CHARTING A COURSE FOR A CANADIAN TRANSITION TO A CIRCULAR ECONOMY

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Executive Summary

There is growing global interest in the *circular economy*, but these discussions tend to focus on the relationships between manufacturers and consumers, neglecting the need for primary resources. World demand for goods and services is increasing. Since we cannot reuse materials forever, we need to inject new materials into the production cycle. Canada plays an essential role in the global economy as a supplier of energy and materials. Natural resource extraction and development are integral to its economy. Canada needs its own approach to the *circular economy* that recognizes the economic importance of natural resources, and that addresses the environmental impacts of these activities.

This paper explores obstacles and opportunities for Canada's natural resource sectors' transition to a circular economy. It looks at the three sectors of mining, energy, and forestry, and focuses on optimizing circularity at the extraction and processing stages. It also looks at environmental impacts such as pollution, including greenhouse gas emissions, and biodiversity loss. *However, it does not directly address the manufacturing or consumer stages, nor does it propose implementation strategies. These elements exceed the scope of this project.*

What does it mean for a resource-based economy to be "circular"?

A resource-based circular economy is ***resource-and energy-efficient***. It uses the smallest necessary quantity of inputs in order to extract and process natural resources. It also ***maximizes value while minimizing waste***. It seeks opportunities to create value within the economy from its residual materials and energy.

In a Canadian context, an effective circular economy also requires strong partnerships with Indigenous peoples, equity among other groups, better coordination across jurisdictions, and clear policy signals.

Figure 1: OURRRR Circular Economy

Why are market forces not enough to move Canada to a circular model?

Several obstacles stand in the way. A ***lack of information or knowledge*** **can make it difficult for extraction and processing firms to** make and sell new products or find new uses for residuals; information gaps also make it difficult for policymakers to target circularity precisely. ***Technological obstacles***, like the inability to efficiently extract some minerals at low concentrations, or the ability to efficiently store solar energy long-term, also pose challenges. ***Liability and Regulatory barriers*** like multiple layers of jurisdiction,

and complex or expensive regulatory burdens all make it more complex for firms to change processes and try new things.

In addition, many of the changes needed to improve circularity can increase short-term ***costs and affect competitiveness*** for natural resource firms. Without clear policy or demand ***signals***, the long-term payoffs of making these changes are uncertain.

So why transition to a circular economy?

Many international markets have already begun shifting towards greater circularity. To remain competitive in the long term, Canada needs to keep up. However, it is not just the threat of being left behind, but also the opportunities to move to the front of the pack, that should motivate Canadian governments and industry.

Canadian firms can gain ***a long-term competitive advantage*** through circularity. It will require time and effort to adjust, but it can lead to long-term boosts in economic growth. Circularity creates opportunities to ***promote new investment*** in research and infrastructure, and to develop ***new market opportunities***. Finally, based on experiences in other countries, experts anticipate that circular economic approaches will ***create jobs***. By reducing waste, circularity provides opportunities for resource-sector activities to ***reduce social and environmental impacts*** like pollution from greenhouse gas emissions.

What can Canada do to support a transition to circularity in the natural resources sector?

Many policy options could help drive Canada's economy towards circularity. Our recommendations would have long-lasting effects and will remain relevant in a variety of economic contexts. Natural Resources Canada can play a key role (directly or indirectly) in each of these five recommendations:

1. ***Support decontamination and re-mining***: Re-mining and decontamination contribute to circularity by retaining value and by restoring the health of ecosystems. The federal government can create a five- to ten-year pilot project to provide financial support for decontamination and re-mining of residual materials from orphaned and abandoned mines. Natural Resources Canada can also support research and development. This recommendation addresses the need for action on abandoned mines across Canada. It also fills a gap in the development of techniques to extract value from residual mining materials by scaling up and commercializing new technologies.

2. ***Support renewable-energy district heating systems***: Renewable-based district heating contributes to circularity by increasing overall energy efficiency and by replacing fossil fuels. Natural Resources Canada can extend its support over the next ten years for renewable-energy-based district heating systems by funding upgrades

and new test systems, by providing technical support, and by facilitating knowledge-sharing. By helping communities overcome high upfront costs to demonstrate this technology, Natural Resources Canada can support renewable energy and promote efficient heating solutions, especially in remote and rural communities.

3. ***Continue to support new technology development and adoption in Canada:*** By supporting new clean energy projects to reach commercialization, this recommendation promotes a future shift to renewable energy and materials. Natural Resources Canada should support the continued funding of the Sustainable Development Technology Fund but work to adjust the environmental performance criteria for eligibility to reflect circular economy principles. This policy also supports Canadian competitiveness in global export markets and sends clear signals to industry about Canada's commitment to circularity.

4. ***Work to reduce harvesting of old-growth forests:*** Encouraging firms to adopt sustainable practices and maximize the value from harvested goods will support a more renewable approach to forestry and will help retain ecosystem health in some of Canada's oldest and most biodiverse regions. It will also protect the large carbon sinks that exist within these forests. Natural Resources Canada should facilitate discussion among Indigenous communities, provinces, and industries to reduce harvesting of old-growth forests, focusing on maximizing value from harvested goods.

5. ***Support industry by filling in network and knowledge gaps:*** Better networks and data could improve circularity of all types. Circularity requires new collaborations between stakeholders. A proactive network or concierge-type service would help link circular economy stakeholders together until such networks develop within the market. Better data would complement this effort by helping develop future policies that would improve circularity.

   Putting these and other measures in place and sending clear messages to stakeholders about Canada's commitment to a circular economy, will help Canada make a transition to circularity. However, this report is the beginning of the journey. Much more work will be needed to support and incentivize all sectors of the Canadian economy into a circular model.

Introduction: The Motivation for Change

In the linear production-consumption models of most developed economies including Canada's,[1] industries extract raw materials from the natural environment and process them into commodities that consumers use and later discard.[2] Many aspects of this linear model cannot be sustained,[3] especially as global population and standard of living rise.[4] Citizens increasingly care about environmental matters.[5] Historically, companies have often not had to assume the full cost of their operations on the environment.[6] The effects of many of these externalities remain unknown, while others have caused successive global issues like smog,[7] acid rain,[8] ozone holes,[9] and climate change. In some cases, waste emissions have caused long-lasting or irreversible harm to ecosystems.[10] Targeted intervention has led to some notable improvements on specific issues.[11] However, the recurrence and gravity of environmental issues caused by externalities have prompted many to look for changes to the system as a whole.

Efforts to change the current linear economic model have manifested themselves in many forms—from industry or government efforts to be efficient to social movements. Both economic and environmental concerns have motivated European countries and others like Japan to find ways to reduce the quantity of new raw materials they must purchase and import. The COVID-19 pandemic has disrupted production and forced countries around the world to confront the viability of their current economic models.[12] In particular this means a better understanding and transparency of global supply chains from end to end.[13]

The circular economy offers an innovative and more sustainable model for extracting, consuming, and managing materials. Canada could use a circular model to address several unresolved challenges to its long-term economic competitiveness. Doing so will help Canada maintain competitiveness on the international scale, as well as address environmental impacts of the energy, mining, and forestry sectors.

Scope of the Report

This report addresses ways in which Natural Resources Canada (NRCan) and other policymakers can spur Canada's transition to a circular economy in the three sectors of mining, energy, and forestry. Specifically, we explore sector-specific and cross-sector initiatives that can be developed or expanded to stimulate market movement towards a circular economy in Canada. These higher-level initiatives are intended to facilitate circularity at an industry or firm level. The project scope excludes: policies aimed at manufacturers and consumers; quantitative costs and benefits analysis of the circular economy transition; selection of "winners" or "losers" at the project- or firm-level; and plans for the implementation of recommended policies. Please see *Figure 2* below for an illustration of our project scope.

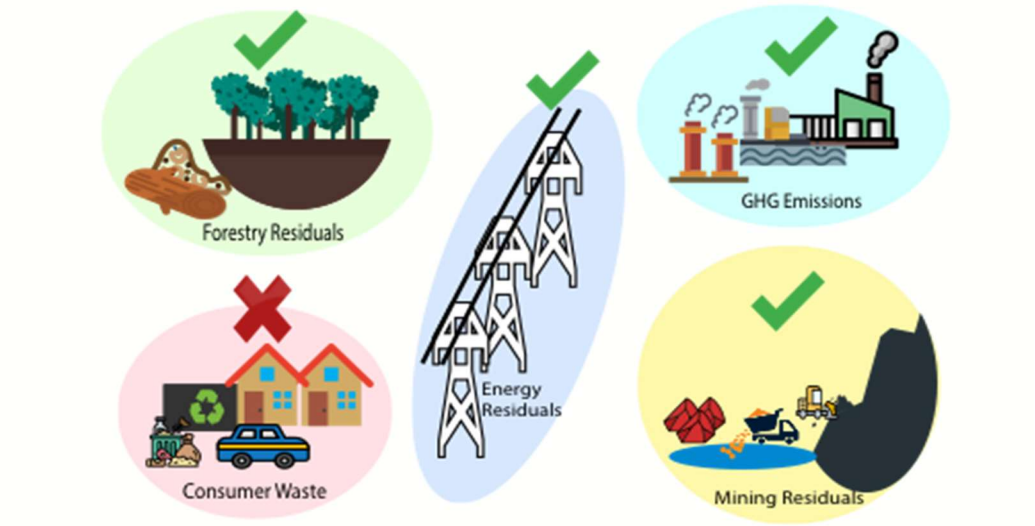

Figure 2: Illustration of Project Scope

Part One of this report describes the context of this policy discussion, explores the meaning of a circular economy, and proposes a circular approach better suited to a resource-based economy and the Canadian context. These questions are timely, since Canada will host the World Circular Economy Forum in September 2021 in partnership with the Finnish Innovation Fund (SITRA).[14] Part Two identifies barriers to circularity in Canada and describes the types of opportunities that circularity presents. Part Three summarizes our methodology. Part Four provides recommendations and addresses some key design approaches.

Part One: Background

Popular approach to Circular Economy

Many different approaches to a circular economy exist.[15] In its ideal form, circularity means making efficient use of every resource and eliminating new resource extraction.[16] A more practical version of circularity reconciles economic development and environmental conservation by finding value in residuals and eliminating the concept of 'waste', which implies that unused materials have no value.[17] Realistically, resource extraction will remain an integral part of the global economy for the foreseeable future, no matter how efficient extraction and development become. The technology does not exist to make use of all residuals coming from extraction and manufacturing or to recycle all materials infinitely. However, these limits don't mean that the economy has to continue on a linear trajectory.

The Ellen MacArthur Foundation was created in 2010 to promote transition to the circular economy[18] and is a leading global voice on circularity. It bases circularity on three principles: designing out waste and pollution, keeping products and materials in use, and regenerating natural systems.[19] It describes a circular economy as restorative and regenerative by design, keeping products, components, and materials at their highest utility and value at all times. Another leading source, the European Union (EU) *First Circular Economy Action Plan,* describes circularity as "where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized."[20]

Circular economy business models focus on manufacturing and consumption energy efficiency, reuse of materials, and waste reduction or recycling policies. EU countries have developed several circular economy guidance documents. Finland, the first country in the world to publish a comprehensive roadmap for a circular economy, describes their plan as an economic model "that does not rely on constantly producing new goods".[21] These

manufacturing- and consumption-centred approaches tend to emphasize not needing new and sometimes expensive input materials and energy to their economies.

All of these circular economy models originate in non-resource-based economies and focus on managing downstream impacts. This fragmented view treats consumers and manufacturers as though they are inside the green economy, and processors and extractors as though they are not. It neglects real opportunities to improve how natural resources are extracted and processed, specifically when it comes to reducing energy and material waste during extraction and processing.

What can circularity look like in a resource-based economy?

Canada has not formally adopted a definition of circular economy. However, many principles and strategies in Canada already support similar ideas (see figure 2 on page 7). Canada's Federal Strategy on Sustainable Development[22] recognizes the principles of intergenerational equity and ecologically efficient use of natural resources. Principles of sustainability and "polluter pays" are incorporated into several federal statutes and policy initiatives, including the Pan-Canadian Framework on Clean Growth and Climate Change.[23] By signing the Paris Agreement, Canada committed to work with 194 countries to limit the global average temperature rise to below 2°C.[24] The current Canadian government has pledged to drastically reduce its own GHG emissions to reach net zero by 2050.[25] This requires an energy transition—whether by moving towards low-carbon sources by expanding wind and solar power industries, improving low-emission technologies for oil and gas, or by investing in carbon capture, use, and storage technology. Such changes could be transformational for Canada's economy, affecting all three natural resource sectors included in this report.

Natural resources constitute an integral part of the Canadian economy.[26] In 2020, Canada's natural resources accounts for 17% of GDP and 1.7 million jobs.[27] Canada operates in a global market economy. Canadian firms sell their wood products in more than 140 countries worldwide.[28] Canada produces more than 60 metals and minerals, and

is among the top producers of many of these, including potash, uranium, copper, nickel, gemstones, and gold.[29] Canada is the sixth-largest energy producer in the world. Its energy sector contributes to the employment of over half a million Canadians.[30]

Demand from Canada's trade partners is shifting. For example, the EU is using its market size to embed circularity standards across global value chains. EU countries are substituting recycled and reprocessed materials for virgin materials.[31] The EU is considering imposing a carbon adjustment on imports. This would ensure that prices of goods reflect their carbon footprint and would deter firms from simply moving carbon-intensive processes out of the EU.[32]

Since value chains and waste flows are international, each country has a role to play in advancing towards sustainable production and consumption.[33] To accomplish this overall goal, several smaller goals must be set in the meantime. As Canada's key trading partners put increasing emphasis on the circular economy, the risk increases that Canada's natural resource industry could suffer. However, this risk can be avoided. Finland recognized Canada as one of eight countries that had great potential to become a prominent global leader in the circular economy.[34] In particular, SITRA (the Finnish Innovation Fund) praised Canada's efforts in its support of "ecopreneurship" in producing grassroots circular economy solutions, as well as in implementing planning tools like roadmaps to success.[35] It highlighted the example of the Toronto Tool Library, which promotes the sharing economy by loaning tools and providing for the use of 3D printers.[36]

Canada is an important player in some respects in sustainable natural resource exploration and extraction. It has strong international partnerships and is working to clarify its obligations to Indigenous rights holders, both of which are essential to Canada's future natural resource projects.[37] In other respects, Canada still has room to improve. The Canadian oil industry has among the highest emissions intensity of all oil and gas producers in the world.[38] The mining industry in Canada bears high costs of liability for mining residuals, and taxpayers inherit responsibility for cleaning up waste if these companies become insolvent.[39] The forestry sector is confronted with opposition to the harvesting of old-growth forests.[40] Canada still has work to do to maximize economic

value by addressing these types of upstream challenges. Doing so will help Canada maintain competitiveness on the international scale, as well as address environmental impacts of the energy, mining, and forestry sectors.

Overall, Canada's commitment to a competitive, sustainable, low-carbon future economy shows that there are compelling reasons for it to lead the world in defining and demonstrating circularity in a resource-rich jurisdiction.

A Canadian Approach to a Circular Economy

No material can be infinitely reusable. As such, the circular economy still requires virgin materials to be injected into the production cycle, and Canada is a key supplier of those materials and energy. Here we propose a Canadian approach for the circular economy to better reflect its place in a global value chain. This approach recognizes two key requirements to bring circularity to Canada's natural resource sector: ***Resource and energy efficiency*** and ***Maximizing value from residuals.***

Resource and energy efficiency: In the last fifty years, the mass of raw materials extracted from the earth has tripled.[41] The *take-make-waste* linear model of resource use is very much the norm in Canada as well. Canada's geography means resource extraction and energy infrastructure are largely out of sight of the general population. Moreover, much of these materials are exported. Countries that import final products avoid bearing the full ecological footprint for the products they consume. Without a clear circular economy plan, Canada risks letting its access to abundant resources continue to discourage efficient use of them.[42] A "rebound effect" happens when new technology creates more cost savings, and those savings are in turn used to increase production and use of virgin materials.[43] The focus of circular economy in Canada will necessarily involve promoting resource and energy efficiency, since the Canadian natural resource economy sits at the extraction and processing stages of production.

By focusing on resource and energy efficiency, Canada's approach to circular economy can mesh with policies and regulations being implemented in Europe and parts of Asia

and acknowledge that remaining competitive on an international scale requires flexibility and adaptation. In addition, using resources and energy more efficiently intersects with the principle of ecologically sustainable development, reflected in federal and provincial policymaking in Canada.[44] Most Canadian stakeholders have not faced the same conservation-based pressures to improve their efficiency as have firms in other jurisdictions, but this can be changed through market and regulatory forces. For example, the forestry sector has been promising in its efforts over the past few decades to repurpose forest-based resources and alter facilities to match changing product needs and regulatory limits. Making use of both physical resources and the innovative, highly skilled workforce has been a winning combination before, and could be a key element in Canada's transition to a more circular economy.[45]

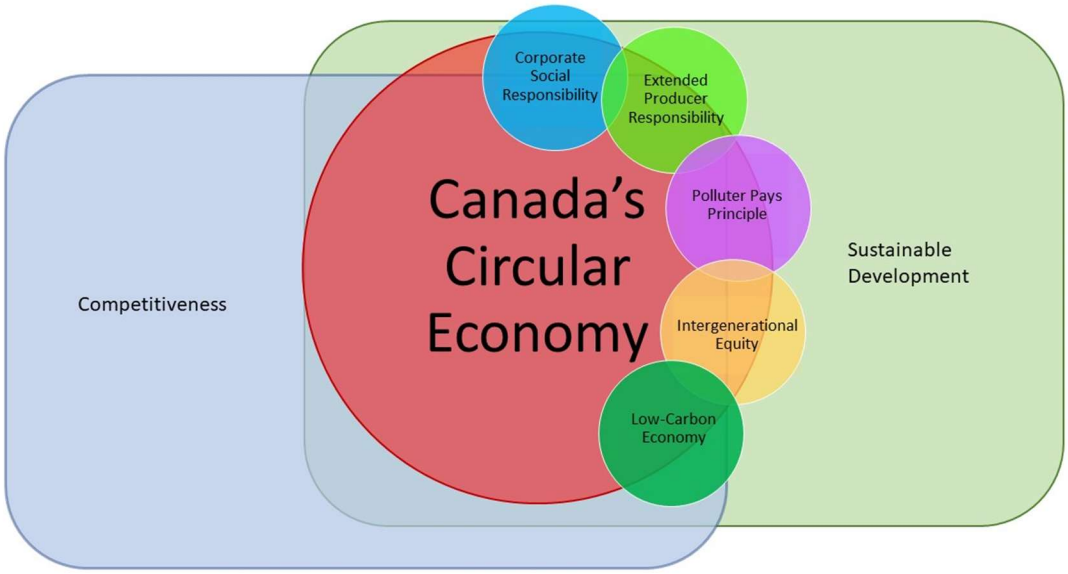

Figure 3: Relationship with competitiveness and sustainable development
Our proposed approach to circularity for Canada overlaps with other related ideas. A circular economy necessarily involves both competitiveness of Canada's firms and industries, and sustainable development. Other economic and legal/policy principles like Corporate Social Responsibility, Extended Producer Responsibility, Polluter Pays Principle, Intergenerational Equity and Low-Carbon Economy all contain elements of circularity.

Maximizing Value, Minimizing Residuals: Resource efficiency goes hand-in-hand with getting more value for what you put in. The idea of increasing value without necessarily

producing more can be summed up in the statement: **maximize value while minimizing residuals.** Maximizing value must be done at all levels, including the international scale. This means that in a changing world, Canada plays one part in the global supply and value chain. Its pursuit of a circular economy can include changes it is already making to carry out its existing international obligations under the *Paris Agreement* and the *United Nations Sustainable Development Goals (SDG)*. Domestically, maximizing value includes cost savings. In the mining sector, this could be recognizing the residual value of minerals and metals along the entire supply chain, from mine tailings to end-of-life consumer batteries. Maximizing value also includes designing products to extend their lifecycle. Finally, minimizing residuals helps address the environmental component of circularity and is consistent with the well-accepted principle of sustainable development. Minimizing residuals includes finding new and better uses for unused materials and byproducts, and reducing the volume of non-usable outputs.

Key Consideration: Participation and Inclusion of Indigenous People in the Transition: The often-quoted statistic that two-thirds of Canadians live within 100 km of the Canada-U.S. border is used to explain Canada's close relationship with the U.S.[46] It is also true that over 600 Indigenous communities are within 100 km of major mine and mineral projects in Canada.[47] Examples of close relationships with Indigenous communities in the north could be support for alternative energy methods to replace expensive and emissions-heavy diesel.[48] Indigenous people could be disproportionately affected by the transition to a circular economy and therefore can play an integral role in new opportunities. This means that the circular economy in Canada ***needs to include Indigenous peoples at all steps of the transition,*** as this is an ongoing and long-term project**.** NRCan's Indigenous Partnerships Office-West (IPO-West) has made some strides in this regard. It has been building relationships with Indigenous communities outside of the formal Crown consultation process to ensure general engagement before project-specific consultations take place.[49] IPO-West also co-leads the Strategic Partnerships Initiative—West Coast

Energy alongside Indigenous Services Canada, for providing grants and contributions funding for projects led by Indigenous communities.[50]

Modelling This Approach

A viable policy support for circular economy includes introducing circular economy structure and thinking, and supporting consumers and firms in the transition to circular economy. The elements of a circular economy will differ from country to country depending on the type and composition of the national economy. After reviewing existing circular economy assessment metrics, we have developed an original tool, the *"OURRRR" Circular Economy Evaluation Tool,* that is more appropriate to an economy based on natural resources—like Canada's. The details of this tool are described in Appendix 1. The "OURRRR" evaluation tool helps visualize the important changes that would improve circularity in the natural resources sector (see Figure 4).

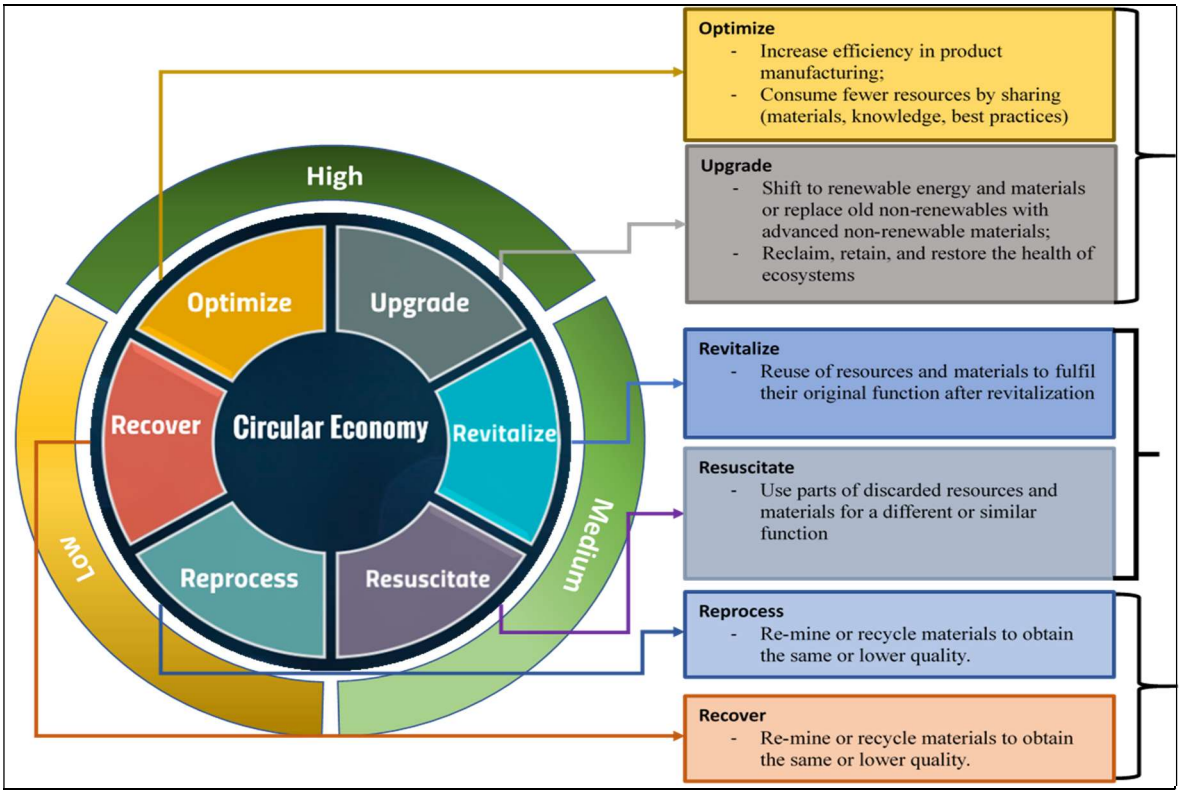

Figure 4: "OURRRR" Circular Economy Evaluation Tool

The "OURRRR" Circular Economy Evaluation Tool includes: Optimize, Upgrade, Revitalize, Resuscitate, Reprocess and Recover. It illustrates a hierarchy, with the 'most circular' activities marked as HIGH at the top, descending clockwise to MEDIUM and LOW as the activities contained within it contribute less to improving circularity.

Part Two: Challenges and opportunities

What are the obstacles to getting to circularity in Canada?

Many other countries have naturally moved towards circularity in response to scarcity and the high costs of primary resources and waste disposal. Given that Canada has not faced these same constraints, a number of obstacles to circularity have built up in Canada's natural resource sectors or have not been addressed. These inadvertent barriers discourage stakeholders from adopting a circular economy approach that could generate additional value[51] and prevent reduction of the economy's ecological footprint.[52]

Understanding how market failures prevent circularity is key to identifying relevant policy solutions. For ease of analysis, we discuss these obstacles in four categories: knowledge, technological, legal/regulatory, and finally, short-term cost and competitiveness.[53]

Information and Knowledge Gaps

Key information that could improve circularity and efficiency is not easily accessible to the policymakers that could use it. Perhaps because the concept of circularity is so new, information gaps prevent decision-makers from quantifying costs and benefits of adopting more circular approaches to natural resource development, or knowing what options might work best. For example,

- Good information is available on different sectors' carbon dioxide emissions, allowing policymakers to make educated decisions about how to reduce Canada's greenhouse gas emissions, but collated, reliable information is not available at the same level of detail for most other industry byproducts or residual materials. The National Pollutant Release Inventory tracks toxic emissions from many industries,[54] and Statistics Canada measures natural resource stocks and flows in the Natural Resource Assets Accounts and Material and Energy Flow Accounts[55], but no comprehensive databases of non-hazardous wastes, sewage, and air pollutants other than greenhouse gases exist;[56]

- The mountain pine beetle, protection of caribou habitat, and export markets all have an impact on supply and demand in the forestry sector, but information about each of these is collected by a different regulator;[57]
- Many types of scrap materials like process residuals or consumer wastes in Canada are already recovered, recycled, or reused beneficially, but no entity comprehensively measures or reports this.

As a policymaker, it is understandably difficult at this stage to identify targeted policies to improve circularity or to compare possible policy options.[58]

At an industry level, innovation along the value and supply chains requires communication. Commercial interests may deter companies from sharing with competitors the proprietary information that makes their processes more efficient.[59] In parallel, until firms perceive potential value in the resources they can recover, they may not perceive those resources as potential inputs for them or anyone else.[60] For example, while most mines consider rock to be a 'waste product', a gold mine in Newfoundland discovered that its crushed rock had commercial value as a construction aggregate.[61]

More generally, value chains do not always develop organically. The transition to circularity takes innovative thinking—new products, new markets, different processes, different materials—along with communication and organization.[62] For example, the B.C. pulp and paper industry has actively advertised its search for a use for residual biomass.[63] However, other firms and processors may not even know these possibilities exist yet. To improve value chains, downstream firms need to understand the possibilities.[64] Otherwise, supply chains will tend to follow path dependency and not coordinate as well as they could.[65] For example, some stakeholders indicated a lack of engagement between some manufacturers of consumer products and processors. As a result, processors know only what the manufacturer buys, but not what they might like to buy; the manufacturer only knows what is currently available, and not what could be provided if demand existed. This lack of communication prevents changes towards new technologies and new materials.

Technical and Logistical Obstacles

By "technological obstacles" we refer to genuine technical or scientific capacity barriers to achieving circularity. Beyond acknowledging the existence of these obstacles, understanding the cause or source of the capacity gap is crucial to understanding why the gap exists and identifying appropriate solutions. This is a key role for the government, as individual corporate players tend not to engage in research and development unless the anticipated benefit *to them* is likely to exceed the cost of the R&D phase.[66]

Some gaps are common across all countries/industries. For example, residuals from conventional mining production in Canadian gold mines contain about $10 billion US in total metal value, more than an entire year's worth of production value.[67] However, small particle size, large volume of waste rock, and the presence of harmful elements like mercury and arsenic mean that conventional techniques cannot practically mine this value.[68] Researchers in Canada[69] and across the globe[70] are making progress in the search for solutions in order to recover this value.

Canada's climate and geography pose additional technical challenges. Opportunities for efficiency that work elsewhere are not yet viable here, or are limited to certain areas of the country. For example, the need to heat or cool infrastructure for much of the year[71] limits energy-reduction strategies. In Canada, solar panels generally produce less than one fifth of their maximum capacity (see also Box 1).[72] Only areas with high solar radiation or otherwise high energy costs will find it economical.[73] Canada's low population density,[74] its concentrated energy distribution, and remoteness of resource projects mean that, energy sources aside, electricity transmission infrastructure is expensive to build. Bringing energy sources like biofuels to remote areas also requires transportation over long distances. The need to transport materials over long distances stretches the supply chain and further affects costs. Though natural resources are found in remote areas, manufacturing tends to take place in larger centres. This also limits economic opportunities for remote, often Indigenous, communities.

Other gaps still relate to the particular characteristics of Canada's natural resources. For example, Canada has large proven supplies of rare-earth metals,[75] but extracting them efficiently to maximize value is a challenge that remains unsolved.

Box 1: Sunny Days: Texas vs. Old Crow Solar Projects[76]

The high energy prices for oil and gas companies to run their plants in Texas, USA was overcome by shining some sunlight on the situation. To be specific, solar energy was introduced to power oil pumping stations in Texas. As of 2019, Texas was the country's sixth-largest producer of solar power in 2019. Making use of an abundant renewable energy source to power current resource extraction is one step in the right direction.

Conversely, the Arctic fly-in community of Old Crow, Yukon has traditionally relied on diesel fuel for all its power needs. In 2018, supported by funding from the Yukon and federal governments, Old Crow installed a 940-kilowatt solar array and 612 kWh of battery energy storage. The project is co-managed by the Vuntut Gwitchin First Nation and ATCO Electric Yukon.

In its first year of operation, the project reduced the community's reliance on diesel—by nearly 200 000 litres to be exact. This project significantly reduces waste and greenhouse gas emissions associated with flying in diesel and using it for power. On long summer days, it has the potential to meet all of the community's energy needs.

However, the equipment sits idle for much of the year. Throughout the winter, when heating and other demands are the highest, Old Crow receives only a couple of hours of weak sunlight per day. Unless its solar array is paired with another source of energy, or with a long-term energy storage mechanism, Old Crow will remain reliant on diesel as its primary source of energy. In lacking sunny days, there is a need for novel ways of energy collection and storage.

Regulatory and legal obstacles

Some circularity initiatives create risk. For example, even if mine tailings contain value or a site has potential for re-use if decontaminated, voluntarily disturbing stable tailings may be considered too high-risk because of the potential severity[77] of negative impacts. Understandably, the status quo is to not disturb tailings. However, this does not address long-term risks[78] nor does it promote circularity.

Easing liability for ongoing operations would not resolve this issue. A firm that knows it won't bear the cost of its operations' environmental impacts has less incentive to minimize these impacts (creating a 'moral hazard' in economic terminology).[79]

Regulation provides important protections including for human health, the environment, the economy. However, regulations designed with other objectives in mind may inadvertently get in the way of circularity. Multiple regulatory hurdles make it more difficult for new market entrants and for the development of new products or processes. For a case study of regulatory barriers faced by a proposed re-mining operation in Quebec, please see Box 2 below. Even within jurisdictions, there is no single window for permits and approvals under different laws. For example, Ontario's Ministry of Energy, Northern Development and Mines offers a 93-page outline of potential regulatory requirements *in addition to* those for which it is responsible.[80]

An absence of regulatory support can also impede firms from maximizing value. Even navigating the opportunities for government supports and initiatives designed to help industry is itself a highly complex task.[81] Canada has identified and responded to this particular obstacle with the launch of the Clean Growth Hub in 2018, which helps businesses find the right programs.

Canadian firms are subject to regulation by municipal, provincial, and federal governments, and by the governments of countries with which they export products or import raw materials. These layers make it even harder to navigate the rules, especially with a new process or product.

Differences in regulation between two or more jurisdictions may result in firms shipping waste or carrying out operations less sustainably in regulated jurisdictions.[82] Because of firms' ability to avoid regulation like this, some regulatory municipal pricing policies have no (or only have a small) effect on global manufacturers.[83]

Box 2: Managing Magnesium When There's an Unwelcome Guest[84]

Alliance Magnesium has a plan to re-mine residuals in Quebec. The challenge? The residuals they want to re-mine contain asbestos tailings. Managing these tailings while avoiding the spread of dangerous asbestos fibres is a difficult feat.

Alliance intends to re-mine old tailings to get both magnesium and silicon. Its demonstration project is producing 6,700 tonnes of primary magnesium from the tailings and will also use existing materials—mostly car parts—to produce 5,000 tonnes of recycled magnesium. In its commercial phase, it plans to produce 35,000 tonnes of primary magnesium and 15,000 tonnes of recycled magnesium, and could create 250 jobs in the region.

The regulatory and funding obstacles have taken eight years so far to overcome. To convince investors that its operations were prudent, Alliance followed rigorous securities regulations that were designed for initial mining ventures, despite its project being a re-mining operation. It obtained three separate certificates of authorization from Quebec, each of which required studies and supporting material and imposed forward-looking obligations. It carried out studies on tailings dispersion, technical feasibility, and paid for filing of six families of patents, including international protection.

In parallel, the project has prompted regulatory hearings over whether asbestos-mine-related projects like this should be supported and whether particular disposal methods should be applied. In the context of these hearings, some citizens' groups are calling for Alliance to undertake additional environmental assessments.

Strict regulatory requirements are necessary when dealing with hazardous materials, but they can create costly, long, and uncertain obstacles.

Short-term cost and competitiveness challenges

These challenges occur at three different levels: policy, competitiveness, and demand.

First, the crucial economic importance of natural resources to Canada means that there is little incentive to reduce production of raw materials. These industries make up 17% of Canada's GDP and provide skilled jobs for millions of Canadians, including in many rural and remote communities. Understandably, the traditional definitions of downstream circularity that emphasize replacing or reducing the need for primary extraction have less appeal in Canada.

At the industry and firm levels, in the short term, many of the changes needed to improve circularity have high upfront costs and may have higher operating costs than current systems. Installing a new energy system carries a high upfront cost, as does reconfiguring a pulp mill to make biofilm. Virgin plastics are a very affordable input and more easily available than recycled plastics in Canada.[85] Expecting firms to make these changes is a hard sell in the absence of clear policy or demand signals.

Imposing changes by legal and regulatory means, while feasible, can result in firms facing higher burdens in Canada than elsewhere. Another circularity measure, making firms more accountable for externalities, would also increase costs in the short term. Negative environmental externalities like pollution, including greenhouse gas emissions, are liabilities borne by society as a whole rather than the firm that generates them. In the resource sector, most negative externalities occur at the extraction, processing, and

manufacturing stages.[86] These externalities are significant. The Auditor General for Canada indicates that for mine site clean-up in three provinces, total environmental liability exceeds $7 billion, most of which is not backed by any securities held by the provinces.[87] Had these historical costs been internalized, market forces would have motivated firms to seek value and minimize waste. Because they are not, the linear economy remains less costly for firms and more convenient. Manufacturers continue to use virgin materials, even when recycled or reused materials might be feasible.[88] These externalities also hide potential value that other parts of the value chain might consider worthwhile.

Finally, lack of interest from the demand side of the market relates back to the knowledge obstacle. Prices of goods do not reflect externalities like environmental impacts. Sustainable goods therefore remain comparatively more expensive,[89] yet consumers may lack information or incentive to differentiate between sustainable and unsustainable products.[90] The large number of links in the supply chains between resource extraction and consumers prevent them from seeing the environmental impact of the products and services they buy. Consumers' ingrained behaviour and cultural norms also temper transition to circularity.[91] Because of lack of demand, sustainable products tend to yield less profit and for this reason firms are less interested in internalizing externalities.

What Opportunities Can Be Created Through Circularity

The European Union (EU) has been moving towards a circular economy for decades. The idea of a circular economy has started to gain traction in developing countries as well, including China, one of the world's largest economies and largest polluters, and who is actively developing over ten circular economy initiatives.[92] Canada may have trouble remaining competitive in the long run if it does not keep up with these shifting markets. However, Canadian government and industries can find motivation not only from the threat of being left behind, but also in the opportunities to move to the front of the pack.

The World Economic Forum estimates that a fully circular world economy could create consumer products savings of $700 billion US a year.[93] A circular economy doesn't just reduce costs, but could also **improve efficiencies** and transform firms to **gain competitive advantages** in Canada. Without necessarily referring to the circular economy, several sectors in Canada have taken the initiative to reduce production costs and improve efficiencies. For example, a Calgary-based Canadian clean tech firm called Acceleware Ltd. is using radio frequency heating technology to recover heavy oil (see Box 3, below, for details). Some of these innovations are not quick fixes to the current business model for moving towards a circular economy. Industries may need to change their current business models completely;[95] hence industries tend to ignore these innovations. However, firms that adopt advances like these can transition towards a circular economy and stay competitive in the market.

If Canada can overcome the obstacles, the circular economy could increase competition by reducing demand uncertainty and instability in supply, increasing proficiency and profitability through exposure to new production methods, building stronger consumer relationships, and increasing differentiation in the sector.[96]

Even though it will require time and effort to improve industrial

Box 3: New Technology Making Waves: Acceleware's Radio Frequency Heating (RF XL) [94]

A Calgary-based Canadian clean tech firm called Acceleware Ltd. has come up with an energy-efficient way to recover heavy oil. This process boosts oil recovery while simultaneously significantly lowering GHG pollution and water usage.

In Canada, heavy oil and bitumen production done on site often uses steam-based technology. The two most common types are steam-assisted gravity drainage (SAGD) and cyclic steam stimulation (CSS). These technologies heat the oil to high temperatures to separate the contents for extraction and transportation. Both methods need large volumes of freshwater and release high levels of CO2 into the atmosphere. This has attracted much environmental criticism. Acceleware looks to replace SAGD and CSS with radio frequency heating technology, which they call RF XL. This method puts electromagnetic energy through transmission lines to heat the structure, saving a huge fraction of freshwater. It can even reduce GHG emissions by 25% to 100%. Companies may see their operating and capital costs cut by over 40% when compared to SAGD technology. The RF XL technology was first tested in 2019 and is pending approval for testing in Alberta's oil sands.

Acceleware's technology will not solve market or access issues faced by the oil and gas industry, but it could deliver both economic and environmental benefits—something that producers and consumers can get on the same wavelength about.

competitiveness, it is estimated that businesses with a *take-make-waste* approach will shift to a *take-make-reuse* circular approach over the next 10 years.[97] It can boost net economic growth by 4% after accounting for the disruptive aspects of the model.[98] Circular firms can retain the value of raw material, products, and resources.[99] One of the components of the circular economy is that new products are produced from residuals (see Box 4, below, for an example of re-mining operations in Australia). However, this is not a novel idea. Canada has used residuals as inputs under the name of 'waste exchange' before.[100] For instance, a team at the University of Alberta is researching ways of producing biofuels from lignin, a structural material contained in vascular tissues of trees and straw.[101] One of the most plentiful and underused renewable carbon-based residuals, lignin is a non-commercialized byproduct of pulp and paper processing. Through this research, the Canadian forestry sector can open up major business prospects for another alternative energy option if lignin can be efficiently and economically turned into biofuel.

Box 4: Speak of the Devil! The Return and Re-mining of Tasmania's Hellyer Mine[102]

In 2012, after 23 years of mining gold, silver, and lead, the Hellyer Mine in Tasmania, Australia ceased its operations because they were no longer economically viable. But less than five years later, a new owner, NQ Minerals, has found another way to make profit and care for the environment at the same time. Its restart and refurbishment programs have allowed it to continue operating by sourcing its minerals from the existing tailings dam. It is estimated that materials worth $1 billion US remain in those tailings. This focuses efforts on finding value from residuals.

Currently, the ore is shipped to central facilities for further processing as the separation of minerals from the other residuals is a multi-step process for which costs remain relatively high. That said, Hellyer has reached commercial production in 2018–2019 and is looking to more projects for commercializing residual materials to sell on international markets.

If technologies and refining processes continue to improve, the combined focus on both re-mining legacy mine sites and environmental remediation has strong potential applicability around the world.

Canada can promote **new investment and markets** through a circular economy. The federal government has taken several initiatives in this direction already. They have invested in the mineral sector to develop a pan-Canadian advanced battery technology strategy to establish a battery production supply chain in Canada. The supply chain includes everything from advanced exploration projects to end-of-life recycling. The

strategy would leverage Canada's mineral and metals to foster domestic industry of specialized markets and battery technologies and recycling technology of the future. It would encourage investment, attract manufacturing companies for electric vehicles, and establish Canada as a global leader in stationary energy storage.[103] Canada has made similar investments in initiatives to develop tall wood buildings (see Box 5 for details).

Box 5: An Arboreous Undertaking: The Market for Tall Wood Buildings in Canada[104]

The "concrete jungle" is a term used to describe urban skyscrapers, but in forest-rich Canada, the construction industry is increasingly interested in wood-frame high-rise towers—also called tall wood buildings. Alberta and other jurisdictions have changed their building codes to increase the floor limit for tall wood buildings from six to twelve floors. Changes are also expected at the federal level, as the National Research Council is revising the National Building Code of Canada in 2020 to permit tall wood buildings over six storeys high.

Wood has several benefits over steel and concrete. It stores carbon dioxide. It also helps reduce carbon emissions by replacing energy-intensive steel and cement. The wood used in high-rises, known as cross-laminated timber, is strengthened through an innovative process to greatly increase its strength, making it comparable to steel and concrete.

Using this technology, Vancouver's Acton Ostry Architects Inc. built an 18-story dormitory for the University of British Columbia. When completed in 2017, it was the tallest wooden building in the world.

With changes in building codes and innovative projects already underway, this seems like a tall order that Canada was designed to fill.

Electrification is a prime example of opportunities for **increased process efficiency and decreasing nuisance and other social/environmental impacts.** Under the Clean Growth Program, Canada announced a $5 million project to help Goldcorp Canada Inc.'s Borden Mine in Chapleau, Ontario replace all diesel mobile equipment with battery electric vehicles (EV). This investment is a step towards an environmentally sustainable way of producing ore that significantly reduces air pollution, including greenhouse gas emissions. It makes mining operations much quieter and shrinks the surface footprint of ventilation and other systems. The Borden project will create approximately 250 jobs for local and Indigenous communities.[105] Another example of increasing efficiency while reducing environmental impact is that of district heating from renewable sources from byproducts such as biomass (see Box 6, below, for details).

Box 6: Connect Four: Heating, Cooling, Savings, and… Wood chips? [106]

District heating works by connecting multiple buildings to the same system to heat homes or offices collectively. Much like municipal water services, it saves having to install and power individual systems for each building. District heating systems can be water- or steam-based and can use excess energy from sources local to the area, like waste heat from industry, biofuels, or solid waste. The system distributes heat to buildings through pipes that can have hot or chilled water. Sweden became the first country to create efficient links between its traditional energy-intensive manufacturing industries (which generate much surplus energy) and its well-established district heating distribution systems.

District heating from renewable sources is not new in Canada. In 1980, Prince Edward Island established Canada's first biomass-fuelled district heating system: the Charlottetown District Energy System. Wood chips supply almost half of the biomass energy supply for the system. The other half comes from urban waste disposal.

A more recent example of district heating in Canada is the Teslin Biomass Project in Yukon. It received $595,000 for biomass wood chip boilers from NRCan. Lowest-grade wood materials like sawdust, chips, undergrowth, and other byproducts from forest clearing power this system. This helps Yukon prevent forest fires and is helping the community become self-sufficient, by creating jobs and by saving the cost of 120 000 litres of diesel fuel each year.

Nova Scotia is also exploring district heating. The province wants to follow P.E.I.'s system and convert 100 public building heating systems. They are testing biomass energy systems in six public buildings, using wood chips from private woodlots. Each test site will use 300-2000 tonnes of wood fuel chips annually.

Provinces and private firms have also taken initiatives to incorporate circularity in their business models. For instance, in British Columbia, a construction firm called "Unbuilders" has taken a circular approach focused on the inner loop of remanufacturing and reducing consumption of wood, creating a sustainable alternative to traditional demolition practices. They reclaim wood from their demolition process and market it in a secondary business called "Heritage Lumber." In this way, they have introduced an additional product to the market, and integrate the entire supply chain into the circular approach.[107] Practices like these can ensure that the highest value for forest-based products is always considered, whether it is used for the production of biochemicals, bioplastics, textiles, engineered wood products, food, or biofuels. Therefore, the Canadian natural resource sector supply chains are ripe for applying best circular practices.

Like in Europe, circular economy approaches are expected to **create jobs** in Canada. The federal government has committed to meet Canada's climate change commitments while creating outputs, middle-class jobs and growth for Canadians in a sustainable and competitive manner in the natural resource sector.[108] Given the recent economic downturn and challenges in the oil and gas industry in Alberta,[109] the circular economy

offers relevant opportunities for job creation and diversification.[110] It aims for a systemwide, deeper degree of innovation in both business and technology.

The circular economy model is still a disruptive business model. In 2018, a survey of 79 large firms indicated that only 18% of them managed to actively and successfully include business model innovation because it is hard to find scalable solutions easily.[111] However, if Canada does not adopt the circular economy approach, they may lose their competitive edge in the global market. If Canada can introduce strategies for energy efficiency and renewable energy strategies, it can create stable employment as jobs will shift from goods- to service-related sectors. This can assist to mitigate the potential adverse impact on raw-material producing economies.[112]

Circular approaches can also manage demand while reducing carbon emissions. Many northern and remote areas of Canada have no access to the electricity power grid. Those areas depend on liquefied natural gas or diesel for electricity.[113] In 2018, the community of Old Crow, Yukon implemented a solar energy project,[114] which used 940 kW of solar capacity and 612 kWh of storage to displace 200 000L of diesel in one summer (see Box 1 on page 13).

A circular economy also provides an opportunity to **advance reconciliation** with Indigenous Peoples. The success of any project heavily depends on community engagement and support. A circular economy encourages the design of projects with sustainability, profitability, conservation, and intergenerational equity all in mind to promote meaningful relationships with Indigenous peoples. Mining companies and Indigenous communities are reaching impact and benefit agreements that include economic and employment incentives, training and mentorship, and environmental and cultural conservation. Capacity development is an important step for the inclusion of Indigenous people. Government can use this opportunity to invest in Indigenous-owned enterprises.[115] In certain instances, Indigenous communities already play important roles in fieldwork, environmental analysis, and conventional land-use surveys, but Canada can do more to remove barriers and promote Indigenous employees working in supervisory and managerial roles in addition to entry-level employment positions.[116]

Part Three: Methodology

We used qualitative methods to study the question of the circular economy in Canada's natural resource sectors (for complete methodology, please see Appendix 1). We reviewed previous circular economy studies and reports and collected relevant information from secondary sources. We have conducted ***Key Informant Interviews*** with 24 experts, government officials, and practitioners to discuss current policies, technologies, laws, regulations and institutions related to the circular economy and natural resources.

We identified 28 potential policy options to help Canada improve its circularity. These options reflect six themes: support existing projects to build scalability; regulatory measures; big picture structural changes; data collection, coordination or analysis; increasing demand; and education or public outreach.

To select our recommendations, we developed a set of criteria and measures to evaluate different policy options. Though policy analysis is inherently normative, analysis must avoid ideological and epistemological arguments.[117] Therefore, we explicitly defined our objectives, criteria, and measures to provide a clear framework for organizing our analysis. The primary objective addresses our principal policy goal of this study, which is effective circularity. Six secondary objectives assess other importance aspects of the policy options: cost effectiveness, administrative feasibility, technical feasibility, equity, competitiveness, and measurability.

From the 28 options, we used a matrix to identify 13 that could lead to medium or high levels of circularity, and that predominantly scored highly on our secondary objectives. These options vary from incremental adjustments to fundamental changes; some are sector specific, while others cut across sectors. Many fall within NRCan's mandate, but we also considered options that cut across all levels of government in Canada.

The following table is a snapshot of the 13 policy options that scored the highest in our analysis, out of the total 28 policy options reviewed.

	Primary Objective	Secondary Objectives						
	Effective Circularity	Cost-effectiveness	Administrative Feasibility	Technical Feasibility	Equity	Competitiveness	Measurability	**Jurisdiction**
ENERGY SECTOR								
Adjust and extend ISED's Sustainable Development Technology Fund	Medium	Medium	High	Medium	Medium	High	High	NRCAN, Other Federal
Work to expand BDC program for commercial-stage projects	Medium	Medium	High	Medium	Medium	High	High	NRCAN, Other Federal
FORESTRY								
Old Growth Logging - Harvest Less Old Growth Forest	High	High	High	High	High	Medium	High	NRCAN
Ban on Single-Use Plastics - ECCC	High	High	Medium	High	Low	High	High	Other Federal
Promote Made-Of-Wood (MOW) Program for Construction and Architecture	High	High	Medium	High	Medium	High	Medium	NRCAN
MINING:								
Financial and Research Support to Re-mine and Decontaminate Orphaned and Abandoned Mines	High	Low	High	Medium	High	Medium	High	NRCAN
ALL or OVERLAPPING Sectors								
A Big-Picture Rethink by Prioritizing Wellbeing in Departmental Decision-Making	Medium	High	Medium	High	High	Medium	Medium	NRCAN
Support the Establishment of Renewable-energy District Heating Systems	High	High	Medium	High	High	High	High	NRCAN, Other Federal
Government procurement and Infrastructure investment in CE materials	High	High	High	High	Medium	High	High	Other Federal
Increase the Output-Based Pricing System	High	High	High	High	Low	Medium	High	Other Federal
Collects data to identify circularity opportunities and gaps	Medium	Medium	High	High	Medium	High	High	NRCAN
Initiate or support "concierge" service	Medium	High	Medium	High	High	High	Low	NRCAN
Continue to support and facilitate collaboration at all levels	Medium	High	Medium	High	High	Medium	Medium	NRCAN

Figure 5: Matrix indicating Top 13 Options

Part Four: Policy Recommendations: What can be done to remove obstacles?

Keeping these constraints in mind, our research and analysis led us to recommend five policy options: one in each of forestry, mining, and energy sectors, and two general recommendations that could be applied to all of these sectors.

Following our recommendations, we provide comments on design principles that apply to all recommendations. These design principles complement the Canadian approach to circularity described in this report by ensuring that policymakers consider key considerations in any policy design and implementation.

Recommendations

Recommendation #1: Financial and Research Support to Re-mine and Decontaminate Orphaned and Abandoned Mines

Proposal: The federal government can provide targeted financial support for mining industries to re-mine (and decontaminate) residual materials from orphaned and abandoned mines through a 5- to 10-year pilot project. Private funding of these projects will also be encouraged. NRCan will support this plan through research and development (R&D) to prove the potential of existing technologies to industry.

Description: The objective is to reduce environmental liabilities through re-mining initiatives that apply modern mining standards, including remediation. This will require NRCan to coordinate with provinces to identify priority sites.

Individual firms often invest insufficiently in R&D, since they do not always reap the full benefits of their innovations; some benefits go to other firms or to society more generally.[118] To fix this, a targeted and temporary public R&D support[119] is warranted. By targeting this pilot only to existing orphaned and abandoned mines, it will not signal to industry that the government will assume responsibility for ongoing or future contamination. It is temporary because it is a pilot project that should help firms overcome the high financial barriers which currently exceed the value gained. Doing this

now will help de-risk future investments for industry, potentially helping access the estimated $10 billion US value of Canadian gold tailings, among other metals.[120]

The current market in Canada has failed to account for or make use of mining residuals. This has caused lasting impacts on the environment through ground, air, and water contamination; and enormous quantities of 'waste' in the form of gravel, sludge, slag, tailings, and other byproducts.[121] Some of these materials have potential to be profitable residual resources instead of waste. Re-mining would use material that has already been mined and reduce the need for new extraction when possible.

Financial support would encourage companies to re-mine residual projects and decontaminate legacy sites. NRCan already supports these broad objectives through its work with the Mine Environment Neutral Drainage (MEND) Program and the National Orphaned and Abandoned Mine Initiative (NOAMI).[122] It has specifically promoted efforts in this direction through its *Mining Value from Waste Initiative*.[123] By decontaminating existing sites as they are re-mined, it would reduce long-term liability for contaminated areas, rehabilitating the environment. It would create jobs, especially in Indigenous communities near to mining sites. NRCan already has experience financing similar initiatives for cleaning up abandoned oil wells. Therefore, supporting projects in the mining sector would not be novel. It would also support other ongoing federal initiatives to address contamination on Crown land.

Contribution to Circular Economy: A pilot program has enormous potential to improve circularity. NRCan's R&D creates a base level of understanding on the efficiency of mining residuals and consumption of fewer resources. Carrying out projects based on this and similar research would fulfill the 'optimize' strategy of our circular economy evaluation tool. More generally, re-mining residual materials contributes towards upgrading in our circular tool through retaining value of metals. Decontamination would separate hazardous waste from reusable residuals. The process can also help in restoration of material flows. The policy also contributes to 'reprocess' under the circular tool by re-mining or recycling materials to obtain the same or lower quality. Since the policy would

encourage reprocessing of residuals and at the same time reclaim, retain, and restore the health of ecosystems, it scores high on our circularity metrics.

Recommendation #2: Adjust and extend ISED's Sustainable Development Technology Fund

Proposal: NRCan should support the continued funding of the Sustainable Development Technology Fund but work to have the environmental performance criteria for eligibility adjusted to reflect circular economy principles.

Description: Innovative solutions often need help bridging the gap between proof of concept and commercialization.[124] This fund, under the purview of the Minister of Innovation, Science, and Economic Development, is a well-established source of financing for green technology projects at pre-commercial stages (technology readiness levels 3–7). Some projects supported by the Fund do ultimately reach the market: in 2018, about 25% of completed, funded projects had entered the market.[125]

This fund does not target the Natural Resources Energy sector in particular, but development of alternative energy and energy-efficiency technologies do fall within the scope of the fund.

Assisting in the development and promotion of Canadian scientific and technological capabilities with regard to natural resources falls within Natural Resources Canada's mandate.[126] However, many stakeholders have emphasized the need to break down silos and avoid duplication. Creating a distinct bridging mechanism for projects that support circularity when a significant, effective, similar policy is already in place would not be practical. Moreover, most or all projects that improve ecological sustainability will have circular components. The Fund is currently funded only to accept projects through 2022.[127] This creates uncertainty for projects currently in research and development phases. NRCan could support an extension of funding or could itself seek a budget for the Fund.

The Fund's requirement for environmental performance is only that the environmental performance of the proposed technology be "better than that of existing technologies".[128] This is a low bar. Changing this requirement to a circular one such as

"how will the proposed technology reduce waste generation" or "how will the proposed technology repurpose previously unused byproducts" will help focus Canada's spending on projects that will increase circularity. It will also signal Canada's commitment to circularity. By requiring all projects to show circularity, Canada will send clear, predictable signals about government priorities and will help researchers and industries adjust and plan accordingly.

Contribution to Circular Economy: By supporting innovative Canadian clean energy projects and helping them reach commercialization, this policy recommendation promotes a future shift to renewable energy and materials (upgrade). It also supports a future of competitive Canadian firms by helping them to create products for Canadians and for export to other markets. Commercialization of renewable and energy-efficient projects can add value across sectors by reducing energy costs. If combined with public relations or branding opportunities in the future, it may also add value by differentiating Canadian operations from those of other firms. For example, by submitting to certified standards of extraction and production methods, members of the Canadian forestry sector distinguish their products. It would also support retention of intellectual property and of employment opportunities within Canada. Continuing long-term funding programs like this sends positive signals to Canadian firms, while avoiding duplication of administrative requirements.

Recommendation #3: Harvest Less Old Growth Forest

Proposal: NRCan works as a facilitator among the provinces and industries to reduce harvesting of old-growth forests and instead focus on getting maximum value from harvested goods. NRCan can coordinate, develop best practices documents, and provide data, resources, and expertise.

Description: Old-growth forests can store some of the highest rates of carbon per hectare in the world.[129] In doing so, they act as a carbon bank, accumulating carbon in the soil, trees, and organic matter.[130] By preserving intact ecosystems and also shifting away from clearcutting, firms will have less need to build new roads and infrastructure. This

recommendation would incentivize sustainable replanting and harvesting strategies in order to maximize value.

For example, in B.C., although the forestry industry faces much criticism for clearcutting old-growth forest, it is still common.[131] The British Columbia government commissioned an independent *Old Growth Strategic Review* in 2019 to hear the public's views on the matter. The reviewers describe a "surprising" consensus to get past political cycles and safeguard old-growth forests, and the final report will be made public later this year.[132] Another report urges British Columbia to do a major revision of its old-growth forest calculation method and increase monitoring. According to this second report, the low ecological bar and lack of monitoring requires an immediate moratorium on harvesting while the province updates its old-growth forest management strategy.[133] The opportunity cost for industry to reduce harvesting of old-growth forests is high because thes forests yield the highest-value timber. However, implementing the policy will create incentive for the industry to extract maximum value from their harvests. A single scientific definition for old-growth forests does not exist. This complicates the decision-making and policy implementation processes. NRCan and provinces are working together to characterize these forests based on region. While NRCan can research and recommend measures for forestry publicity or education under section 3(1)(b) and 3(1)(c) of the *Forestry Act*, provincial governments have the authority to limit old-growth forest logging.

Contribution to Circular Economy: This policy scores highly on circularity because it contributes to the 'upgrade' category in our circular economy tool by focusing on retaining the health of the forest ecosystem. It also contributes to the 'optimize' category as it would make industries maximize the value from harvested goods. The policy will create market motivation for circularity by encouraging firms to adopt sustainable practices if their future profitability depends on the productivity of the same piece of land.

Recommendation #4: Support the establishment of renewable-energy district heating systems

Proposal: NRCan should extend its support for renewable-energy-based district heating systems in areas where fuel or energy costs are high. The support includes funding upgrades for old systems and installation of new test systems; providing technical support; and facilitating the sharing of knowledge between projects.

Description: Renewable district heating is a significant addition to the shift into a more circular economy. It connects multiple buildings to the same system to heat homes or offices collectively. It can serve as an alternative to power-grid-fuelled heating and fossil fuels. Many regions of Canada rely on natural gas, diesel, or oil for heating. This makes energy charges expensive and unpredictable. The district heating system can make areas self-reliant for energy and reduce greenhouse gas emissions.[134] Given Canada's high heat demand, Canada can combine the residuals created from its natural resource sector with district heating distribution systems to meet the demand. It will lead to good utilization of waste heat and residuals. However, district heating projects have high start-up costs[135] and require a certain threshold of constant demand.[136] Without the demand certainty[137] and financial insurance, utility companies cannot afford to take on the upfront cost alone.[138] So, firms need government support. The project manager of Teslin Biomass Project mentioned that without the federal grant, their project could not survive.[139] For new renewable district heating NRCan can not only provide financial grants but also share expertise and knowledge from previous projects. For instance, NRCan can help Nova Scotia successfully implement their biomass district heating by facilitating knowledge-sharing from the Teslin and Charlottetown District Heating systems. This knowledge-sharing can serve as a catalyst to overcome financial and technical barriers associated with implementing and testing a project. This recommendation has several co-benefits. Federal government will be supporting local utilities and firms. This can help Canada improve its relationship with local communities, especially Indigenous communities. Installing district heating systems can also contribute to broader initiatives aimed at

decreasing dependence on non-renewable heating resources and helping build employment. For example, before the project, Teslin Council was heavily dependent on diesel for heating. With this project in place, the Yukon government can reallocate that budget on other priorities like the economy and job creation.

Contribution to Circular Economy: The policy will contribute to the 'optimize' category of circular economy tool as it would increase the efficiency of energy generation and use. As these district heating projects use renewable energy sources, these systems make communities less fossil fuel dependent. The United Nations Environment Program describes renewable district heating systems as the most efficient clean solution to heating and cooling for many communities by increasing electricity quality and allowing higher shares of renewables. Therefore, by encouraging district heating projects, this policy would help Canada to shift to using renewable energy and contribute to the 'upgrade' function of the circular economy evaluation tool. District heating reuses residuals which means it is 'resuscitating' to create more cyclic flows. It uses parts of discarded materials in a new product with a different function.

Recommendation #5: Fill knowledge and communication gaps in industry and government

Proposal: NRCan can develop a proactive network and concierge-type service to help link circular economy stakeholders until such networks are better established. It should collect and collate relevant data and, where possible, make that data available to other stakeholders.

Description: Circularity requires communication and collaboration between stakeholders around the circle, including between stakeholders who have not traditionally worked together. Stakeholders have not yet succeeded in developing these networks on their own. Since coordination of policies and cooperation with other jurisdictions are expressly part of NRCan's mandate,[140] NRCan can play a key role in breaking down silos of information within industries and between government departments and jurisdictions.

Data collection by NRCan could complement this effort. Concentrated knowledge about supply and value chains for natural resources can help NRCan make decisions about

circularity in the future. Better data would help to identify obstacles or market failures, develop measurable indices for circularity, and develop future policies that would improve circularity.

NRCan should begin by compiling data from sources like Statistics Canada, Innovation, Science and Economic Development, the National Pollutant Release Inventory, the National Orphaned/Abandoned Mines Initiative, export data, corporate registries, and provinces. Statistics Canada may be able to assist with this database or provide advice on its development. Where knowledge gaps remain, NRCan or Statistics Canada can use their information-gathering authority to request data from firms and provinces.

Non-commercially sensitive parts of this compiled database can be accessible to industry and provincial partners. This would increase the likelihood that market forces, rather than government intervention, bring about these movements towards circularity.

Contribution to Circular Economy: This recommendation supports all aspects of circularity. Helping firms develop networks and knowledge will reduce current and future obstacles. Collecting data will allow NRCan to measure the transition and, when necessary, target future policy interventions where they are most needed.

Other Policy Options

In addition to the recommendations profiled above, the following policy options could also be implemented. They scored similarly high in our matrix.

Work to Expand BDC Cleantech Practice's Commercial-Stage Projects

This recommendation makes use of existing institutions that have a good history of funding clean energy projects.[141] The Business Development Bank of Canada has a funding stream called the Cleantech Practice that focuses on technology at technology readiness levels 7 through 9.

Implementing this policy option alongside the Sustainable Development Technology Fund recommendation above would ensure even stronger coverage across the technology readiness spectrum and greatly reduce any uncertainty for investors.

Increase the Federal Output-Based Pricing System (OBPS)

This policy option would use the Pan-Canadian Framework on Clean Growth and Climate Change as the mechanism for increasing the carbon tax at the federal and provincial levels. The Output-Based Pricing System (OBPS) forces industries, including the mining and energy sectors to internalize the cost of emissions.[142] Increasing benchmarks apply to firms' annual greenhouse gas emissions. Firms that choose to emit above the benchmark must pay a tax or buy credits from other firms.[143] Firms that produce below the annual benchmark receive credits and can sell them at a profit.[144] Because the OBPS is a market-based and flexible policy that puts a price on carbon pollution, it is one of the most cost-effective ways to reduce emissions, while protecting a firm's competitiveness.[145] This option supports a high degree of circularity by nudging firms to use more energy-efficient technology for their natural resource operations, reducing overall greenhouse gas emissions.

Promote Made-of-Wood (MOW) Program for Buildings and Architecture

NRCan could work with Export Development Canada to increase market opportunities for wood-based products in the construction of innovative tall wood buildings, timber bridges, and low-rise wood buildings in other countries. The building designs would be innovative, energy-efficient and would generate less greenhouse gas emissions than traditional buildings. It would also create market opportunities for Canada's forestry sector. This policy could build upon the domestic "GCWood" program.

Ban on Single-Use Plastics

Environment and Climate Change Canada, supported by NRCan, could implement its proposed ban on single-use plastics. A regulatory prohibition would end or limit non-circular plastic consumer products. Demand would increase for circular-friendly substitutes like forestry-based alternatives (biofilm), reusable plastic, and metal. Since Canada would be an early adopter of such a ban, Canadian industries could gain an edge that would help them compete in other markets, as other jurisdictions transition away from single-use plastics.

Government Procurement and Infrastructure Investment in circular economy goods

Canada could create demand and lead by example by formulating government-wide procurement and investment strategies. These strategies could prioritize materials and energy created through circular extraction, refinement and processing. Furthermore, it could work with provincial, territorial, and municipal partners to eliminate the barrier of differing procurement requirements. However, this option primarily affects consumption. Concerns were also raised that this option could run afoul of international trade rules.

Continue to Support and Facilitate Collaboration at All Levels

NRCan could expand its networks of research and industry contacts with other jurisdictions. It could harness the current momentum towards online collaboration to expand its support of formal and informal conferences and discussions. These efforts would assist in establishing a strong working definition of circularity in Canada over the short term and preparing the country for more tangible upgrades to industrial processes in the long term.

A Big-Picture Rethink by Prioritizing Wellbeing in Departmental Decision-Making

NRCan could phase in wellbeing vocabulary alongside traditional measures like Gross Domestic Product, and work towards developing a department-wide policy framework. By incorporating alternative definitions of measuring growth, NRCan could more fully account for lifecycle effects of business decisions. This would have a positive impact on circularity. It would send clear signals that would allow natural resource stakeholders to make long-term decisions about increasing circularity of their operations. It would signal to the world that Canada's natural resources are environmentally and socially conscious—an invaluable boost to the Canadian "brand".

Approaches to Design of Circular Policy in Canada:

Each of these policy recommendations has the potential to improve circularity without sacrificing other goals like long-term competitiveness. However, policy design will influence how well these recommendations meet these goals and priorities. The following elements are important for the design and implementation of any of these recommendations:

- **Clear policy signals from the government**: To support firms making these transitions, the federal government must provide as much certainty as possible to help reduce investor risk. A clear action plan should define the circular economy and how it relates to other sustainability goals. Industries and firms are capable of remarkable transformation towards circularity. Canada's pulp and paper industry remained competitive through tightening of effluent regulations from the 1970s to the 1990s. As NRCan and other government departments shift towards promoting a circular economic model, this shift should be signalled to industry stakeholders so that they can develop appropriate, sustainable, long-term plans.
- **Cooperation and Defragmentation of information:** The transition to a circular economy in Canada must be accompanied by the breaking down of silos of information, whether within industries, jurisdictions, or between government departments. This includes work with other federal departments, municipal, provincial, territorial, and Indigenous governments,[146] and even with other regional jurisdictions like the United States. Other departments can be asked explicitly to contribute to this effort.
- **Protection and sharing of knowledge:** Developing technology and maintaining any intellectual property rights within Canada are key elements to long-term competitiveness. Supporting Canadian companies here in Canada is a long-term winning strategy because it keeps value—including intellectual property—within Canada. However, it is also important to encourage companies to develop knowledge-sharing licenses and agreements so that innovative advancements can benefit stakeholders across Canada and worldwide.
- **Indigenous participation**: Many Indigenous communities are located near natural resources. Indigenous people also have an important role in decision-making about future projects and risk near their communities. In addition, many remote Indigenous communities are looking for innovative, effective solutions to energy and input/output challenges. Working with Indigenous communities to support Indigenous-led projects and enterprises, Indigenous employees at senior levels,

and helping firms to do the same is consistent with Canada's commitment to reconciliation. However, unresolved issues stand in the way of a closer and more meaningful relationship. Canada needs to continue addressing questions of Aboriginal title, and Indigenous rights and jurisdiction including over subsurface rights.[147] Legal obligations under section 35 of the *Constitution Act*; Canada's commitment to renewed nation-to-nation, government-to-government, and Crown-Inuit relationships,[148] and to the United Nations Declaration on the Rights of Indigenous Peoples and the principles of free, prior, and informed consent;[149] and geographic proximity all signal the need for strong action.

In the mining sector, the Canadian Minerals and Metals Plan (CMMP) acknowledges the need for NRCan and other federal departments to put Indigenous rights at the forefront of the relationship between the Crown and Indigenous peoples.[150] The difficult conversations on the duty to consult, accommodate, and of free, prior, and informed consent need to start from a foundation of a relationship of equals.[151] NRCan can address this crucial task in forward-looking circular economy projects.

The *Resources for the Future* report from Canada's Economic Strategy Tables states that "Canadian natural resource sector partnerships with Indigenous communities are the recognized global best practice."[152] Positive relationships with Indigenous peoples should only be a point of pride for the Canadian government on international markets once Canada has put its intentions for reconciliation into practice.

- **Gender-based Analysis Plus (GBA+) and other measures of equity**: Circularity focuses on economic and environmental impacts, but other measures of good policymaking complement circular economy policies. The federal government has already incorporated Gender-based Analysis Plus into its decision-making framework. Other relevant elements include equity between firms, between sectors, and between urban and rural/remote communities.

Conclusions

As part of a global economy, Canada must keep up and remain competitive, including by transitioning to a circular economic model. However, Canada plays an essential role in the global economy as a supplier of new energy and materials. The concept of "*circular economy"* needs to account for this context.

The policy recommendations in this report will help Canada address barriers to circularity currently faced by the natural resource sector. By addressing these barriers, Canada can demonstrate its commitment to a circular approach and can support future competitiveness of Canadian firms.

These recommendations are just the beginning. More support, including ongoing work by Natural Resources Canada and external consultants, will help identify additional relevant and targeted steps.

Transitioning to a circular economy will require ongoing adjustments across the economy but is a positive step that will ultimately support the long-term prosperity of Canada's natural resource sector.

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Appendices

APPENDIX 1: METHODOLOGY

Our study uses a set of qualitative methods to study the question of circular economy in Canada's natural resource sectors. We used various research tools for collecting qualitative data and conducting research, including:

- Literature Review and Data Collection:
    - Desk review of previous circular economy studies and reports;
    - Collection of relevant information from secondary sources, for example, statistics (e.g. energy, mining, forestry sectoral data, financial data), laws, regulations, institutional structures, academic journals, books, etc.
- Qualitative approach:

We undertook two types of qualitative approaches:

In the research phase, we held **Key Informant Interviews**, in which we interviewed 24 relevant government officials and experts. The respondents were selected from:

- Natural Resources Canada (6 different sectors)
- Forest Products Association of Canada
- Mining Association of Canada
- Emissions Reduction Alberta
- Smart Prosperity Institute

We then used a set of objectives to evaluate different policy options. We have divided the objectives into a primary objective and six secondary objectives.

We used Jurisdiction as a filter criterion to differentiate between options that could be adopted by the Government of Canada alone and those involving shared or provincial jurisdictions.

We used a matrix to compare the filtered options. Our analysis of this matrix included the relative weights of each objective and captures the uncertainty tied to the options. Our recommendations are based on the ability of each option to meet the overall circular economy and secondary objectives.

Primary Objective: Effective Circularity

The primary objective of our recommendations is to address the issue of circularity. We are using the components of our developed circular economy assessment tools as factors to assess the circularity of the options.

After reviewing existing circular economy assessment metrics, we have developed an upstream-focused metric for a resource-based economy like Canada, which is called the “OURRRR” Circular Economy Evaluation Tool. The”OURRRR”evaluation tool is built off two pre-existing frameworks: “9R” and “ReSOLVE”. While 9R focus is very broad and includes all multidisciplinary content, ReSOLVE’s focus is quite narrow, and it is on the utilization of physical assets. “OURRRR” framework will act as the preliminary assessment evaluating the “circularity” of each proposed policy option, where three levels of circularity have been distinguished.

Figure: “OURRRR” Circular Economy Evaluation Tool

Level	Strategy	Description
High	Optimize	Increase efficiency Consume fewer resources by sharing materials, knowledge, best practices, etc.
	Upgrade	Shift to renewable energy and materials or replace old non-renewables with advanced non-renewable materials Reclaim, retain, and restore the health of ecosystems
Medium	Revitalize	Reuse of resources and materials to fulfill their original function after revitalization
	Resuscitate	Use of discarded resources and materials for a different or similar function
Low	Reprocess	Re-mine or recycle materials to obtain the same or lower quality.
	Recover	Recover potential energy from waste

Assessing Effective Circularity through the Canadian Circular Economy Framework:

Description	See Evaluation Tool, above
Factors	Contribution to strategies of Optimize, Upgrade, Revitalize, Resuscitate, Reprocess, Recover
Ranking	
Low	The policy option has a strategy that is unclear on how it contributes to the circular economy OR it meets the criteria for 'reprocess' or 'recover'. It is more like the definition of a linear model of production and consumption.
Medium	The policy option sets out a clear strategy for contributing to circularity, and evidence supports the claim that the plan will meet the criteria for 'Revitalize' or 'Resuscitate'. Policy options that do not directly address circularity, but that are necessary steps for improving circularity in the future, are also ranked as 'medium'.

High	The policy option sets out a clear, concrete plan for contributing to circularity, and evidence supports the claim that the plan can meet the criteria for 'Upgrade' or 'Optimize'.

Secondary Objectives

In addition to the primary objective of circularity, we considered six secondary objectives. For each objective, we assigned each policy option a score of high, medium or low, which follows the convention that higher return values are better than lower return values.

1. Cost-Effectiveness

Description	Relative cost-effectiveness for society of options that can improve circular economy. Cost effectiveness is the extent to which an option has achieved, or is expected to achieve, its results at the lowest possible cost to society.
Factors	Net anticipated benefit to society
Ranking	
Low	Evidence suggests that a lack of cost-effective approaches undermined the potential achievement of the option's target.
Medium	Evidence suggests that there are some cost-effective approaches but still undermines the potential achievement of the option's target.
High	Evidence suggests that cost-effective approaches highly supported the option's targets. One example of this is if the option is commercialized and readily deployable.

2. Administrative feasibility:

Description	The complexity of the planning and implementation of the option; Timeframe of implementation; and administrative burdens on government. This objective provides a qualitative assessment of whether it is plausible that a policy option be implemented.

Factors	The anticipated relative time and other resources (including finances) required for planning and implementing the option, and the administration complexity of the option.
Ranking	
Low	Involves complex procedures, high cost, high planning burden, lengthy process and/or untimely implementation
Medium	Uncertainties about timing of planning or implementation
High	Straightforward or easy process, low cost, ease of planning, short and timely implementation

3. Technical feasibility:

Description	Measures the options based on the availability, scale, stage of technology. Like administrative feasibility, this objective provides a qualitative assessment of whether it is plausible that a policy option be implemented.
Factors	Extent to which relevant technologies are commercialized, deployable, scalable.
Ranking	
Low	Major technical obstacles exist for getting it to the implementation phase
Medium	Technology exists, but is still in its early stages or has not been widely implemented
High	Technology exists and is widely available for implementation

4. Equity

Description	This category evaluates whether options may help to achieve long-term social equity by equitably distributing burdens, including on non-industry

	stakeholders (e.g., affected residents/citizens), industry, and to future generations.
Factors	Ensure that the most disadvantaged don't bear a disproportionate share of costs, shared liability, geographical fairness, treating big firms and small firms fairly
Ranking	
Low	Disproportionately affects specific groups, or exacerbates existing inequity or exclusiveness
Medium	No readily apparent change to the current environmental equity or proportional distribution of costs and benefits across communities; no one group bears any disproportionate change in benefits or burdens
High	Clear promotion of social, environmental, economic equity and inclusiveness

5. Competitiveness

Description	Extent to which the option can ensure positive economic benefits for Canada's natural resource sector and/or extent to which option boosts economic opportunities or market competitiveness for Canadian firms.
Factors	sectoral-level competitiveness of Canadian firms; private sector cost-effectiveness; increased export opportunities; creation of new markets or products (diversification); maximize revenue within domestic value chains; increased private sector participation in markets.
Ranking	
Low	Option supports none of the factors, or economic effects too uncertain/indirect to anticipate.
Medium	Policy option is likely to meet one of the factors described above
High	Policy option likely to meet two or more of the factors above; direct contribution to the growth of Canadian economy

6. Measurability

Description	The ability to evaluate the impact of the proposed policy option if implemented. Measurability is essential in order to evaluate whether an implemented policy is meeting its objectives. Though implementation is out of scope of the present project, it is important to assess whether there was reasonable potential for measurement at the stage of selecting options.
Factors	Existing or potential standards, metrics, or benchmarks. This may include qualitative and/or quantitative analyses.
Ranking	
Low	No identified metrics/benchmark, or no capacity to measure; intangible, unable to directly assess the benefit immediately/require more work to report
Medium	Some effort required to identify metric/benchmark and/or to measure it; intermediate results available, requires more substantial changes to the organization.
High	A metric/benchmark exists and capacity to measure exists.

Selected Sources for Appendix 1:

Okorie, Okechukwu, Konstantinos Salonitis, Fiona Charnley, Mariale Moreno, Christopher Turner, and Ashutosh Tiwari. "Digitisation and the circular economy: A review of current research and future trends." Energies 11, no. 11 (2018): 3009.

Williams, Jeremy. “The ReSOLVE framework for a Circular Economy.” The Earthbound Report, last modified September 12, 2016. https://earthbound.report/2016/09/12/the-resolve-framework-for-a-circular-economy/

Michael Howlett et al, Studying Public Policy: Policy Cycles & Policy Subsystems, 3rd ed (Canada : Oxford UP, 2009) 195.

Brian W. Hogwood and Lewis A. Gunn, Policy Analysis for the Real World (UK: Oxford UP, 1983) 219.

APPENDIX 2: POLICY OPTIONS

We assembled a large number of policy options for consideration. Our goal was to think broadly and avoid pre-picking "winners" or "losers" before considering each option as objectively as possible through our matrix. All concrete policy options were run through our matrix in order to identify final recommendations. The report itself focuses on the recommended options.

ENERGY SECTOR

1) Adjust and Extend ISED's Sustainable Development Technology Fund: (Support existing projects to build scalability)

Ensure that this fund, under the purview of the Minister of ISED, is extended beyond its present funding cycle, and adjust its environmental requirement to reflect a circular approach.

- **Effective Circularity:** Possibility of prioritizing or increasing funding for projects with higher circularity. However, not all projects will make it to market. Assesses projects as the requests come in, so not picking the "most" circular out of a range.
- **Cost-Effectiveness:** The cost of the fund is discretionary, but previous top-ups have varied from $30M to $300M. If the policy is successful it will yield high benefits. The opposite can happen too.
- **Administrative Feasibility:** Projects that come out of the R&D stage need help to be scaled up to the commercial stage. The programming is already created by the Government of Canada, under the purview of the Minister of ISED and provides funding for projects that have demonstrated proof of concept but are pre-commercial.
- **Technical Feasibility:** There is technology readiness for Level 3-8, but there might be need for more technical support.
- **Equity:** The program is less likely to disproportionately affect any group of people and the effect on environmental benefit is not apparent. It may affect a subset of start-up companies or established firms which apply for funding.
- **Competitiveness:** The existing projects created 10,943 jobs since fund creation; 27 new projects have entered the market. It provides bridge support between R&D and

commercial stages for Canadian projects. It also supports projects that private sources are also willing to support.

- **Measurability:** The impact of the policy is measurable as ISED has evaluation metrics.
- **Score:** This option is both administratively and technically feasible, since the infrastructure and program already exist. The Fund already is subject to measurement through annual evaluation by ISED. The cost of the fund is discretionary, but previous top-ups have varied from $30M to $300M. The efficiency of the fund is difficult to assess. Not all projects that receive funding will succeed. However, because the eligibility criteria require that projects receive some private funding, projects that have no commercial value are unlikely to be accepted. Some of the projects supported by the Fund do ultimately reach the market: in 2018, about 25% of completed, funded projects had entered the market.

Selected Sources:

CO2 Sciences, and The Global CO2 Initiative. Global Roadmap for Implementing CO2 Utilization. Global CO2 Initiative, August 13, 2019. https://deepblue.lib.umich.edu/handle/2027.42/150624.

Innovation, Science and Economic Development Canada. “Evaluation of the Sustainable Development Technology Fund.” Audits and Evaluations. Government of Canada, March 2018. https://www.ic.gc.ca/eic/site/ae-ve.nsf/eng/h_03866.html.

2) Work to Expand BDC Cleantech Practice's Commercial-Stage Projects (Support existing projects to build scalability)

Ensure and/or expand commitments to future investments through the existing framework of Business Development Bank of Canada's Cleantech Practice

- **Effective Circularity:** No overall structure that directly relates to circularity. Increase anything that falls into the broad category of "cleantech". Projects come from several areas (biorefinery products, energy efficiency, energy infrastructure, extractive processes and products, power generation, recycling, recovery and remediation, transportation, water and wastewater, industrial processes and products, agriculture). Projects are assessed as the requests come in, so they do not necessarily pick the "most" circular.
- **Cost-Effectiveness:** Provides funding to all eligible projects, but not all projects will make it to market. Last commitment was $700 million to BDC in January 2018 until 2025 with $153 million for fiscal year 2019.
- **Administrative Feasibility:** Few or no changes would need to be made to the existing administrative framework through BDC. Cleantech Practice already has separate monitoring and reporting requirements than other BDC streams.
- **Technical Feasibility:** This recommendation focuses on technology readiness levels 7 through 9.
- **Equity:** The program is not likely to disproportionately affect any group of people. Effects on the environment are too indirect to measure. Cleantech Practice has excess capital protected so that is not used in other BDC funding.
- **Competitiveness:** Supporting pre-commercial projects may increase long-term competitiveness. Projects are selected by experts in financing small- and medium-sized cleantech businesses. BDC has a good history of funding clean energy projects. Cleantech Practice is not used in calculation of the BDC Internal Capital Ratio, presumably to protect this stream and encourage its future growth.

- **Measurability:** Funding **(**money promised, allocated, and used year-over-year) is measured. Success of cleantech investments is measured via the Clean Growth Hub. Measuring effectiveness of funding is difficult, but work is ongoing to address this.
- **Score:** Depending on the supported programs, the policy can have very high circularity, or medium to low circularity. Therefore, we scored the policy as medium for circularity. This option is both administratively and technically feasible, since the infrastructure and program already exist. The Fund already is subject to measurement through annual evaluation by BDC. The cost of the fund is discretionary, but the last commitment was $700 million to BDC in January 2018 until 2025. The efficiency of the fund is difficult to assess. Not all projects that receive funding will succeed.

Selected Sources:

Bioindustrial Innovation Canada. “BioDesign.” Canada's Bioeconomy Strategy. BioNB, BIOTECanada, FPInnovations and Forest Products Association of Canada, May 14, 2019. https://www.bincanada.ca/biodesign.

Business Development Bank of Canada. “Who We Are.” BDC. Accessed July 5, 2020. https://www.bdc.ca/en/about/who-we-are/pages/default.aspx.

Business Development Bank of Canada. “2019 Annual Report.” BDC, June 11, 2019. https://www.bdc.ca/en/documents/annualreport/bdc-annual-report-2019.pdf.

Smart Prosperity Secretariat. “New Thinking.” Canada’s Roadmap to Smart Prosperity. Smart Prosperity Institute, February 2016. https://institute.smartprosperity.ca/sites/default/files/newthinking.pdf.

FORESTRY

3) Old Growth Logging - Harvest Less Old-Growth Forest (Regulatory measures)

- **Effective Circularity:** Focusing on re-harvesting would incentivize fully sustainable replanting and harvesting strategies like partial harvesting and avoiding the use of pesticides. It would reduce the footprint of forestry on old-growth forests. It may create market motivation for circularity. Firms will be more likely to adopt sustainable practices if their future profitability depends on the productivity of the same piece of land.
- **Cost-Effectiveness:** The policy may involve cost of convening meetings, developing a best practices document or other leadership tools.
- **Administrative Feasibility:** The policy may involve convening meetings, developing a best practices document or other leadership tools.
- **Technical Feasibility:** There is previous and ongoing research on old growth forests.
- **Equity:** The policy will help to reduce the environmental footprint of forestry, especially on old-growth forests and preserve ecosystems in old growth forests.
- **Competitiveness:** The policy may create market motivation to maximize value from harvest. Some firms may see this as an invitation to clear cut.
- **Measurability:** Directly measurable based on provincial data.
- **Score:** The policy scores high in circularity as it helps to retain ecosystem health and it maximizes value from harvested trees. The costs involved to implement this policy will offer a net positive outcome to society, with some lost opportunity cost for forest producers. If there is sustained pressure on this recommendation, the lost opportunity cost will translate into efficient cost-savings from medium- and long-term responsible land use. This recommendation scores high on cost-effectiveness. As there is previous and ongoing research on old growth forest, developing tools will be fairly simple. The

discussions with provinces for facilitating this move can also start immediately, with existing forums and scope of mandate through the Canadian Council of Ministers of the Environment. Therefore, it scores high in both administrative and technical feasibility. Even though the policy might help to maximize value from harvesting and diversifying the market, the forestry industry might see this policy as negatively affecting their sectoral-level competitiveness. So, the policy scores a medium in competitiveness. However, the policy ensures preservation of future resources and ecosystems, so it increases intergenerational equity and environmental equity. The policy can directly be measured based on provincial data. This recommendation scores high on the equity and measurability category.

Selected Sources:

Lavoie, Judith. "'Indicative of a Truly Corrupt System': Government Investigation Reveals BC Timber Sales Violating Old-Growth Logging Rules." News. The Narwhal, October 7, 2019. https://thenarwhal.ca/indicative-of-a-truly-corrupt-system-government-investigation-reveals-bc-timber-sales-violating-old-growth-logging-rules/.

Price, Karen, Rachel F. Holt, and Dave Daust. "B.C.'s Old-Growth Forest: A Last Stand for Biodiversity." Veridian Ecological Consulting, April 2020. https://veridianecological.files.wordpress.com/2020/05/bcs-old-growth-forest-report-web.pdf.

4) Ban on Single-Use Plastics - ECCC (Regulatory measures)

- **Effective Circularity:** Ban single-use plastics in Canada, subject to certain exceptions (healthcare, etc.). Single-use plastics are high-volume, low-quality products that are generally not circular. We recommend including consumer and other single-use plastics, though some exclusions may be appropriate for medical equipment, etc. For increasing circularity, this option should be paired with:

  Supporting municipal composting initiatives: if composting can become widespread, it may increase use of compostable materials over other alternatives. It could also (if soil quality is tested properly) replace peat, potash, and other products used to support agriculture. This could lead to job redistribution from mining to composting centres (likely to be distributed across the country) and reduction of emissions from mining (though some emissions are created by decomposition). Potash and other mined products could be sold profitably to other countries.

  Supporting municipal biofuel initiatives: This may incentivize the use of residuals, but it will still lead to combustion. It is less circular than composting.

- **Cost-Effectiveness:** The cost for government of implementing this policy is low.
- **Administrative Feasibility:** The policy would require a regulation under existing law. The policy requires enforcement by existing inspectors/police. Timely implementation may be affected by demand for single-use plastics during the COVID-19 pandemic.
- **Technical Feasibility:** Government will have to define single-use plastics.
- **Equity:** It will disadvantage the petrochemical sector by reducing demand for disposable plastics, but may increase demand for other plastic, pulp and paper, or metal-based alternatives.
- **Competitiveness:** This would increase demand for substitute products including reusable plastics or metals and forestry-based alternatives like paper and biofilm. It could stimulate innovation within the sector. It could also make Canada a leader in these products, giving

Canadian industries an edge that could help in other (non-domestic) markets as they reduce their single-use plastic consumption.

- **Measurability:** It can measure the diverted residual or change in quantity of residual produced.
- **Score:** The policy scores high in circularity as this will be a shift to renewable materials. The policy will increase efficiency as the cost-effectiveness of banning is high. The policy needs additional enforcement support from ECCC. It scores medium in administrative feasibility and high in technical feasibility. The policy scores low in equity as it disproportionately impacts the plastic industry. Nonetheless, the overall competitiveness for Canada increases. The impact of the policy is also high. ECCC, not NRCan, could implement the policy.

Selected Sources:

Canadian Environmental Protection Act, 1999 S.C. 1999, c. 33

Government of Canada. "Canada to Ban Harmful Single-use Plastics and Hold Companies Responsible for Plastic Waste." June 10, 2019. https://pm.gc.ca/en/news/news-releases/2019/06/10/canada-ban-harmful-single-use-plastics-and-hold-companies-responsible.

5) Promote Made-Of-Wood (MOW) for Buildings and Architecture (Increasing demand)

- **Effective Circularity:** The idea is to increase international market opportunities for wood-based products in the construction of innovative tall wood buildings, timber bridges, and low-rise wood buildings in international markets. This proposal would reduce GHG emissions from renewable and sustainable forestry resources. The building designs would be innovative and energy efficient.
- **Cost-Effectiveness:** The project could be funded from the Softwood Lumber Action Plan that is $867 million to expand overseas markets.
- **Administrative Feasibility:** Some challenges may arise in coordinating EDC, NRCan, industry stakeholders, and the provincial government to promote this project.
- **Technical Feasibility:** This program is similar to NRCan's Green Construction through Wood (GCWood), therefore NRCan and EDC can use similar guidelines for this policy.
- **Equity:** The policy will disadvantage the market for non-timber construction materials.
- **Competitiveness:** Demonstrated innovative traditional and non-traditional wood-based buildings and timber bridges can be replicated. Not only would it increase market opportunities for international communities dependent on forestry activities but also help to generate new revenue and increase competitiveness of the forestry industry.
- **Measurability:** There are rating systems such as Leadership in Energy and Environmental Design (LEED) that can be used to measure how sustainable, efficient and cost-effective these wood buildings are. However, it is difficult to measure how exported goods are being used.
- **Score:** The policy will increase high levels of circularity as it increases efficiency in building construction and helps to retain the health of ecosystems. If successful, the policy improves export market and market competency with a low amount of investment. Since GCWood has already been implemented, the technical knowhow is already there. The

policy would require NRCan to work with EDC to influence the export market, which creates some administrative complexity. Even though the policy will improve the global environment, it disadvantages the brick market. It is also difficult to measure the impact of the policy as some aspects will be international. Even though this option passes through our cut-off point, the risk of implementing this option is that EDC might not be able to influence the international market to get Canadian wood.

Selected Sources:

Natural Resources Canada. “Green Construction through Wood (GCWood) Program.” Forest Sector Funding Programs. Government of Canada, June 22, 2020. https://www.nrcan.gc.ca/green-construction-through-wood-gcwood-program/20046.

MINING SECTOR

6) Financial and Research Support to Re-mine and Decontaminate Orphaned and Abandoned Mines (Supporting Scalability)

Targeted financial support to re-mine (and decontaminate) residual materials through a 5- to 10-year pilot project. NRCan to support R&D to demonstrate the potential of existing technologies to industry.

- **Effective Circularity:** Efforts are being made to identify opportunities to gain value from mining 'waste', but the potential value that can be extracted generally exceeds the costs and/or risks of such a project. Incentives would encourage firms to decontaminate existing legacy sites (specifically orphaned and abandoned mines). This option would reduce long-term liability for contaminated areas and would rehabilitate the environment.
- **Cost-Effectiveness:** The cost of decontamination and re-mining is high. For example, in 2016 British Columbia estimated the outstanding liability for known abandoned mining sites in its jurisdiction alone at $508 million. If not properly done, disturbing stable mining tailings can cause further environmental contamination.
- **Administrative Feasibility:** It may be possible to proceed by contribution to existing provincial programs. In this case, administrative complexity would be low. There is some existing work through the Federal Contaminated Sites Action Plan (FCSAP) started in 2005 until 2020 and recently renewed for another 15 years. Potential lessons learned to be shared on these projects.
- **Technical Feasibility:** New technological support required for re-mining and decontamination. Technology exists in some capacity but may require proof of efficacy.
- **Equity:** The option is expected to clean up environmental liability through the process of re-mining and using modern day mining standards.

- **Competitiveness:** It could improve negative perceptions of the mining industry. It could also support innovation: with costs supported by the government, firms may be more likely to try new techniques to obtain value from mining waste. It may create jobs.
- **Measurability:** Measurable by number of sites; cost of liability reduced
- **Score:** This option scored high on circularity because it would support restoration of the environment. It is administratively feasible, and measurable. Because it would restore environmental quality in remote and rural areas and create jobs, it was perceived as improving equity. However, subsidies like this are not considered very efficient. It was not clear that technology exists to decontaminate all sites. It was also not clear whether subsidizing these activities would make the industry more competitive.

Selected Sources:

Government of Canada. "Action plan for contaminated sites." July 24, 2019. https://www.canada.ca/en/environment-climate-change/services/federal-contaminated-sites/action-plan.html.

Government of Canada. "Mining Value from Waste: A Potential Game Changer." May 23, 2019, https://www.nrcan.gc.ca/simply-science/21944.

Ministry of Forests, Lands and Natural Resource Operations. "2016 Biennial Report." Crown Contaminated Sites Program. Government of British Columbia, June 9, 2016. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/site-remediation/docs/reports-and-presentations/biennial_report.pdf.

Zinck, Janice, Bryan Tisch, Terry Cheng, and Rory Cameron. "Mining Value from Waste Initiative: Towards a Low Carbon and Circular Economy" In REWAS 2019: Manufacturing the Circular Materials Economy. Ed. by Gabrielle Gaustad et al. https://www.springerprofessional.de/en/rewas-2019/16481690?tocPage=1.

ALL or OVERLAPPING Sectors

7) A Big-Picture Rethink by Prioritizing Wellbeing in Departmental Decision-Making (Big picture/Structural changes)

- **Effective Circularity:** By incorporating alternative definitions of measuring growth, focus can shift to better consider the lifecycle effects of business decisions and hence have positive effects on circularity. The policy would indirectly promote all forms of circularity. It would also promote non-producer aspects of circularity (manufacturing, consumer). This would reduce the silo effect and send a signal that everyone, not just natural resource producers/regulators, is responsible for increasing circularity.

  Wellbeing and circularity do not have to mean abandoning or reducing primary production. A government-wide, market-wide approach would help negate this perception.

  This signal could push others in supply chains to look for greater value.

- **Cost-Effectiveness:** It would require political capital. Some initial studies required to determine what factors should be included in the index. Much work on this has been done already by other countries, especially New Zealand, and could serve as a starting point.

- **Administrative Feasibility:** Integrating vocabulary into NRCan's documents would require policy. Obtaining support for a pan-government change like this would initially require a high level of administrative effort. However, once in place, administrative complexity would be negligible.

- **Technical Feasibility:** Initial studies are needed to determine what factors should be included in the index.

- **Equity:** Sustainable economic activity and protection of the environment are both part of the *OECD Better Life Index*. Adopting this index or a similar one (as New Zealand has done) would integrate these priorities into government decision-making.

- **Competitiveness:** This policy would send clear signals that would allow natural resource stakeholders to make long-term decisions about increasing circularity of their own operations. It would signal to the world that Canada's natural resources are environmentally and socially conscious and could boost to the Canadian "brand".
- **Measurability:** The index would include measurable factors (see for example the OECD Better Life Index). Impact on circularity would be measured by proxies.
- **Score:** By incorporating circularity into all decisions, adopting a wellbeing approach would support a commitment to the long-term transition to a circular economy. It would send clear signals that would allow natural resource stakeholders to make long-term decisions about increasing circularity of their own operations. It would signal to the world that Canada's natural resources are environmentally and socially conscious, an invaluable boost to the Canadian "brand". Other jurisdictions have demonstrated that adopting a wellbeing index, even for important decisions like budgeting, is possible. Making decisions based on wellbeing would have a positive impact on equity. It could be cost efficient. Administratively, working with wellbeing criteria would not be complex for NRCan. It would require a phase-in period with traditional measures like GDP. Developing a pan-governmental approach would be highly complex.

  This is a big-picture, long-term, broad-scope policy option. It is within the scope of the project but for long-term success, it requires several departments to support this strategy. The scope of upfront studies required for a Canada-specific application contributed to it not being retained as a final policy option.

Selected Sources:

Bleys, Brent. "Beyond GDP: Classifying Alternative Measures for Progress." Social Indicators Research 109, no. 3 (2011): 355–76. https://doi.org/10.1007/s11205-011-9906-6.

Giannetti, B.F., C.M.V.B. Almeida, Feni Agostinho, and Donald Huisingh. "A Review of Limitations of GDP and Alternative Indices to Monitor Human Wellbeing and to Manage Eco-System Functionality." Journal of Cleaner Production 87 (2015): 11–25. https://doi.org/10.1016/j.jclepro.2014.10.051.

Kapoor, Amit, and Bibek Debroy. “GDP Is Not a Measure of Human Well-Being.” Economic Development. Harvard Business Review, October 4, 2019. https://hbr.org/2019/10/gdp-is-not-a-measure-of-human-well-being.

Mckenna, Tom, Ralph Blaney, Rob W. Brooker, David A. Ewing, Robin J. Pakeman, Paul Watkinson, and David O'brien. “Scotland’s Natural Capital Asset Index: Tracking Nature’s Contribution to National Wellbeing.” Ecological Indicators 107 (2019): 105645. https://doi.org/10.1016/j.ecolind.2019.105645.

Organisation for Economic Co-operation and Development. “OECD Better Life Index.” OECD. Accessed June 12, 2020. http://www.oecdbetterlifeindex.org/.

Osberg, Lars, and Andrew Sharpe. “Comparisons of Trends in GDP and Economic Well-Being - the Impact of Social Capital.” Essay. In The Contribution of Human and Social Capital to Sustained Economic Growth and Well-Being: International Symposium Report. Organisation for Economic Co-operation and Development. Human Resources Development Canada, 2001. https://www.oecd.org/innovation/research/1824740.pdf.

The Treasury New Zealand. “Our Living Standards Framework.” New Zealand Government, December 12, 2019. https://treasury.govt.nz/information-and-services/nz-economy/higher-living-standards/our-living-standards-framework.

“Measuring Wellbeing: the LSF Dashboard.” New Zealand Government, December 12, 2019. https://treasury.govt.nz/information-and-services/nz-economy/higher-living-standards/measuring-wellbeing-lsf-dashboard.

8) Support the Establishment of Renewable-energy District Heating Systems (Supporting existing projects to support scalability)

This policy would support renewable-energy-based district heating systems, in areas where fuel or natural gas costs are high.

- **Effective Circularity:** The energy can use residual products such as waste wood to fuel these systems and make communities more energy independent. The policy will help Canada to shift to renewable energy and materials, increase efficiency in producing energy and consumers will have shared energy resources.
- **Cost-Effectiveness:** The cost will vary depending on geography. For example, a recent project by the Teslin Tlingit Council received $595,000 to buy biomass wood chip boilers as part of a larger project aimed at reducing reliance on non-renewable heating fuels.
- **Administrative Feasibility:** NRCan would need to work with different levels of jurisdiction (e.g. provinces, territories, municipalities, and Indigenous governments) There could be some administrative complexity.
- **Technical Feasibility:** Technology exists. At present there are 6 climate-friendly district heating projects that are approved.
- **Equity:** It can serve as an alternative to traditional heating systems. It is generally used as a sustainable heating substitute for fossil fuels. This helps to reduce GHG emissions. The policy also increases self-reliance of communities that otherwise have to bring in diesel or other energy sources.
- **Competitiveness:** The policy will help to create construction and maintenance jobs, e.g. Teslin District Heating System. Can provide benefits to a certain energy sector depending on the source of the heat.
- **Measurability:** The project guidelines of the current 6 climate-friendly district heating projects can be used to measure the effect.
- **Score:** Several studies all around the world showed that compared to small heating projects, a combined district heating system is more cost effective. The setting up cost

would be high, but the operating cost will be lower. Therefore, in the long run increasing to district heating systems will be cost efficient. Implementing the policy will require NRCan to work with provinces, territories, and municipalities as well as other project proponents. This might create some level of administrative complexity. However, NRCan has established working relations with most levels of governments. Therefore, the administrative complexity would be medium. Since district heating projects already exist, technical feasibility of this option is high. The project guidelines can be also used to measure the impact of the policy. The policy ensures intergenerational equity and environmental equity as it increases accessibility to energy, and also reduces GHG emissions. This policy can also help in creating jobs and a new energy market and scores high on competitiveness.

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9) Government Procurement and Infrastructure Investment in Circular Economy Materials (Supporting existing projects to support scalability):

The option will set procurement guidelines for government officials to formulate government-wide procurement and investment strategies to achieve the national circular economy goal

- **Effective Circularity:** By modifying existing procurement guidelines, the government can use its buying power to favour broad categories of goods and services that help it meet its circular economy strategy. Lifecycle analysis of products will help it follow the stages of processing and manufacturing of products. The European Commission has a guidance document on public procurement for a circular economy that focuses on closed energy and material loops in the supply chain. This would allow for upfront consideration of waste creation.
- **Cost-Effectiveness:** About the same level of expenditure as normal procurement, with revised guidelines.
- **Administrative Feasibility:** Procurement practices and regulations vary across Canada. This will require coordination across federal, provincial, and municipal levels to assist in best practices. Canada's procurement guidelines will have to be revised to include those best practices.
- **Technical Feasibility:** Actions are within scope of the federal government due to their large consumption of materials. This will require technical considerations of product lifecycles.
- **Equity:** The current guidelines will need to be updated and reviewed. Potential impact on companies that are unaware of the lifecycle analysis of their products.
- **Competitiveness:** As a special consumer group, government agencies can become the preferred choice of circular economy product consumption. Not only can this prioritize methods that reduce energy consumption at the source and protect the environment,

but also can play a role in promoting people's circular economy awareness, and expanding the market.

- **Measurability:** A list of products that have been procured and are in line with the circular economy. It is possible to track changes periodically. Research required to identify all stages of the supply chain for goods.
- **Score:** This option, if implemented, would be a "high" promoter of circularity by favouring efficient and renewable materials. Government procurement is considered an effective way to stimulate market demand and signal government priorities (in this case, circularity). While significant work would be required to develop criteria or standards and to apply them to different types of government procurement, it would be technically and administratively feasible to do so. Overall, this option scored quite highly. However, this option primarily affects consumption-side products and as such was on the periphery of the project scope. This is the main reason why this option was not recommended. Concerns were also raised that this option may run afoul of international trade agreements and rules about government procurement.

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10) Increase the Output-Based Pricing System (Regulatory Measures):

Use the Pan-Canadian Framework on Clean Growth and Climate Change as the mechanism for increasing the carbon tax at the federal and provincial levels. The Output-Based Pricing System (OBPS) will get producers to internalize the cost of emissions into how they operate.

- **Effective Circularity:** Pushes firms towards paying tax, buying credits, or switching to new technology or new methods to reduce GHG emissions.
- **Cost-Effectiveness:** Quite a cost-effective way to reduce emissions along with other carbon pricing systems like the cap-and-trade system. Tax is $20 per tonne of CO2 equivalent this year, going up by $10 per year. The Parliamentary Budget Officer estimated that this policy will generate $2.63 billion in revenue in 2019-2020. The majority of the revenues are from the fuel charge (charge on fossil fuels) as opposed to the industrial facilities emissions (OBPS).
- **Administrative Feasibility:** System largely being put in place or already in place. Administrative cost to administer the Federal Fuel Charge (part 1 of the 2-part federal carbon tax policy) and the Climate Action Initiative (to return money through taxes) is between $30-50 million per year (2018-2022 is estimated at $174.5 million. Lots of costs in start up years, but decline after 2022.
- **Technical Feasibility:** Enforcement may be an issue and measurement of GHG emissions.
- **Equity:** The reporting requirements under the *Greenhouse Gas Pollution Pricing Act* have increased burdens on companies. Companies have already adjusted to some of these requirements, but more adjustments are anticipated in the next couple of years. Concerns from citizens and governments mostly about the fuel charge, also about the OBPS. Some legal challenges from Ontario and Saskatchewan.
- **Competitiveness:** OBPS is market-based and flexible. It puts a price on carbon pollution. Potential that trade-exposed businesses will leave Canada due to increased standards and reporting requirements.

- **Measurability:** Will reduce CO2 emissions, since the output-based pricing system applies to industries emitting over 50,000 tonnes of CO2e per year; however, unsure of the exact number of companies that will aim to be below this.
- **Score:** By setting increasing benchmarks on the amount of GHG emissions a firm can emit per year, firms that choose to emit above a certain level have to pay a tax or buy credits from other firms in order to keep their GHG emissions below a pre-set amount. Firms that produce below the annual benchmark receive credits and can sell them to other, more emissions-heavy firms to make a profit. For these reasons it was deemed to be a highly cost-effective option. It directly targets GHG emissions and scores highly on circularity by indirectly forcing firms to increase energy efficiency of their operations as well as shifting to renewable energy sources. The OBPS scored lower on equity due to potential price increases passed onto manufacturers and consumers down the line and the heavy burden placed on large companies with many operations and emissions.

Selected Sources:

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11) Collecting Data to Identify Circularity Opportunities and Gaps (Data collection/analysis):

- **Effective Circularity:** This policy option is designed to better NRCan's business knowledge and develop a public database. This database will be compiled from a collection of data through existing resources from other federal agencies (i.e. Statistics Canada), provincial databases, and private sector to document gaps in value chains. Consequently, NRCan can obtain information to oversee and make future policy decisions to optimize the value chain in Canadian natural resources sector, improving efficiency and circularity.
- **Cost-Effectiveness:** This option should be cost-effective because it will be collecting existing and available data.
- **Administrative Feasibility:** There are two ways in which this option could be implemented: either the government should collect data and then would be in a position to act on it; or, the government should require publication of data, so that industry, market, and government would all be in positions to act on the data. There would be more industry resistance to the latter than the former.
- **Technical Feasibility:** The technology itself exists in the forms of data transmission technologies or data analysis tools.
- **Equity:** Data plays a decisive role in how decisions are made, but sometimes the way data was collected and used can lead to biases that can have a significant impact on the outcome. While the aim is to identify hidden circular opportunities and gaps, better use of existing data could provide an opportunity to improve industry information for future ventures, and government knowledge for future policy-making.
- **Competitiveness:** The option would help to improve the overall picture of Canada's natural resources sector. Significant supply issues like forest fires, invasive species, and the presence of species at risk, may affect the availability of primary materials, but Canada lacks an overarching view of these different issues in different provinces. Data can help companies forecast economic conditions, grasp market conditions, understand consumer demand, and improve R&D efficiency. Making better coordination and use of existing data

from various natural resources sectors not only has great potential business value, but also provides new ideas for enterprises to improve their competitiveness.

- **Measurability:** We can periodically review the size and topics covered by this database. It is also possible to measure the number of visits by NRCan, other federal departments, and the public. While these do not measure economic circularity per se, they provide an indication of whether the data is being used.
- **Score:** Without information, it is difficult to assess what policy interventions are needed and to compare the effectiveness of different options. A more complete vision of the sectors would help NRCan identify future policies that would improve efficiency and circularity and develop measurable indices for circularity. Eventually, this could enable NRCan to find and measure opportunities to maximize value and minimize waste along the value chain. By sharing compiled information (to the extent possible) with industry, NRCan would increase the likelihood that market forces, rather than government intervention, bring about these movements toward circularity. This option was originally proposed for the forestry sector, but in light of similar concerns raised in other sectors, we agreed to include this as a policy option for all sectors.

Selected Sources:

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Treasury Board Secretariat of Canada. "Open Data 101." Open Government. Government of Canada, June 18, 2019. https://open.canada.ca/en/open-data-principles.

12) Initiate or Support A "Concierge" Service (Data collection/coordination/analysis)

NRCan could support the development of a concierge-type service (like the Clean Growth Hub) to help share information along the value chain until such networks are developed within the market.

- **Effective Circularity:** Before making significant changes to their operations, upstream processors want security: knowing that demand for their new processes or materials exists or is likely to exist soon. This is essential in order to develop the infrastructure to make the right products. NRCan could work with its network (ECCC, ISED, provinces) to help create the signals that would motivate downstream users to network and work with those upstream. A series of meetings followed by a written policy document would be a first step to signaling government commitment to this process. Helping firms develop networks and knowledge will reduce current and future obstacles. It has the potential to affect circularity indirectly.

    - **Cost-Effectiveness:** Fairly low cost anticipated, with no need for new program creation. Will serve to de-risk upstream changes to circularity. If upstream industry knew what was wanted downstream, they would make the right changes and develop the right products.

  If market signals already exist, then once parties are "matched", economic incentive would be enough for both upstream and downstream users to move to more circular products and practices

- **Administrative Feasibility:** It requires coordination of federal, provincial, and industry stakeholders. It could be initiated in the short term through a webinar or conference; implementation and results likely to be medium or long term. The current crisis may make networking difficult in the short term. Some of this work steps in other department jurisdictions.

- **Technical Feasibility:** No foreseeable problems for technical feasibility of this service. It would use existing government capabilities (website design, online and telephone communication).
- **Equity:** A key element of circularity is seeing the whole picture of where things come from and go. Firms need to look both backwards and forwards in the value chain. Breaking down silos is critical to improving communication and de-risking changes towards circularity. It has the potential to break down barriers between industry stakeholders and government.
- **Competitiveness:** It can help realize existing potential within the country by connecting distant players (physically or in the value chain).
- **Measurability:** Industries surveys could be used to determine successes and failures and where to look next.
- **Score:** The policy would have high circularity if works well, but the outcome of the policy is not clear, therefore, it scores medium in circularity. The cost related to this policy is fairly low, so it has high efficiency. High level of coordination required between different levels of government, so scores medium in administrative feasibility. NRCan has the required technological knowledge for this policy. It helps the smaller firms to become competitive So, it scores high in technical feasibility, equity and competitiveness. The impact is difficult to measure directly, measurability is low.

Selected Sources:

"Frequently Asked Questions: Clean Growth Hub." Government of Canada. February 7, 2020. https://www.ic.gc.ca/eic/site/099.nsf/eng/00002.html.

13) Continue to Support and Facilitate Collaboration at All Levels (Data collection/coordination/analysis):

NRCan should expand networks of research and industry contacts with other jurisdictions. It could harness the current momentum towards online collaboration to expand its support of discussion fora and formal conferences.

- **Effective Circularity:** Supporting collaboration will indirectly support movement towards all types of circularity.
- **Cost-Effectiveness:** High, but indirect. Costs involved in this option are quite low. Human resources are needed to develop and maintain networks, and some costs will also be incurred for sponsoring events.
- **Administrative Feasibility:** No regulatory change needed. Requires ongoing effort to collaborate, network. May require Memoranda of Understanding (MOUs) or funding for conferences and events.
- **Technical Feasibility:** No technical obstacles foreseen.
- **Equity:** Neutral or slightly positive. Sharing of information may help smaller players and communities more than large firms.
- **Competitiveness:** Research and 'solution-finding' support future competitiveness. Helping to bridge gaps and break down silos may also create new opportunities for Canadian firms.
- **Measurability:** Number of events, stakeholders, and satisfaction of users can be measured. It will be difficult to measure the impact this measure has on circularity.
- **Score:** NRCan has a key role to play in breaking down silos of information, whether within industries, jurisdictions, or between government departments. Circularity requires taking consideration of the past and the future steps in the lifecycle of materials. Moreover, research and 'solution-finding' are activities that benefit from collaboration. NRCan is already playing this role to some extent. Extending these efforts would assist in

establishing a strong working definition of circularity in Canada over the short term and prepare the country for more tangible upgrades to industrial processes in the long term**.** This option scored medium in circularity and low in measurability because of the difficulty in measuring direct impact of this role on the circular economy. It scored highly in efficiency and feasibility. Although this was an important option, given NRCan is already playing this role, it was not included in the main recommendations.

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Appendix 3: MATRIX SCORES

For the secondary objectives we gave a simple score of 1, 2 and 3 to low, medium, high, respectively.

Note: In the far left column, green indicates final recommendations, white indicates other top options, and grey indicates options not retained.

Scores for Energy Sector and Forestry Sector

	Primary Objective	Secondary Objectives							
	Effective Circularity	Cost-effectiveness	Administrative Feasibility	Technical Feasibility	Equity	Competitive-ness	Measurability	**Score - Secondary Criteria**	**Jurisdiction**
ENERGY SECTOR									
Adjust and extend ISED's Sustainable Development Technology Fund	Medium	Medium	High	Medium	Medium	High	High	15	NRCAN, Other Federal
Work to expand BDC program for commercial-stage projects	Medium	Medium	High	Medium	Medium	High	High	15	NRCAN, Other Federal
Impose waste capture and use thresholds	Medium	Medium	Medium	Low	Medium	Low	Medium	10	Other Federal
FORESTRY									
Plan for advanced refineries	High	Medium	Medium	Medium	Medium	Medium	Low	11	NRCAN, Other Federal, Provinces
Old-Growth Logging - Harvest Less Old Growth Forest	High	High	High	High	High	Medium	High	17	NRCAN
ECCC's plastics ban	High	High	Medium	High	Low	High	High	15	Other Federal
Support growth of the domestic recycled plastics sector	Medium	Low	Medium	Medium	Medium	Medium	Medium	11	NRCAN, Other Federal, Provinces
Promote Made-Of-Wood (MOW) program for buildings and architecture	High	High	Medium	High	Medium	High	Medium	15	NRCAN

Scores for Mining Sector

	Primary Objective	Secondary Objectives							
	Effective Circularity	Cost-effectiveness	Administrative Feasibility	Technical Feasibility	Equity	Competitive-ness	Measurability	**Score - Secondary Criteria**	**Jurisdiction**
MINING:									
Boost funding for provincial recycling programs for lithium-ion batteries	Medium	Low	High	Low	Medium	Medium	Medium	11	NRCAN
Full Extended Producer Responsibility for Mining Waste	Low	High	Medium	Low	Medium	Low	High	12	NRCAN, Provinces
Reduce liability risk for diligent decontamination and re-mining of abandoned sites	Medium	Medium	Medium	Medium	High	Low	High	13	NRCAN, Other Federal, Provinces
Financial and Research Support to Re-mine and Decontaminate Orphaned and Abandoned Mines	High	Low	High	Medium	High	Medium	High	14	NRCAN
Develop a waste classification system based on value of residual material	Low	Medium	Low	Low	Medium	Low	Medium	9	NRCAN
Promote partnership programs to address inactive, orphaned sites	Medium	Low	Low	Medium	Medium	Medium	Low	9	NRCAN, Provinces
Launch public education campaign for recycling of lithium-ion batteries	Low	Medium	Medium	High	Medium	Low	Medium	12	NRCAN
Improve/consolidate government knowledge of mining value chains	Medium	High	Medium	High	Medium	Low	Medium	13	NRCAN

Scores for All or Overlapping Sectors

	Primary Objective	Secondary Objectives							
	Effective Circularity	Cost-effectiveness	Administrative Feasibility	Technical Feasibility	Equity	Competitive-ness	Measurability	Score - Secondary Criteria	Jurisdiction
ALL or OVERLAPPING Sectors									
A Big-Picture Rethink by Prioritizing Wellbeing in Departmental Decision-Making	High	High	Medium	High	High	Medium	Medium	15	NRCAN
Ecnourage networked approaches to overcome low density	High	High	Low	High	Low	High	Medium	13	Provinces
Support the Establishment of Renewable-energy District Heating Systems	High	High	Medium	High	High	High	High	17	NRCAN, Other Federal
Government procurement and Infrastructure investment in CE materials	High	High	High	High	Medium	High	High	17	Other Federal
Increase the Output-Based Pricing System	High	High	High	High	Low	Medium	High	15	Other Federal
Increase federal recycled content standards for plastics	Low	Medium	Low	High	Medium	Medium	High	13	Other Federal
Regulation to require labelling re: how long spare parts will be available	Medium	Low	Low	Medium	Medium	Low	High	10	Provinces
Collects data to identify circularity opportunities and gaps	Medium	Medium	High	High	Medium	High	High	17	NRCAN
Develop branding opportunities	Medium	Low	Low	Medium	Medium	High	High	12	NRCAN
Develop educational materials about circular economy	High	Medium	High	High	Medium	Medium	Low	13	NRCAN
Initiate or support “concierge” service	Medium	High	Medium	High	High	High	Low	15	NRCAN
Continue to support and facilitate collaboration at all levels	Medium	High	Medium	High	High	Medium	Medium	15	NRCAN

**Note that “collects data” and “concierge service” options were combined into a single recommendation.*

List of Acronyms

CE	Circular Economy
CMMP	Canadian Minerals and Metals Plan
COVID-19	Coronavirus Disease of 2019
CSS	cyclic steam stimulation
ECCC	Environment and Climate Change Canada
EU	European Union
GBA+	Gender-based Analysis Plus
GCWood	Green Construction through Wood
GDP	Gross Domestic Product
GHG	Greenhouse gas
ISED	Department of Innovation, Science, and Economic Development
IPO-West	Indigenous Partnerships Office-West
KII	Key Informant Interviews
MEND	Mine Environment Neutral Drainage
MOW	Made-of-Wood
NOAMI	National Orphaned and Abandoned Mine Initiative
NRCan	Natural Resource Canada
OBPS	Output-Based Pricing System
OURRRR	Optimize, Upgrade, Revitalize, Resuscitate, Reprocess and Recover
R&D	Research and development
SAGD	Steam-assisted gravity drainage
SITRA	Finnish Innovation Fund
SDG	Sustainable Development Goals

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