measure the impacts of a CE; and regulating waste and end-of-life products.

In the private sector, Canada has strengths in several industries that could be leveraged to support the transition towards a CE, including construction, plastics, food and agriculture, mining, forestry, energy, and textiles. Engaging these industries in the transition will help identify and pursue opportunities to improve business competitiveness. Within industry, there is also an opportunity to develop cooperative strategies to complement existing competitive ones; industrial symbiosis and eco-industrial parks have already provided environmental and economic benefits in Canada, and these efforts could be expanded to support the CE.

- There are significant opportunities to advance the CE in Canada's **construction** sector, including design for longevity, disassembly and deconstruction, energy efficiency, and ease of maintenance; the recovery of construction materials from demolished buildings; and opportunities to meet policy commitments around construction waste and zero-carbon buildings.
- **Plastics** represent a significant early opportunity for action on the CE. Only a small proportion of plastic waste in Canada is currently recycled, and recent bans in Asia on plastic waste imports have provoked a crisis for the industry in Canada. Ongoing actions on reducing plastic waste could be built upon to advance the transition towards a CE and help Canada meet its commitments under the Canada-wide Strategy on Zero Plastic Waste and Ocean Plastics Charter. The Panel highlights that sustainable procurement contributes significantly to advancing a CE transition for plastics by creating a demand for post-consumer recycled plastics.
- Reducing **food** waste in Canada represents a significant economic opportunity; local food production that incorporates sustainable practices can help address food insecurity in remote communities.
- **Mining** in Canada produces waste that can be reprocessed to improve sustainability and derive additional economic value; further, clean energy technology is expected to significantly increase demand for certain minerals and technology metals in the coming decade. The durability, recyclability, and versatility of minerals make them key components of a CE, but work would be necessary to realize a more abundant value chain for both primary and secondary sources of minerals.

- Canada's **forestry** industry has already begun to implement circular bioeconomy strategies and practices, such as producing biofuels from existing pulp and paper processes, replacing plastics with wood-based alternatives, and advancing wood-based buildings.
- Although the CE emphasizes moving away from fossil fuels and towards renewable sources of energy, at this time, it is more effective to engage Canada's **fossil fuel** industry in the CE transition than to exclude it. Indeed, Canada's fossil fuel industry has opportunities to implement circularity that are consistent with the government's commitment to net-zero by 2050, including methane capture for energy recovery, extracting lithium from saltwater brine waste used in oil wells, and producing renewable natural gas from organic waste. Carbon capture and recycling (e.g., to produce fuel or concrete) is also a potential circular opportunity, though the ultimate impacts and circularity of such practices are debated.
- The **textiles** sector has significant potential for circularity, given its considerable environmental impacts, underutilization of products by consumers, low rates of recovery and recycling, and the potential economic benefits of circular approaches. Despite the current lack of EPR for textiles in Canada, circular strategies are being pursued in many municipalities.

What are the challenges (e.g., governance, technological, economic, trade, cultural) to realizing these opportunities?

Governance challenges for a CE in Canada primarily involve a lack of coordination in circular action, whether at the level of government policies within or across jurisdictions, between private organizations in different sectors, within supply chains, or within business hierarchies. Policies —including regulations, taxes and subsidies, and procurement — incentivize and "lock in" the linear system. Meanwhile, there is insufficient incentive for circular leadership. Indigenous communities in Canada have the potential to lead in the CE but face legal and institutional barriers to doing so.

Some **technological** challenges exist with respect to improving waste management and recycling processes, and Canada's current low levels of circular innovation represent both a challenge and an opportunity for investment. However, in many cases, a CE can be advanced without waiting for costly R&D. Rather, challenges relating to lack of innovation often result from the slow adoption of existing technologies (which can be affected by economic and regulatory factors), technical or logistical difficulties in developing circular business models, and gaps in data to support the adoption of circular practices or policies.

The core **economic** challenge to a CE within Canada is the low cost of disposal and of purchasing virgin materials relative to recovering and using secondary materials. From a business perspective, the high risk and cost of investment to adopt a CE is a key challenge, along with a lack of demand from sources such as procurement. Canada's business community is largely composed of SMEs, whose limited financial capacity impedes testing new business models such as PaaS and refurbishing. Geographic factors complicate some circular practices due to population density and the high costs of transportation.

Trade barriers to a CE include import/export restrictions on secondary materials and a lack of harmonized international standards supporting a CE. For Canada, the relatively large portion of natural resource exports is a particular challenge. The high level of integration of supply chains across the Canada–U.S. border could create challenges if a CE is not coordinated between both countries. This does not mean that Canada should wait for the United States to take the lead on the CE, but rather that a CE strategy for Canada should consider mechanisms for increased harmonization or, if harmonization is not possible, mitigating the effect of discrepancies in policy.

Cultural challenges exist for both companies and individuals. These challenges involve a lack of common understanding of the CE concept, a lack of practical skills enabling circular practices, and a societal structure that normalizes and facilitates linear consumption. Despite growing interest in environmental and circular behaviour, a CE is not accessible for many. While the CE could have benefits for rural and remote communities, these areas face challenges related to infrastructure gaps in transportation, waste processing facilities, and digital connectivity, which make it difficult to implement circular strategies.

What are the implications of advancing or not advancing a CE in Canada?

To understand the implications of advancing or not advancing a CE in Canada, the Panel conducted modelling of domestic material flows, allowing for simulations for different policies intended to promote circularity. Four different scenarios were modelled to illustrate the impacts of various CE approaches on material flows in Canada: a BAU scenario and three additional scenarios which begin scoping out the effects of various combinations of measures on material inputs and wastes and on the circularity of the economy. None of the scenarios are intended to represent an "ideal" situation for Canada; they are meant to start a conversation. The results from these scenarios indicate that adopting circular approaches has the potential to substantially reduce waste production.

- The **BAU scenario** results in no change in the circularity rate of 6.1%, with a projected 40% increase in total material inputs (domestic extraction and imports) and in waste by 2040.
- The **EU27 scenario**, increasing Canada's circularity to match the EU27's approaches, results in a circularity rate of 14.4%. There is a substantial reduction in material inputs (approximately 40%) and a modest reduction in waste (13%) in 2040. This represents a reduction of 1.2 gigatonnes of materials processed compared to the BAU scenario.
- The **France scenario** results in a circularity rate of 21.3% and a greater reduction in material inputs (approximately 44% compared to current levels) and in waste (approximately 26%) by 2040.
- The **EU27 with net-zero (EU27 + net-zero) scenario** results in a circularity rate of 20.3%. However, there is virtually no change in material inputs (approximately 2% less than current levels), instead seeing a major shift in the composition of material inputs away from fossil fuels and towards metals. There is a substantial reduction in waste (approximately 27%) by 2040.

Figure 9.1 summarizes the results for each scenario, focusing on circularity rate, circularity gap, and processed materials (in gigatonnes).

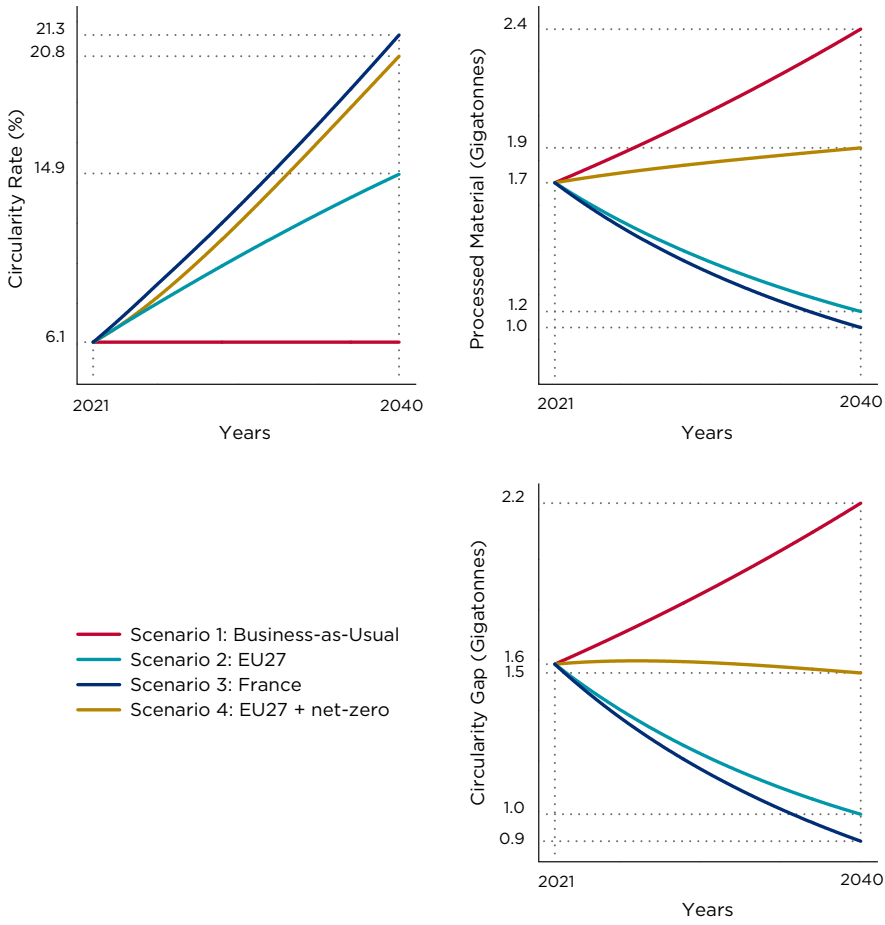


Figure 9.1 Implications of CE Policies in Canada: Four Scenarios

Scenario 1 (BAU) is based on the continuation of the current pattern of materials flows, projected out 20 years; Scenario 2 (EU27) simulates the impact of Canada transitioning over 20 years to the average performance of the EU27 in 2017; Scenario 3 (France) simulates the impact of Canada transitioning to the performance of France in 2017 over 20 years; and Scenario 4 (EU27 + net-zero) is the same as Scenario 2 but with the addition of a net-zero target for GHG in 2050.

The three circularity scenarios represent a substantial reduction in environmental impacts, while the BAU scenario places unsafe strain on planetary boundaries. However, the extent of the changes in the EU27 scenario, the French scenario, and the EU27 + net-zero scenario are very significant and will not be easy to achieve. For example, the EU27 scenario represents a 30% increase in durability, sharing, and production efficiency by 2040 across the entire economy. Moreover, economic growth after 2040 would increase material inputs and waste in the absence of further movement towards circularity. The faster the economy grows, the faster the movement towards circularity must be to achieve any desired reduction in material inputs and wastes. Further, evidence suggests that materials efficiency allows resource needs to increase at a slower rate than economic growth, but not necessarily that resource use can, in the long term, be decreased while maintaining economic growth. Thus, the Panel identifies a need for a discussion regarding whether consumption needs to be stabilized or reduced in addition to implementing CE measures. The Panel also highlights the potential risk for a rebound effect, offsetting the benefits of the CE if increased materials efficiency leads to increased consumption.

In addition, these scenarios — and particularly the EU27 + net-zero scenario — provide an insight into the cascading and competing effects of policies on material requirements. For example, the reduction in GHG emissions from fossil fuels could imply an increase in other processed materials, such as metals, to produce renewable energy to maintain the same energy demand. In this case, climate mitigation measures may represent an opportunity for the mining sector in Canada, and circular approaches could help to meet targets for responsible mining practices while also helping to establish and secure critical mineral supplies necessary for the green energy transition. In this respect, the CE could be seen as an overlooked core component for the climate change agenda, not only reducing emissions related to materials extraction and processing but also accounting for the materials requirements of zero-carbon at the outset by embedding circular principles early on.

Ultimately, the systemic change required to transition to a CE provides opportunities for Canada to meet its economic, environmental, and social goals. Moreover, the global implications of not advancing the CE are significant. The current approach to production and consumption is environmentally unsustainable and results in inequitably distributed risks to humans. Indeed, the extent of human impacts on the biosphere has greatly exceeded planetary boundaries for biodiversity and biogeochemical flows and is also beyond safe operating spaces for climate change and land-use system change. The economic impact of the unsustainable linear approach to production and consumption is likely to include price volatility and supply chain interruptions that result in trillions of dollars in lost economic growth in the coming decades.

9.2 Panel Final Reflections

It is increasingly unsustainable to continue producing short-lived, disposable products and pursuing unlimited economic growth while ignoring mounting social and environmental costs. The Panel's model projects that a BAU scenario will result in a 40% increase in the requirement for new materials in Canada by 2040. For Canada to remain within its equitable share of planetary capacity, action must be taken now to reduce both the amount of new materials entering the economy and waste and pollution leaving it. While the CE cannot singlehandedly solve all these problems, it has the potential to contribute many solutions, as it invites all levels of society (from governments to industries to consumers) to make a change in their economy. As such, the CE is recognized as an important contributor to move us towards a more sustainable economy, and as a good long-term investment.

Implementing a CE would help Canada achieve its GHG reduction commitments while also enabling economic productivity.

Implementing a transition towards a CE would have major implications for other ongoing economic, environmental, and social agendas and societal transformations, such as investment in low-carbon technology, electrification of infrastructure, and waste reduction. The CE has the potential to improve land use and biodiversity. It presents an important opportunity to help meet Canada's Paris Agreement commitments and become carbon neutral by 2050 while also meeting existing energy needs. The CE also enables economic productivity, making it an essential element of a sustainable future for many societal stakeholders. Overall, the CE represents a more informed and efficient approach to design, production, and consumption that makes businesses, consumers, and citizens aware of the value of materials and how to best maintain that value. To achieve this, Canada needs a long-term vision for a circular society and an action plan that includes how citizens can live a better everyday life within the planetary boundaries and new business opportunities for sustainable companies.

Advancing a CE in Canada requires businesses and governments to collaborate and innovate, building on existing initiatives.

Implementing a CE begins with building on the economic, social, and technological solutions that are already available. Canada has many CE initiatives, but collaboration is necessary to leverage existing investments and to share data and knowledge. This is consistent with SDG 17, which calls for "effective public, public-private and civil society partnerships" for sustainability. A successful approach is likely to prioritize regional solutions in the near term while building a national "umbrella" for coordinated action. Scaling up the seeds of circularity

that already exist in Canada and learning from international practices will guide immediate action. Procurement represents a powerful tool to pull circular solutions by leveraging existing public spending. Attracting investment to support continued implementation of and innovation in circular strategies and practices is vital, particularly in sectors where Canada has the potential to be a circular leader. While provincial and territorial EPR programs are widely used in Canada, they have not produced the results needed for greater circularity in the movement of materials or the reduction of waste. Better incentives for design for circularity should result in less waste and increase recycling. The transition towards a CE will also require materials innovation, such as phasing out the use of materials that cannot be effectively reused or recycled or that are associated with sustained environmental impacts. Moreover, it is important not merely to replace undesirable materials but also to reduce total material inputs.

Effective decision-making to support a CE requires the collection of additional data on material flows and social impacts.

Data collection and monitoring frameworks are essential to the successful implementation of a CE. Effective decision-making requires detailed information about material and energy flows, as well as social factors such as awareness of circularity. The social implications of the CE require more investigation. Much of the current discourse on the CE concerns its environmental and business aspects; links between the CE and social equity are less clear. Effective and just implementation of the CE requires a clear understanding of how civil society and households will be involved in the transition and how the CE affects social equity and opportunity. Identifying winners and losers from CE programs and policies is a first step in mitigating the negative impacts of a transition towards a CE. In this respect, it is important to keep in mind that the linear economy also creates winners and losers due to the inequitable distribution of both economic gains and the effects of pollution.

The CE is best seen as an aspirational direction in which to move and ultimately involves transformative, system-wide change.

The CE invites and requires us to reimagine the economy in a new way that focuses on preserving and regenerating resources rather than consuming finite resources and producing waste. Ultimately, this means major socio-economic changes are necessary, including shifts in cultural norms, business practices, and economic and environmental policy, with implications for innovation, infrastructure, international trade, and social development. The CE will require realigning businesses and rethinking entire supply chains. The cross-cutting nature of these changes requires particular attention to mechanisms for

oversight, accountability, and defined leadership, to ensure ownership of implementation. Overall, the CE needs to be transformative and ambitious.

At the same time, the economy will never become completely circular, in the same way that it is not currently completely linear. It is impossible to live solely off recycled materials — some portion of materials will be lost, requiring some amount of new material to replace it. Circularity is thus a direction to move in, bringing us closer to sustainability targets. In this sense, the CE is both practical and aspirational. There are small wins on this pathway, such as reductions in food waste or packaging, that are somewhat easier to implement and have straightforward benefits. These small wins are valuable in contributing to systems change and demonstrating the potential of the CE to investors and other stakeholders who can accelerate the transition. However, there is a risk that incremental actions and a watered-down conception of the CE will fail to deliver on its promise. It is important that CE targets be ambitious as well as realistic while recognizing that perfect circularity is not possible.

Existing commitments to avert an environmental crisis create a foundation on which to build a common vision for a prosperous and sustainable circular society.

The current economic system is no longer sustainable due to increasing social and environmental costs. In the Panel's view, failing to act quickly and comprehensively on this issue would leave Canada out of an equitable and sustainable future and written out of international agreements. Without a CE, even Canada's relatively abundant natural resources would be unable to meet growing demand or support the clean energy transition, leading to shortages, price volatility, and supply chain disruptions. Canada would suffer the environmental consequences of increasing waste, degrading its land and water. The economic and environmental disruption will disproportionally burden marginalized communities and communities in Northern Canada.

In contrast, a CE more closely resembles the processes seen in nature, where valuable materials are not wasted but continue to cycle through the system. In an ideal CE, every product is safe, durable, repairable, and upgradeable. Broken or obsolete products can be repaired, and non-functional parts can be remanufactured and replaced. Local repair shops create jobs and minimize energy spent on transporting goods across Canada. Collection systems clearly and effortlessly direct end-of-life products into streams for repair, remanufacturing, or recycling as appropriate. Libraries or sharing services in communities provide access to rarely used tools and appliances, such as power drills or steam cleaners, making these items more accessible regardless of income or storage space and maximizing their use rather than leaving them gathering dust in closets. Combinations of transit

systems with car or bicycle rentals render private vehicle ownership optional rather than mandatory for personal mobility. Old buildings are reconstructed instead of demolished, and new buildings are designed to be easily adapted for different uses as needed. Material inputs are minimized, and where resource extraction is necessary, it operates efficiently and captures a variety of useful by-products that would otherwise become waste to be landfilled or incinerated. Declining pollution would improve ecosystem health, which in turn will have positive impacts on humans. Ultimately, the CE creates sustainable links among the economy, society, and the environment.

Creating this economy requires everyone to contribute and collaborate. Individual action and siloed approaches in different jurisdictions or industries are insufficient. Because economic systems are created by governments, businesses, civil society, and households, advancing the CE will engage and integrate all these actors through multisectoral dialogue. Existing commitments — such as the Paris Agreement, SDGs, and Aichi Biodiversity Targets — create a moral responsibility for Canada to address the constraints of limited environmental capacity. The CE represents a way to fulfill these commitments. It is imperative to begin planning and implementing a CE now, not only because a failure to do so will leave us behind but because implementing a CE provides significant opportunities. If Canada rises to the challenge, a CE represents a pathway to shared and sustainable prosperity.

Appendix

Tracking Material Flows in the Canadian Economy Using the SankeySim Model

As part of this assessment, the Panel created a model to simulate the impacts of various circular policies on the quantities and flow of raw materials that move through the Canadian economy. The Panel's model, called 'SankeySim,' is based on the well-known Sankey diagram that is widely used for illustrating the flow of materials, energy, and water through an economy and/or its sub-sectors. Sankey diagrams are an effective way to display data on sources, uses, and dispositions of various commodities. Most of the discussions about making economies more circular focus on materials, though measures that affect material flows generally have implications for the use of energy and water.

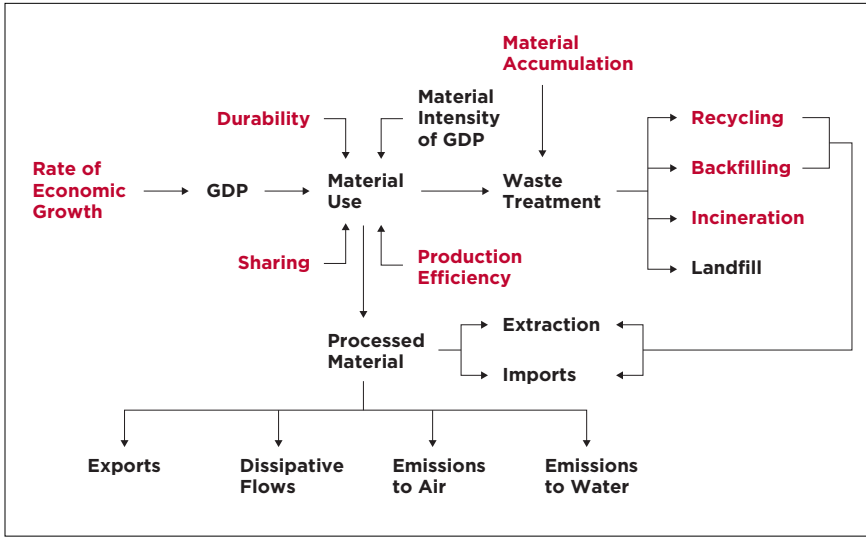
The main purpose of the SankeySim model is to estimate the impact of changes to the quantities and flows of materials as they move through the economy stemming from economic growth and changes in key circulatory measures (the variables) that are affected by policy, business practices, and consumer behaviour. The SankeySim model does not simulate the link between policy and behaviour but starts from the change in behaviour (e.g., more recycling) that a policy is intended to achieve.

This appendix provides a summary of the model structure; more details on the data and parameters can be found in Victor and Chapariha (2021).

The Structure of the Model

The SankeySim model starts from a provisional material flow account for Canada in 2017 based on the material flow accounts produced by Eurostat. Four categories of materials are considered: biomass, fossil fuel, non-metallic minerals, and metal ores. These accounts include domestic extraction, imports, domestic material consumption, and exports (Eurostat, 2020). The model simulates the impact of changes affecting material flows in the economy, including the use and disposal of material, as well as the impacts these changes have on the system. By providing information on the proportion of waste available for reuse and recycling, the circularity gap can be estimated from various scenarios. In addition, the model can provide an estimate of the overall circularity rate for a given scenario.

Figure A.1 shows a simplified version of the structure of the SankeySim model. For purposes of exposition, this description is in terms of total material flows (mass). In the SankeySim model, the same logic applies to all four categories of materials.



Source: Victor & Chapariha (2021)

Figure A.1 Simplified Structure of the SankeySim Model

Terms indicated in red represent variables that are adjusted to create different circularity scenarios.

The economic driver of the system is Gross Domestic Product (GDP). The rate of economic growth is shown in red to indicate that its value is set by the model user. GDP multiplied by the *material intensity of GDP (tonnes/$)* determines annual *material use (tonnes/year)*. Material intensity can be varied in the SankeySim model by changing *durability*, *sharing*, and *production efficiency*. In this model, durability includes reuse. Each of these 3 parameters reduces the material requirements for a given level of GDP. More durable products and more shared products provide the same level of service to users with reduced materials for any given level of GDP. In the SankeySim model, changes in these variables are applied to the entire GDP when, in fact, only some components — capital equipment and consumer durables, for example — can be made more durable or shared. Due consideration should be given to this fact when using the model to experiment with changes in durability and sharing.[1]

The ratio of *processed material: material use* is an indicator of the efficiency of primary materials used to produce processed materials. The multiplication of the ratio by *material use* determines *processed material (tonnes/year)*. *Material use*

1 It is possible that increasing durability will result in increasing material accumulation, but this is not provided for automatically in the SankeySim model. Model users can allow for this relationship by selecting appropriate values for complementary changes in durability and material accumulation.

(which is net of discards in the European Union database) is either accumulated in the economy (i.e., kept in the economy for more than one year, primarily building materials) or "consumed" and then sent to *waste treatment (tonnes/year)* where it is divided among *recycling, backfilling, incineration,* and *landfill (all in tonnes/year).* Landfill receives whatever remains after the other three possibilities have been calculated based on historical proportions that can be modified by the model user.

Waste that is recycled or backfilled reduce *extraction* and *imports.* Recycled materials re-enter the production process, whereas backfilled materials are "used for reclamation purposes in excavated areas or for engineering purposes in landscaping and where the waste is a substitute for non-waste materials" (Eurostat, 2015). *Processed material* that is not included in *material use* is exported, disposed of as *emissions to air, emissions to water,* or *dissipative flows* (all in tonnes/year) based on historical proportions as modified by the model user.

Simulating the Impacts of Policies Promoting Circularity

The Panel identified key policies from the public and private sectors intended to promote circularity at various stages of the value chain. These key policies were used to produce the simulation variables in the model. Table A.1 provides a summary of the selected policies with their expected effects on circularity with a link to the variable used in the model (as a slider).

Table A.1 Value Chain, Policies, and Circularity

Value Chain Steps	Policies Intended to Promote Circularity	Effects on Circularity	Simulation in the SankeySim Model	What to Expect
Primary and secondary material production	Material standards	Increases product quality and durability	Durability slider	Reduction in materials and waste. No change in circularity rate %. Reduction in circularity gap (tonnes).
	Resource efficiency	Decreases need for virgin material	Production Efficiency slider	Reduction in materials and waste. Increase in circularity rate %. Reduction in circularity gap (tonnes).
	Intensity targets	Decreases need for virgin material		

Value Chain Steps	Policies Intended to Promote Circularity	Effects on Circularity	Simulation in the SankeySim Model	What to Expect
Design	Combined material and energy efficiency	Optimizes material and energy use	Durability and Material Accumulation sliders	Reduction in materials and waste. Reduction in circularity gap (tonnes).
	Modularity	Increases product life by being repairable		
	Design for durability	Increases product life		
	Design for disassembly	Increases product life by being repairable		
	Life-cycle design	Increases product life by being repairable and recyclability		
Production	Tax reform	Increases incentive to adopt CE approaches	Recycling and Backfilling sliders	Reduction in materials and waste. Increase in circularity rate %. Reduction in circularity gap (tonnes).
	Industry capacity building	Increases capacity to produce CE products		
	Extended producer responsibility	Increases incentive to adopt CE approaches		
Sales	Tax reform	Increases incentive to choose CE products Reduces virgin material and energy use	Recycling and Durability sliders	Reduction in materials and waste. Increase in circularity rate %. Reduction in circularity gap (tonnes).
	Labelling and certification	Increases incentive to choose CE products Reduces virgin material and energy use		
	Information and awareness	Increases incentive to choose CE products Reduces virgin material and energy use		
	Public/private sustainable procurement	Increases incentive to choose CE products Reduces virgin material and energy use		

Value Chain Steps	Policies Intended to Promote Circularity	Effects on Circularity	Simulation in the SankeySim Model	What to Expect
Use	Sharing economy	Reduces production, and, in turn, extraction and emissions	Sharing slider	Reduction in materials and waste. No change in circularity rate %. Reduction in circularity gap (tonnes).
	Product-service systems	Reduces production, and, in turn, extraction and emissions		
Waste	Waste targets, disposal bans and landfill fees	Limits the amount of allowed waste	Recycling and Backfilling sliders	Reduction in materials and waste. Increase in circularity rate %. Reduction in circularity gap (tonnes).
	Waste avoidance	Reduces the amount of waste, optimize production	Recycling and Backfilling sliders Production efficiency slider	Reduction in materials and waste. Increase in circularity rate %. Reduction in circularity gap (tonnes).
	Reuse	Increases reuse	Durability slider	Reduction in materials and waste. Increase in circularity rate %. Reduction in circularity gap (tonnes).
	Remanufacturing	Increases remanufacturing		
	Recycling	Increases recycling	Recycling slider	Reduction in materials and waste. Increase in circularity rate %. Reduction in circularity gap (tonnes).

Source: Victor & Chapariha (2021)

Data inputs to support Selected Scenarios used in this report

The SankeySim model can be used to simulate a wide variety of scenarios in which the material flows of the Canadian economy are affected by changes in key variables. In this report, the four selected scenarios presented in Chapter 2 are based on adjusted data from 2021 and the outputs are the projections obtained for 2040. Table A.2 provides a summary of the data entered in the model for each commodity type.

Table A.2 Details of the Canadian Material Flow Database Produced for Four Classes of Commodities (in Thousand Tonnes)

	Biomass	Fossil fuel	Metal ores	Non metallic minerals	Total	Sources
Initial Extraction	288,209	414,084	204,814	456,553	1,363,660	1
Initial Direct Material Inputs	314,524	497,687	251,195	520,961	1,584,367	1
Initial Exports	110,769	284,316	70,130	48,821	514,036	1
Initial Dissipative Flows	18,961	–	–	3,346	22,307	2
Initial Emissions to Air	115,904	125,673	526	1,067	243,171	3
Initial Emissions to Water	859	–	–	4	863	2
Initial Incineration	6,555	1,928	535	1,069	10,088	2
Initial Material Accumulation	60,378	85,315	179,851	442,641	768,186	4
Initial Recycling	13,382	2,786	8,060	45,164	69,391	2
Initial Backfilling	91	165	20	46,914	47,190	5
Initial Processed Material	327,997	500,638	259,275	613,039	1,700,949	4
Initial Material Use	81,504	90,649	188,618	559,800	920,571	4

Source: Victor & Chapariha (2021)

Values are based on estimates from:
1. International Resource Panel
2. EU27 GDP extrapolation
3. Environment and Climate Change Canada
4. Other sources (see Victor & Chapariha, 2021)
5. EU27 ratio of backfilling to domestic material inputs

For each scenario, parameters were set using set values (e.g. GDP rate was set at 1.8% for all scenarios) and scenario specific values associated with various circular approaches. All simulations were set to start in 2022 and for a period of 20 years. The detailed data used for each scenario are presented in Table A.3.

Table A.3 Variables Used and Simulation Results for Each Scenario

Model Settings	Scenario 1 BAU	Scenario 2 EU27	Scenario 3 France	Scenario 4 EU27 + net-zero
Rate of economic growth %	1.8	1.8	1.8	1.8
Year change begins	2022	2022	2022	2022
Phase-in period (yrs)	20	20	20	20
Change in Recycling %	0	-9	46	-9
Change in Backfilling %	0	-62	-59	-62
Change in Incineration %	0	-9	-75	-9
Change in Durability %	0	30	33	30
Change in Sharing %	0	30	33	30
Change in Production Efficiency %	0	30	33	30
Change in Material Accumulation %	0	-28	-29	-28

Simulation Results in 2040	Scenario 1 BAU	Scenario 2 EU27	Scenario 3 France	Scenario 4 EU27 + net-zero
Circularity Rate %	6.1	14.4	21.3	20.3
Circularity Gap (thousand tonnes)	2,223,636	988,421	881,541	1,549,419
Waste Reduction (thousand tonnes)	(117,841)	38,715	75,654	77,786
Materials Reduction (thousand tonnes)	(639,269)	595,947	702,828	34,949
GDP $billions (2012 dollars)	2,870	2,870	2,870	2,870
Material Intensity of GDP (tonnes/$m)	450	212	199	443
Material Intensity of GDP Change %	–	(53.0)	(56.0)	(2.0)
Processed Material to Material Use	1.85	1.85	1.85	1.46
Processed Material to Material Use Change %	0	0	0	(21)

Source: Victor & Chapariha (2021)

Assumptions and Limitations

All models are simplifications of what they are intended to represent. The choice of what to include and what to omit should be guided by the purpose of the model. In the case of an empirical model like the SankeySim model, the simplifications are also influenced by which data is available, so a model can also be useful in helping identify what additional data should be gathered.

The main purpose of the SankeySim model is to show how the material use and disposition in the Canadian economy would change in response to various circularity measures. Energy and water were not included, although a similar approach could be used for modelling them. With this purpose in mind, the most important limitations of the SankeySim model are:

- The lack of a comprehensive Canadian material flow database necessitated the creation of a database consisting of existing Canadian data and some estimated data based on comparisons with the EU's economy.
- The high level of aggregation in terms of materials (four subcategories), geography (no sub-national differentiation), and economic sectors (none explicitly identified).
- No distinction is made between goods and services when the former are more directly related to material flows.
- No allowance is made for the import of recovered materials and export of materials destined for recovery as in the EU statistics.
- Economic, environmental, and social costs and benefits of the various circularity measures are not included.

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CCA Reports of Interest

The assessment reports listed below are available on the CCA's website (www.cca-reports.ca):

Building Excellence
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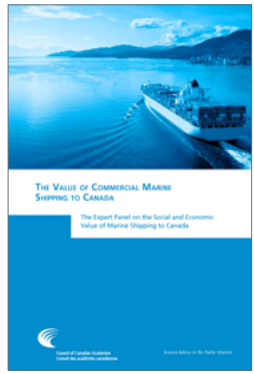

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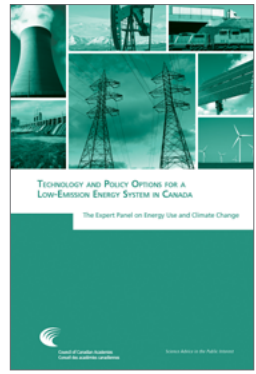

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