Smart Prosperity Institute

REPORT

A VISION FOR A CIRCULAR ECONOMY FOR PLASTICS IN CANADA

THE BENEFITS OF PLASTICS WITHOUT THE WASTE AND HOW WE GET IT RIGHT

FEBRUARY 2019

1. EXECUTIVE SUMMARY

Canada's current *take-make-waste* model for plastics harms the environment and squanders economic opportunity.

Plastics are ubiquitous. While they bring benefits to society, the use of plastics today is a highly wasteful, linear, take-make-waste model that is harmful to the environment, unsustainable in the long-term, and a missed opportunity as value is literally thrown away. This current linear economy for plastics requires energy and generates emissions for each production cycle. This would largely be avoided if plastic was otherwise reused or effectively recycled. The opportunity for Canada's chemical industry to drive innovation and growth in plastics recycling and renewable plastic chemistries is lost.

A plastics circular economy reduces waste and emissions while capturing value.

A plastics circular economy is one that minimizes wasteful use of plastics, produces plastics from renewable sources, is powered by renewable energy, reuses and recycles plastics within the economy without leakage to the environment, and, by extension, generates no waste or emissions.

A plastics circular economy in Canada would recirculate materials in an environmentally- and financially-sustainable closed loop.

A circular economy is characterized by the closed loop flow of materials. Its systems recirculate materials using renewable energy, do not deplete resources and can be perpetuated indefinitely without any accumulation of waste in the environment. A plastics circular economy in Canada would have three key characteristics: renewable resins, the use of renewable energy to power each life-cycle stage, and the recirculation of hydrocarbon molecules that either displace the demand for raw materials or are consumed as nutrients in living systems without harm.

Five barriers currently face the evolution of a circular economy for plastics in Canada.

Canada does not have a plastics circular economy because under current economic and policy conditions, the cheapest way to use plastics is the take-make-waste linear economy. Five barriers to a plastics economy in Canada include: economic disparities driven by direct production subsidies for fossil-based plastics; un-priced and unmitigated externalities; poor exchange of information; technological barriers; and existing policies and regulations that block the development of circular economy practices.

Circularity will result from market evolution, not revolution. It will not happen overnight.

This evolution involves building new commercial relationships, transforming existing exchanges and relationships, redesigning products and packaging, reinventing products and packaging systems to be delivered as services, developing technologies, making investments and changing operations. It also involves shifting consumer cultural norms to change patterns in the consumption and use of plastics, increase participation in circular resource recovery systems, and to prevent plastic pollution.

Governments at all levels have a vital role to play in catalyzing a circular economy for plastics.

Waste policy falls largely (though not exclusively) within the jurisdiction of Canadian provinces and territories. The federal government and the provinces and territories should establish a collaborative approach to national harmonization of definitions, standards, targets and measurement protocols. This report recommends three initial policies and three supporting policies that will catalyze a circular economy for plastics in Canada.

2. INTRODUCTION

The current linear economy has given us a plastics problem in Canada. The use of plastics today is a highly wasteful, linear, take-make-waste model that is harmful to the environment and misses economic opportunities as value is literally thrown away. This linear economy for plastics requires energy and generates emissions for each production cycle that would largely be avoided, were plastic otherwise reused or effectively recycled. Canadian individuals are increasingly concerned with plastic waste and environmental impact. With their consumer and citizen power, they are demanding that businesses and governments respond with a more sustainable approach to plastics.

Fortunately, Canada also has a plastics solution. There is the opportunity to move towards a plastics circular economy that produces plastics from renewable sources, is powered by renewable energy, reuses and recycles plastics within the economy without leakage to the environment, and generates no waste or emissions. A plastics circular economy would be a growth economy recirculating plastics in a manner that harnesses their extraordinary material properties but without waste.

If we are going to strive towards a plastics circular economy, we need to start by answering two key questions: Why do we waste plastic? And what can we do to divert plastics away from disposal and back into the productive economy? That is precisely the purpose of *A Vision for a Circular Economy for Plastics in Canada.* This report seeks to answer these critical questions, exploring the un-priced pollution and waste associated with producing, using and disposing of plastics that subsidizes the plastics linear economy.

This report draws on these findings to inform the development of a Canadian plastics action plan. It looks at the environmental and economic costs of the current linear economy for plastics, and the economic realities that entrench the take-make-waste status quo. It also sets out a definition of a circular economy for plastics in this country, alongside key characteristics at each life-cycle stage. Finally, this report recommends informed and effective policies and market interventions that will catalyze a circular economy for plastics in Canada.

Readers should note that, while this report focuses on plastics specifically, the lens through which the plastic problem is viewed applies to a great many products, packaging, materials and processes that are currently operating with a linear approach but could find systemic solutions in a circular economy.

Circularity will result from market evolution, not revolution. It will not happen overnight. This evolution will involve building new commercial relationships, transforming existing relationships, redesigning products and packaging, reinventing products and packaging systems to be delivered as services, developing technologies, making investments and changing operations. It will also involve shifting consumer cultural norms to change patterns in the use, consumption and recovery of plastics.

There is a role for everyone to play in the transition to a circular economy for plastics in Canada. By their nature, circular economies involve market collaborations. Achieving a circular economy will require new interactions between individuals, governments at all levels, and businesses to evolve from a linear, wasteful model to one that is circular and regenerative. It would be a waste to miss an opportunity to reduce environmental harm while capturing economic value.

It is time to evolve from a linear, wasteful model to one that is circular and regenerative.

3. HOW DO WE CURRENTLY USE AND WASTE PLASTIC?

Plastics are found nearly everywhere. They are in most durable goods such as textiles, flooring, vehicles, electronics, electrical equipment and appliances, in single-use products such as drinking cups, cutlery, straws, plates, bags and wet wipes, and in packaging.

The ubiquity of plastics in products and packaging is due to their light weight, durability and ease of manufacturing as well as their relative low cost. They are an essential material in a wide range of applications that require specific performance and safety standards including aircraft, vehicles, electronics, food packaging and medical devices. For many products, the design processes and supply chains of the business-as-usual economy are built around the properties of plastics.

In Canada, only 12% of the approximately 3.84 million tonnes of plastics generated annually is collected for recycling.

3.37 million tonnes of plastics per year are not recycled

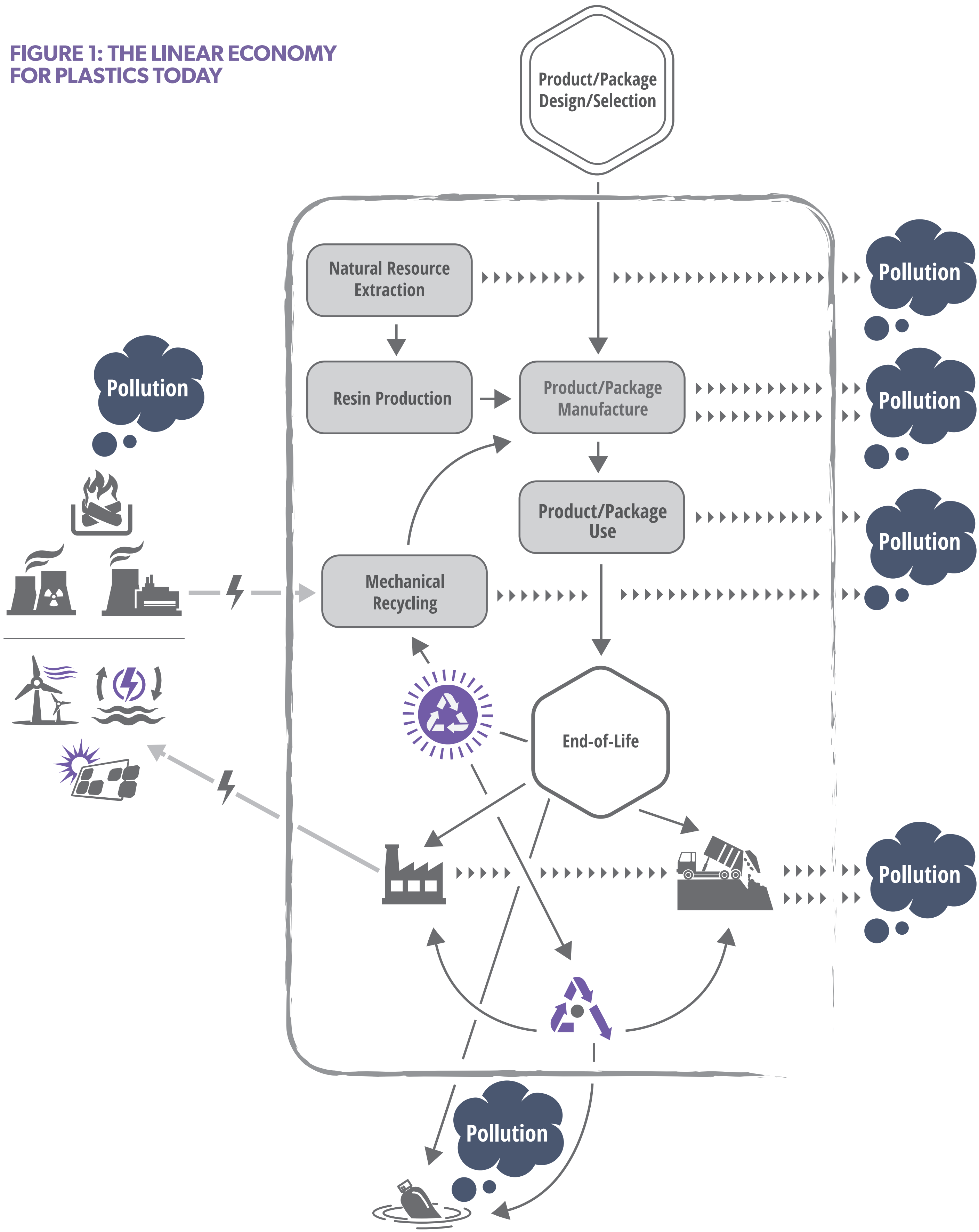
3.1 What are plastics?

Plastics are produced from building block molecules (monomers) which are then chemically linked to form chains (polymers). Polymers of different types may be compounded with other polymers and additives to form plastic resins designed to meet specific engineering requirements. In 2017, 99% of the monomers used in manufacturing plastics were derived from crude oil or natural gas (fossil plastics). Polymers can be made to meet a wide range of applications ranging from the low-density polyethylene found in common single-use bags to acrylics that are used for windows in spacecraft.

3.2 The current linear approach to plastics

While delivering clear benefits, the use of plastics today is a highly wasteful, linear take-make-waste model. Raw materials are extracted, manufactured into plastics, used for a finite period of time, and then disposed of. Globally, as little as 2% of plastics may actually end up being recycled for manufacturing in a closed-loop to displace virgin materials.[1] At a value of between $100 and $150 billion annually, 95% of the material value of plastic packaging is lost to the global economy after only a single use.[2] In Canada, only about 11-12% of the approximately 3.84 million tonnes of plastics generated annually is collected for recycling, and less is actually recycled. The majority of Canadian plastics use is collected as waste and disposed of, with a much smaller but significant portion discarded into the environment.

FIGURE 1: THE LINEAR ECONOMY FOR PLASTICS TODAY



The result is that plastics are not just ubiquitous in our economy – they turn up throughout our ecosystems as well. In Canada, plastics are landfilled and incinerated, and may be discharged to the environment through litter and illegal dumping, ineffective waste management practices such as transfer station and landfill blow off, direct discharge to water bodies through untreated sewage and the dumping of used fishing nets into aquatic environments[3]. Microplastics are a significant source of plastics to the environment. These result from vehicle tire wear, spills of plastic pellets used in manufacturing, those discharged from clothing during use and washing, and from paints and coatings.

This current take-make-waste approach to plastics is bad for the planet, and a lost opportunity for economic growth. The loss of 88% of the plastic used in the Canadian economy results in squandered non-renewable fossil resources, increased greenhouse gases and the discharge of plastics to land and marine environments[4]. The waste and pollution associated with plastics not only results in environmental impact but also represents a deadweight loss to the Canadian economy.

3.3 Framing the problem

If we are going to strive towards a plastics circular economy in which value is retained, we need to start by answering two key questions: Why do we waste plastic? What can we do to address the factors that cause us to waste plastic, so as to divert them back into the productive economy?

Why do we waste plastic? What can we do to address the factors that cause us to waste plastic, so as to divert them back into the productive economy?

In answering these questions, we explore the unpriced pollution and waste associated with producing, using and disposing of plastics that acts as an effective subsidy to the take-make-waste plastics linear economy.

We then identify practical policy approaches and market interventions that will address key externalities and shift existing market behaviours towards a plastics circular economy. We will more fully define this in the next section of this brief.

Readers should note that while the focus of this brief is on plastics, the framing of the linear economy problem and the systemic approach to addressing it is applicable to many products, packaging and materials that are used inefficiently in existing linear economies.

3.4 Opportunity lost and found

Polymers comprise about 40% of the output of the global chemical sector, which is the largest industrial energy consumer and the third largest industrial emitter of carbon dioxide[5].

As we use and make plastic today, each kilogram that is not reused or recycled is replaced with another kilogram produced from non-renewable, fossil-based raw materials. This take-make-waste linear economy for plastics requires energy and generates emissions for each production cycle. This would largely be avoided were that plastic otherwise reused or recycled. Ongoing increases in demand for plastics add further demand for energy and generation of emissions.

A circular economy is not simply more reuse and recycling.

Reusing plastics retains more of the embodied materials and energy in plastic products and packaging. As an example, reuse of secondary plastic packaging such as crates for produce or beverage containers amortizes the energy and emissions used to make a plastic package over dozens of uses. As such, reuse offers the opportunity to reduce life-cycle energy use and greenhouse gas emissions associated with the use of one-way packaging[6].

Recycling also reduces life-cycle energy use and greenhouse gas emissions. Recycling Polyethylene Terephthalate (PET)* in the United States, for example, has been shown to reduce greenhouse gases by almost 70%[7] compared to producing PET from virgin resources.

Unfortunately, of the 12% of plastics collected for recycling, a significant portion is not recycled. Some is lost if it costs more to sort than the sorted plastic can be sold for, when plastic resins are commingled during collection. Contamination of plastics by other materials during their collection further increases sorting costs and degrades the yield available for recycling.

Furthermore, a significant portion of the plastic that is recycled in Canada is "downcycled": it results in plastics that do not have the same chemical and physical properties as the original resins, and therefore cannot be used in the original applications. Currently, once "downcycled", plastics are unable to be recycled further and are subsequently disposed of (in landfill or through energy from waste) or discarded to the environment.

Canada's chemical industry includes both plastics production and a robust plastics recycling sector. Both are ideally poised to capture a significant portion of what is expected to be a USD $55B a year global plastics recycling profit pool by 2030[8].

Canada has more than 200 facilities that are mechanically and chemically processing and recycling plastics. Some are using new, emerging plastics chemical recycling technologies that have been recently commercialized or are on the cusp of commercialization. Few of these facilities are operating to capacity. Canada has historically exported significant amounts of mixed plastic waste to China and Hong Kong because it is uneconomic to sort and process it domestically.

This economic reality has been exacerbated as falling prices of the oil and gas used to make virgin plastics has led to a drop in domestic demand for recycled plastics. The price of virgin fossil resources used to make plastics is a key market determinant of how much investment and effort is made to recycle plastics. The lower the prices of virgin fossil resources, the less incentive there is to recycle the more difficult-to-recycle plastics. This is a key barrier we discuss further on in this brief.

Since 2017, Asian markets that have traditionally received Canada's exported

* A lightweight, flexible, 100% recyclable plastic widely used for beverage bottles, packaging, fibre and fabric applications

mixed plastic waste have instituted stringent contamination thresholds, effectively closing them to Canada's mixed and contaminated plastics.

Faced with this market closure, some have proposed burning mixed plastics for energy in place of coal or heavy fuel oil, as a means to avoid emissions associated with those dirtier fossil fuels.

However, using plastics as fuel overlooks the total embodied energy in plastics - the energy required to extract raw materials, to transport them, to form polymers and to then make plastic resins from polymers which are then used in manufacturing.

The energy recovered from burning plastics typically offsets less than 20% of the primary energy demand for making virgin plastics[9] while also generating greenhouse gases and other by-products of combustion. Recycling recovers dramatically more embodied energy and avoids greenhouse gas emissions, as noted above.

As Canada's national energy mix continues down a path of decarbonization, it makes no sense to burn plastics for energy.[10] What makes economic and environmental sense is optimizing the design and use, collection, and recycling of plastic-containing products and packaging. It makes sense to retain embodied materials and energy by maximizing the yield of recycled plastics.

In discussing reuse and recycling, it important to raise reduction – the first "R" in the traditional waste management hierarchy of Reduce, Reuse, Recycle ("the 3Rs"). Opportunities to reduce plastic use through product and package redesign, implementation of reusable systems or use of alternate materials become evident as market players respond to policies to price pollution and address waste. Making the right choice to reduce, reuse or recycle or some combination thereof is not a matter of policy fiat but market decisions. Producers of products containing plastics or using plastics packaging assess options that are fully priced in terms of financial and life-cycle environmental cost.

While increasing reuse and recycling of plastics will be key to a systemic transformation of the Canadian linear economy to a circular one for plastics, a circular economy is not simply more reuse and recycling.

What makes economic and environmental sense is optimizing the design and use, collection, and recycling of plastic-containing products and packaging.

"The energy needed to recycle polyethylene is only a very small fraction of the embodied energy of the original polyethylene. Therefore, when we recycle plastic, we still make use of the embodied energy. When we burn plastic, that energy goes up in smoke."

Mary Anne White, professor of chemistry (Emerita), Dalhousie University

4. WHAT WOULD A CANADIAN PLASTICS CIRCULAR ECONOMY LOOK LIKE?

4.1 What is a circular economy?

Simply stated, a circular economy results in systems that recirculate materials using renewable energy. It does not deplete resources and can be perpetuated indefinitely, without any accumulation of waste (whether solid, liquid or gaseous) in the environment.

A circular economy is characterized by a flow of materials in a closed loop. Value is returned into the cyclical, productive system, rather than wasted. Materials flow as either:

Technical nutrients: Products and packaging are reused, or the constituent materials are recovered for their reintroduction into manufacturing, in a manner that displaces raw materials. In the case of fossil-based plastics, this means the recovery of the embodied natural gas or oil through reuse and recycling, such that it displaces the need to extract those same raw materials from virgin sources[11]; or,

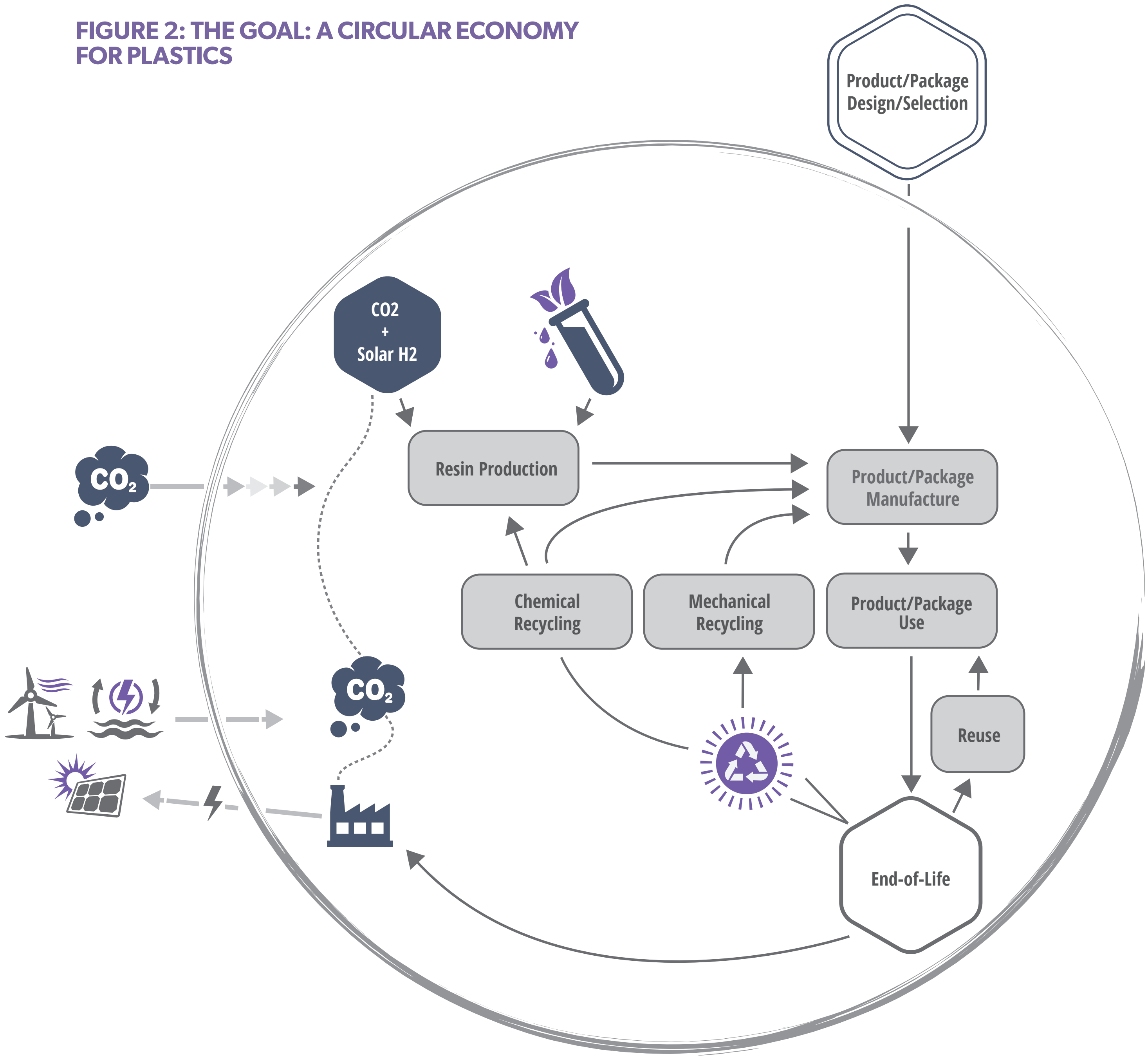
Biological nutrients: Materials in products and packaging are consumed by biological systems, with no adverse impact to those systems.[12]

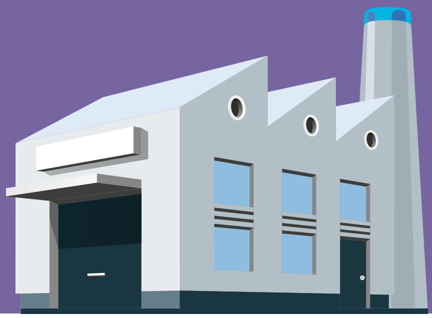
4.2 What would a circular economy for plastics in Canada look like??

A plastics circular economy in Canada could hold immense potential to retain value, reduce costs, drive economic growth and reduce environmental degradation and waste.

A plasticcular economy in Canada would be one that produces plastics from renewable feedstocks and chemistries, is powered by renewable energy, reuses and recycles plastics within the economy without leakage to the environment, and, by extension, generates no waste or emissions. Yet it retains all the benefits plastics have to offer when used in products and packaging.

FIGURE 2: THE GOAL: A CIRCULAR ECONOMY FOR PLASTICS





- **Renewable plastics**
- **Recirculating of plastics** (hydrocarbon molecules) either displacing demand for raw materials in manufacturing,[13] or consumed as nutrients in living systems without harmful impacts to that life or the environment at large
- **Plastics powered by renewable energy**

4.3 Renewable plastics

Canada has a large chemical industry sector which produces plastics. It does this primarily by using natural gas liquids extracted by the oil and gas sector to produce monomer chemical building blocks such as ethylene. These chemical building blocks are used to produce polymers of various types which are then combined to produce plastic resins that have specific physical properties tailored to various applications, ranging from plastics bags to structural components for aircraft.

A plastics circular economy replaces fossil-derived resins with renewable resins that can be produced through at least three different ways. In essence, each of these three pathways involves the production of plastics from sunlight, water and carbon dioxide, which is either captured directly from the atmosphere or by plants.

1. By combining hydrogen and CO_2, monomers such as ethylene, styrene or polypropylene are made.[14] The hydrogen is produced from water using renewable electricity, and the CO_2 is captured from industrial processes or the ambient air.

   Carbon Engineering in Squamish, British Columbia has developed a process to capture carbon dioxide directly from the atmosphere (direct air capture - DAC) which when combined with renewable hydrogen produces hydrocarbons such as ethanol and methanol that can be used to produce plastics.

   Where ethylene is produced from methanol derived from natural gas[15], substituting renewable methanol could be used to make low carbon common plastics such as low-density polyethylene (LDPE).

2. The gasification of biomass (such as woody biomass from forestry slash) makes low carbon methanol or ethanol which is then converted to monomer.

3. The manufacture of renewable resin from the production of bio-plastics such as Polylactic Acid (PLA) is produced directly from cultivated biomass (e.g. corn).

How these alternate approaches to producing renewable plastics will evolve in the market will depend on their relative economics and emerging innovations. The cost of renewable energy continues to drop. Likewise, the DAC pathway to producing hydrocarbons from ambient carbon dioxide continues to drop as capturing carbon dioxide from the atmosphere is commercialized[16].

While renewable plastic chemistries offer future opportunities to sequester carbon dioxide in the plastics product cycle, the more immediate concern is recycling plastics as they are generated by the Canadian economy today. Driving existing and forthcoming mechanical and chemical recycling technologies and practices offers the most immediate leap forward in recirculating plastic molecules.

4.4 Recirculation of plastics

There are four complementary pathways by which the embodied resources and energy in plastics can be recirculated to the next productive cycle:

1. **Reused** such as in the case of reusable plastic totes, crates, pallets, refillable bottles, reusable bags or reusable plastic components in durable goods. In a circular economy where all energy inputs are renewable, life-cycle externalities are internalized and plastics become inherently more valuable. There will be a strong incentive to amortize the materials and energy contained in products and packaging over as many uses as possible.

2. Collected, sorted, washed and **mechanically processed and recycled** to displace resins that would be otherwise sourced from raw materials. Mechanical recycling involves sorting plastics by resin type, such as PET, HDPE, and PP. The sorted material is shredded and then washed and dried. The material can then be melted and reprocessed to make pellets which are then transported to manufacturers of plastic products and packaging.

3. Collected, sorted, washed and **chemically processed and recycled**, to similarly displace raw materials. Chemical recycling may involve:

    - Chemolysis and pyrolysis processes which use chemicals or heat to depolymerize or break plastic polymers into monomer, which can then be used in plastics manufacturing;

    - Catalytic cracking of plastics which use various chemical catalysts to break plastics into monomers or other chemicals that can be used as plastics manufacturing feedstock;

    - Gasification which converts plastics to a gaseous mixture containing carbon dioxide, carbon monoxide, hydrogen, methane and other light hydrocarbons. This mixture can be reformed into plastics and other chemicals for the production of products and packaging.[17]

Plastics can be recirculated through reuse, mechanical processing and recycling, chemical processing and recycling, and energy recovery and CO_2 recirculation.

This energy in a circular economy is used both to deliver goods and services. It is also used to overcome the increase in entropy that results from materials associated with the delivery of those goods and services being dispersed in the economy and environment.

Each of these chemical recycling pathways has been recently commercialized or is in the process of commercialization. Examples include:

- Quebec-based Loop Industries is commercializing a chemical depolymerization process to break PET into its monomers (ethylene glycol and dimethyl terephthalate) for remanufacturing PET;
- Ontario-based Pyrowave Inc. uses a proprietary microwave depolymerization technology to recover styrene monomer from post-consumer polystyrene for the production of polystyrene;
- Quebec-based Enerkem's facility in Edmonton, Alberta employs a gasification process that recovers the hydrocarbons in waste, and converts them to methanol and ethanol which could be used as inputs to plastic production.

Recent developments in plastics that self-depolymerize into monomer under certain conditions offer yet another "designed for recycling" chemical recycling pathway.[18]

4. **Energy recovery and CO_2 recirculation** whereby the renewable energy and CO_2 embodied in the plastic in the production stage is recovered. The CO_2 is directly captured for reuse in industrial chemistry or is returned into the atmosphere. As such, the process of recovering energy from renewable plastics is carbon neutral in a plastics circular economy.

4.5 Plastics powered by renewable energy

Like all biological and human-made systems, a circular economy requires energy to function. This energy in a circular economy is used both to deliver goods and services. It is also used to overcome the increase in entropy that results from materials associated with the delivery of those goods and services being dispersed in the economy and environment.

Today, we move goods and services and recirculate limited amount of wastes using fossil fuels – itself a source of dissipation and entropic waste in the form of emissions and heat.

A circular economy for plastics will require that all resource inputs into it are renewable and the energy to make plastics, move them through the economy, collect them for recycling, and the recycling systems themselves are powered by renewable energy.

Where plastics are rendered unrecyclable through use, they may be subject to energy recovery whereby the CO_2 produced from oxidation of plastic is fed into the production of renewable plastics rendering the system carbon neutral.

It is important to note that virtually all of the technological and operational choices affecting the circularity of plastics (from transportation to recycling technologies) will be influenced by underlying greenhouse gas mitigation policies, such as carbon pricing and measures to promote renewable energy in transportation[19]. It is estimated that in the US switching to renewable energy for the production of plastics would cut plastic-related GHG emissions associated with the current plastics linear economy by 50% to75%[20].

5. WHY DON'T WE HAVE A CIRCULAR ECONOMY FOR PLASTICS TODAY?

Canada does not have a plastics circular economy because under current economic and policy conditions, the least expensive way to use plastics is the take-make-waste linear economy. What are these conditions that act as barriers to a plastics' circular economy?

Under current economic and policy conditions, the least expensive way to use plastics is the take-make-waste linear economy.

1. **Producing plastics from fossil resources is cheaper than reusing, recycling or producing them from renewable chemistries**

    - Direct subsidies to the production of fossil-based plastics;
    - As part of the petrochemical sector the production of fossil-based plastics is integrated with upstream oil and gas production. It benefits from large scale efficiencies whereas recycling systems are of much smaller scale and are constrained by the amount of high quality collected plastics available for recycling and demand for the recycled plastics produced;
    - Renewable and recycled plastic prices must compete with fossil-based resin commodity prices which track closely to the prices of oil and natural gas. Low oil and gas prices make renewable and recyclable alternatives uncompetitive.

2. **Un-priced and unmitigated externalities such as pollution and waste effectively subsidize the status quo linear economy for plastics**

    - Upstream greenhouse gas emissions, discharges, and effluents associated with oil and gas production;
    - Plastic leakage into the environment;
    - Lost resources and embodied energy associated with disposal of plastics; and
    - Air emissions from disposal through incineration/energy from waste (toxic releases as well as greenhouse gases).

3. **The exchange of information between various actors in the plastics life-cycle is poor, leading to non-circular choices**

    - Lack of feedback to packaging designers about the end-of-life implications of their packaging designs, and to producers about packaging design choices;

    - No connection between those building and designing material sorting facilities (typically municipal and private sector processing facilities) and the mechanical and chemical recyclers that receive those materials for recycling to end-market specification;

    - Insufficient knowledge by regulators regarding the flow of plastics contained in products and packaging into their jurisdictions and their suitability for reuse/recycling.

4. **There are technological barriers to circularity**

    - Existing products and packaging and reuse and recycling systems do not receive enough focused effort on innovation because in concert, the other barriers discussed here provide innovators with little incentive to do so.

5. **Existing policies and regulations block or frustrate the development of circular economy practices**

    - No policies; or

    - Ineffective or inefficient regulatory designs and policies that entrench norms and practices that are barriers to circularity such as ineffective plastics collection and recycling systems;

    - Inconsistent standards and policies and conflicting regulatory objectives; and

    - Jurisdictional fragmentation with Canadian provinces, territories and municipalities adopting widely differing regulatory approaches, definitions, performance standards, measurement protocols and administrative requirements. These differences act as barriers to developing large scale provincial, territorial and even pan-provincial resource recovery infrastructure.

In Annex A we identify and describe how these 5 barriers to a circular economy manifest themselves at each life-cycle stage of the plastics linear economy.

Many of these barriers are interrelated and have impacts across the plastics' life-cycle. For example, direct subsidies for virgin resin production might distort producer packaging choices. This in turn impacts packaging design (say, causing the selection of a hard-to-recycle multi-laminate material) which then adversely affects recycling downstream.

These five barriers to a circular economy manifest themselves at each life-cycle stage of the plastics linear economy.

6. WHAT CAN WE DO TO START THE SHIFT TO A PLASTICS CIRCULAR ECONOMY?

Achieving circularity will be the result of market evolution, not revolution – it will not happen overnight. This is because the evolution involves building new commercial relationships, transforming existing exchanges and relationships, redesigning products and packaging, reinventing products and packaging systems to be delivered as services, developing technologies, making investments and changing operations. It also involves shifting consumer cultural norms to change patterns in the consumption and use of plastics, increase participation in circular resource recovery systems and to prevent plastic pollution.

Achieving circularity will be the result of market evolution, not revolution – it will not happen overnight.

Achieving a circular economy is path dependent. As an example, the ability to require increasingly higher levels of recycled content in plastic products and packaging will depend on preceding policies to reform existing collection and recycling practices. As such, an initial set of policies to eliminate or reduce key barriers is critical and will determine whether markets begin evolving towards circularity, maintain the linear status quo, or deviate towards some other outcome.

A shift towards a circular economy begins with incentivizing the building of a reverse supply chain for plastics that divert plastics from disposal back into the successive product and packaging production cycles.

There are three initial policies that overcome many of the barriers identified above and which will kickstart a reverse supply chain for plastics as core function of a plastics circular economy:

1. Assign property rights for end-of-life plastic waste to producers and set end-of-life performance-based regulatory requirements such as recycling targets (i.e. extended producer responsibility – EPR). EPR is a policy mechanism designed to induce producers to build reverse supply chains for products and packaging which in the case of plastics would create a supply of reused plastic components and/or recycled plastics for use in manufacturing;

2. Set recycled content performance standards either as a minimum percentage of recycled content in plastic products and packaging or as a tax mechanism that decreases to zero when the desired plastics recycled content threshold is met. This policy creates demand for recycled plastics generated by EPR and as such is a demand side complement to EPR. A recycled content performance standard is a key element of government circular procurement of products and services involving the use of plastics; and

3. Creating common definitions, performance standards, measurement and assessment protocols that serve to create administrative efficiency, reduce transaction costs for participants in the plastics life-cycle and facilitate the scaling up of reverse supply chains to pan-provincial and territorial regional systems that have scale efficiencies.

There are three additional categories of policies that provide support for the reverse supply chain policies:

4. Prohibitions ("bans") to prevent the supply of certain plastic products and packaging that are difficult to collect and/or recycle ("use bans") while prohibiting the disposal of those that can be recycled ("disposal ban");

5. Economic instruments e.g.:

    a) Single-use plastics tax such as a plastic bag tax (affecting consumer demand);

    b) Waste disposal levies discouraging disposal to landfill; and

6. Pricing greenhouse gas emissions associated with burning plastics as fuel.

6.1 Recirculating plastics through extended producer responsibility (EPR)

Extended Producer Responsibility (EPR)[21] assigns producers the property rights for the end-of-life wastes associated with their products and packaging and requires them to meet collection and recycling performance standards for those wastes. As such, it requires producers to establish reverse supply chains (either directly or through commercial arrangements with third parties) to collect, process and market their products or packaging.

EPR is performance-based regulation that "specifies required outcomes or objectives, rather than the means by which they must be achieved"[22].

EPR is also a market-based policy instrument. In an openly competitive market, end-of-life management costs become yet another cost of business providing producers with an incentive to reduce those costs through efficiency. Such efficiency may be gained through product redesign (i.e. reduction or to enable systems of reuse), the adoption of existing waste management best practices, or through investment in new and innovative technologies and practices to reduce, collect, reuse and recycle producers' wastes.

EPR is distinct from product stewardship whereby producers fund recycling programs operated by third parties such as government recycling agencies and local governments. As an example, under product stewardship for packaging, municipalities operate individual recycling systems "with little or no coordination with other municipal recycling systems and with no connection to the producers whose packaging they manage."[23] As such, each municipality is left to address the changing packaging mix and commodity market realities within its own system. This is both ineffective and inefficient.

To be effective, EPR regulations must:

- **Assign individual producers the regulatory responsibility for achieving performance outcomes.** While producers will almost certainly collectivize their recycling efforts, the individual liability for meeting targets will provide them with a strong incentive to ensure their collective actions towards regulatory compliance are effective.

- **Require stringency**[24] (i.e. set high plastics recycling targets). Stringency incentivizes producers to undertake meaningful plastics collection and recycling efforts. Low stringency entrenches low performing collection and recycling systems, limits scale efficiencies, thwarts new collection and recycling practices, and discourages investment in innovative technologies that would otherwise arise to meet more aggressive environmental targets.

- **Define performance standards and desired outcomes clearly** (i.e. recycling as the production of recycled resins to displace virgin resins). Setting recycling targets for products or materials under EPR without a clear definition of reuse and recycling could result in producers selecting cheaper but environmentally less preferable recycling practices (e.g. down-cycling), thus depriving markets that could make better environmental use of those products and materials. It is this lack of a clear definition of recycling that allowed exports of plastics to Asian markets to be counted as recycling, thus undermining the development of better collection and sorting practices and utilization of domestic recycling capacity.

- **Verify outcomes** (i.e. receipt of recycled plastics by end-market consumers of resin). Regulators must verify all producers are achieving performance standards to ensure a level playing field for producers and the consistent achievement of the environmental outcomes that deliver a circular economy.

- **Provide producers with discretion and economic freedom in their efforts to achieve performance standards.** Focus more on regulating performance outcomes and less on the means to achieve them.

  Stringent performance standards will drive producers to build supply chains involving commercial collaborations amongst themselves, private collection and processing companies and local governments. While the provinces and territories must tailor collection coverage requirements for their geographic and socio-economic realities, these requirements should nevertheless afford producers with the flexibility to employ a host of collection and materials consolidation strategies towards meeting the performance standards while driving efficiency. Where jurisdictions stipulate particular collection systems (e.g. curbside collection or deposit-refund) they should leave producers to make whatever commercial arrangements they choose as long as geographic collection coverage and environmental performance standards are met.

- **Assess broader application of EPR.** Undertake audits of residential and IC&I waste streams to identify plastic products (e.g. textiles and flooring) and products with high plastic content (ELV, appliances etc.) that offer an opportunity to divert plastics from the environment and increase resource efficiency in terms of the suitability of EPR.

- **Be applied consistently across provinces and territories.** As discussed below, producer markets, recycler markets and consumers across Canada should have a common set of objectives across jurisdictions eliminating duplication and conflicting regulatory standards. Canada should create the opportunity for regional EPR-based systems that consolidate, process and recycle materials efficiently and effectively at scale.

6.1.1 Circular economy outcomes for plastics offered by EPR

To date, EPR has been most effectively applied in British Columbia. As a result, the province achieves some of the highest rates of recycling in Canada. In 2017, 73.9% of plastic beverage containers supplied into BC were collected and managed by Encorp Pacific (the producer responsibility organization operating a deposit-refund system on behalf of beverage producers) and 82.5% of plastic used oil and antifreeze containers supplied into BC were recovered for recycling by the BC Used Oil Management Association (BCUOMA).

Since May 2014, producers in British Columbia (via RecycleBC – their producer responsibility organization) have established a province-wide curbside, depot and multi-family reverse supply chain to address producers' regulatory obligations to collect and manage printed paper and packaging (PPP) generated by the residential sector in British Columbia. This supply chain is comprised of commercial agreements with third parties (e.g. municipalities, collection depots and private waste management companies) who deliver the services necessary to collect materials from over 4.5 million residents,[25] sort and recycle those materials, and sell them to end-markets.

The RecycleBC PPP program has induced $20 million in capital investments[26] in the recycling of PPP (a significant portion of which is plastic recycling related)[27], expanded the types of plastics collected,[28] and lowered contamination of collected materials,[29] while concurrently insulating both producers and BC municipalities from commodity risks posed by the closure of Asian secondary plastics markets.[30]

In general terms, application of effective EPR to products and packaging provides for a powerful policy mechanism to help address the five categories of barriers to a circular economy for plastics. Specifically:

1. EPR induces the creation of a reverse supply chain for the collection and recycling of plastics, and by doing so at volume and scale, it creates a large sustained supply of quality recycled resins for the

production of products and packaging. As such it will address, in part, the supply side price disparity between fossil and recycled plastic resin feedstock;

2. It will address, in part, un-priced externalities by mitigating the discharge of plastics to the environment, emissions associated with burning plastics for energy from waste, and energy use and emissions associated with virgin resin production;

3. It will overcome key information asymmetries between:

    a. Producers and plastic recyclers. In working with plastic recyclers to build a reverse supply chain, producers will become more aware of the implications of packaging design choices on system cost, recyclability and end-markets for recovered materials[31];

    b. Regulators and producers; and regulators and recycling markets used by producers. Where regulators seek data on the composition and quantity of products being supplied into end-markets they are better able to establish performance targets, measure outcomes, and enforce performance standards. Clarity on the final disposition of recycled plastics allows for the assessment of progress towards a circular economy;

    c. Producers and consumers. As producers operate reverse distribution systems, they will be able to standardize the list of materials collected across jurisdictions to coordinate education, behavioural nudges, and economic instruments within and across jurisdictions (where EPR requirements are harmonized across jurisdictions) to drive behavioural change in citizens/consumers to increase participation and lower material contamination.

4. It will drive effort to overcome technological barriers. Increasingly stringent recycling targets drive innovation both in terms of informing design of products and packaging for increased reuse and recyclability, but also in terms of recycling systems design to more effectively sort and process materials for use in manufacturing; and

5. For residential printed paper and packaging it will overcome the inertia of status quo municipal recycling practices in Canadian jurisdictions. Applied in a uniform and principled manner, EPR will transform existing practices and norms around recycling. It will result in a common set of materials that are collected province and territory wide, contribute to provincial and territorial education towards increasing participation and reducing contamination, and streamline the collection, transfer and processing of materials (thus overcoming the fragmentation associated with municipal recycling).

Recognizing recycled content is a critical commitment to closing the loop on plastic waste.

6.2 Recycled content performance standards

Recycled content performance standards are a demand side policy that complements EPR as a supply side measure. Where producers are working to establish reverse supply chains for the collection and recycling of plastics, recycled content performance standards help create demand (backstopping capital investments in recycling) and shape the processes and technologies employed in the supply chain. For example, where production is geared to meet a 25% recycled content standard[32] for polypropylene, PET, polyethylene and polystyrene packaging, the supply chains established under EPR will be built to meet demand for those resins. As such, there won't be a need to "find markets" for materials, providing certainty for recycling systems investors as precondition to investments in further innovations in recycling.

Recycled content performance standards create a market for recycled materials that moves in step with the demand for plastic products regardless of input prices from other feedstocks. Such an approach will overcome the economic barrier posed by fluctuating virgin commodity prices even as demand for plastic products continues to grow.

Recognizing recycled content is a critical commitment to closing the loop on plastic waste. Consumer product companies producers have made global commitments to recycled content targets. As an example, in April 2018 42 companies in collaboration with the UK WRAP announced the UK Plastics Pact which makes a number of pledges to reducing plastic waste between now and 2025, including a commitment to a 30% recycled content in all plastic packaging. The following companies have made plastic recycled content commitments: Colgate-Palmolive Company: 25% by 2025; Danone: 100% by 2025; Nestle: 25% by 2025 in Europe; Coca-Cola: 50% by 2030; and, Unilever: 25% by 2025, Walmart, 20% in private brand packaging by 2025.

Under the G7 *Oceans Plastic Charter,* Canada has committed to working with industry towards increasing recycled content by at least 50% in plastic products where applicable[34] by 2030.[35]

A recycled content performance standard can be applied in two ways:

- As an increasing percentage recycled content requirement in products or packaging; or

- As a sliding tax on fossil-based plastics that decreases as the percentage of recycled content in a product or package increases. Here, the tax decreases to zero at the desired percentage recycled content performance standard.[36]

In either case, a recycled content standard can be easily monitored at the point where the mass balance of inputs and outputs from resin production facilities that are supplying manufacturers using making products or packaging. Manufacturers would declare the recycled content of the plastics used to make their products or packaging with regulators having the ability to verify those declarations from resin production to finished product or package using 3rd party audits.

Recycled content standards help to address barriers to a circular economy for plastics. Specifically:

1. They create a market for recycled plastics that is differentiated from virgin plastics by specific demand for recycled plastics;

2. They help to match the increasing supply of recycled plastics generated through EPR and other policy measures to increase recycling with demand in the production of plastic products and packaging;

3. They address the unpriced externalities of plastic waste by creating demand for recycled plastics, making the disposal and discharge of plastics to the environment less economically attractive;

4. They help overcome key information asymmetries between producers and plastic recyclers. Producers working with plastic recyclers, resin manufacturers and product and packaging manufacturers will become more aware of the opportunities to capitalize on the recycled plastics generated by their EPR supply chains; and

5. They help drive effort to overcome technological barriers. Increasingly stringent recycled content standards will drive demand for high quality recycled plastics and in turn speed up innovation in material separation and mechanical recycling. At the same time, it will offer chemical recycling of plastics the opportunity to achieve commercial scale.

While EPR is not a prerequisite for introducing recycled content standards, the most efficient and effective approach would be to coordinate these two policies to drive both supply and demand for recycled plastics higher concurrently.

The introduction of recycled content standards must be phased in such that producers, recyclers/resin producers and packaging manufacturers can anticipate the standards coming into force and begin preparations to meet them. Some resins (notably PET, HDPE and LDPE) are collected in sufficient quantity and quality that recycled content standards can be initiated in short order.

Recycled content standards for plastics should be designed to allow the substitution of recycled content with renewable plastics where the embodied energy and emissions associated with renewable plastics are shown to be equivalent or better than those of recycled plastics.

To date there here has not been a nationally coordinated effort to establish a recycled content performance standard. Recycled content standards for plastics are best established at the federal order and applied nationally. Having different requirements across Canada will only result in additional and unnecessary costs and complexity.

Recycled content standards help to address barriers to a circular economy for plastics.

6.2.1 Recycled content standards and government procurement

One of the fastest ways to jump start demand using recycled content performance standards is to embed the requirements in government procurement[37]. The public sector – municipalities and their subsidiary operations, provincial and territorial ministries and their agencies, boards and corporations and the whole of the federal government – in aggregate is the largest purchaser of goods and services in Canada. As an example, a federal requirement that all plastic packaging supplied under service or purchase agreements will require a minimum of 25% recycled content would have a dramatic effect on the packaging choices made by suppliers and in turn the demand for recycled resins in Canada. Government procurement can reshape markets[38].

One of the fastest ways to jump start demand using recycled content performance standards is to embed the requirements in government procurement.

Where governments implement such standards there may be a limited number of competitors (perhaps even only one) that meet those standards initially. In fact, a key purpose of green procurement standards is to create markets and drive competition for the government's business against those standards. This then drives market norms with the attendant positive externality that green products and services are adopted widely as their costs decrease due to market competition and scale.

Of note, on September 20th 2018, the Canadian government made a commitment to procure sustainable plastics products noting that, "Public procurement can be used to support markets for more sustainable plastics products, such as those that can be reused or repaired, are remanufactured or refurbished, are made with recycled plastic content, or can be readily recycled or composted at their end of life."[39]

6.3 Definitions, performance standards and assessment protocols

Currently, Canadian provinces and territories use a patchwork of inconsistent definitions, standards and protocols. Given the fundamental importance of definitions, performance standards, and assessment protocols in setting the proper trajectory towards a plastics circular economy it critical that there be a common and clear set of definitions, standards and performance assessment protocols across Canada.

In pursuing a circular economy for plastics, Canadian policy makers should seek to "tear down the borders" not by relinquishing their jurisdiction over waste but by harmonizing policies, regulatory definitions, administrative protocols and measurement and reporting procedures. Producer markets, recycler markets and consumers across Canada should thus have a common understanding of Canada's plastics policy objectives and their role in a nascent circular economy for plastics. This will not only eliminate duplication, inconsistencies and administrative inefficiencies but will reduce barriers to undertaking a national effort towards a circular economy for plastics[40].

While the logistics of delivering an EPR program for printed products and packaging may be entirely different in Whitehorse than it is in St. John's, a producer building EPR delivery systems in those cities should face identical regulatory definitions and administrative procedures (e.g. producer registration, reporting etc.) irrespective of the provincial and territorial jurisdiction they are operating in. Commonality of definitions, rules and regulatory requirements will facilitate the connection of local supply chains into sub-national regional catchments that have scale efficiencies to warrant large scale investment in reuse and recycling innovation.

Given this overarching need for harmonization at the policy level, there is a key role for the federal government to play in this regard.

6.3.1 Intergovernmental collaboration towards a circular economy for plastics

Waste policy (and by extension the implementation of EPR policy) falls largely (though not exclusively) within the jurisdiction of Canadian provinces and territories.

The *Canadian Environmental Protection Act* (CEPA) provides the federal government with a number of pathways to take action on plastics. These actions range from regulating any stage of the plastic life-cycle on a national basis once a particular type of plastic is classified as a toxic substance under CEPA Schedule 1 (Toxic Substances List) to issuing non-binding instruments such as environmental objectives, guidelines and codes of practice as well as the negotiation of performance agreements, and requirements for pollution prevention plans. As an example, plastic microbeads[41] recently were regulated under CEPA.

Given the jurisdiction afforded to it under CEPA, the federal government can play a vitally important role in increasing the efficiency of provincial waste management policies by collaborating with the provinces and territories to:

- Set national definitions of a circular economy for plastics and EPR that capture key characteristics of sound life-cycle principles and policy design that provinces and territories can adopt for circular economy policy implementation;
- Establish national definitions for classes of products, packaging and materials to be regulated under provincial implementation and administration of EPR. These include relevant definitions of plastics based on composition and recyclability; by extension,
- Establish a common Canadian set of protocols for producers to register and report the quantity and composition of their supply of plastic products, products containing plastics and plastic packaging;

The federal government can play a vitally important role in increasing the efficiency of provincial waste management policies by collaborating with the provinces and territories.

- Set national plastics performance standards for recycling and recycled content targets. Such standards would ensure that wherever plastics are recycled they are recycled to a common operating standard, thus preventing past practices of exporting mixed and contaminated plastics to jurisdictions with poor recycling practices;

- Establish a common Canadian set of targets for measuring progress towards a circular economy for plastics. By extension, establish a national plastics mass balance and national reporting of avoided environmental burdens;

- Establish rules for government procurement of supplies and services that consume or use plastic products, plastic containing products, and plastic packaging that incorporate the national recycled content target;

- Establish a national schedule of increasingly stringent plastics recycling targets and recycled content standards; and,

- Coordinate the identification and tracking of producers, products and packaging designated under EPR as imported into Canadian jurisdictions via e-commerce/online sales.

The federal government and the provinces and territories should establish a collaborative approach to national harmonization of definitions, standards, targets and measurement protocols.

6.4 Bans and taxes on the sale of plastic products and packaging

Globally there has been a proliferation of laws and regulations banning various types of single-use plastics at all levels of government. Most recently the European Union reached an agreement to ban single-use plastic products such as plastic cotton swabs, cutlery, plates, straws, drink stirrers and sticks for balloons.

The most commonly banned single-use plastic product is plastic bags that are often discarded and pose recycling challenges. Although many bans are relatively recent, they are effective in reducing the contribution of plastic bags to the waste stream.[43]

Bans by themselves address a small fraction of the total plastic waste stream and on their own are incapable of solving the much larger and more systemic problem of global plastic pollution.

Proponents argue that these bans contribute to raising the profile of the plastic problem and should be implemented at the national level to maximize their impact.[44] They may serve as a stepping-stone towards more comprehensive solutions. They may also nudge individuals to undertake additional actions, ranging from reducing their consumption of plastics to pressuring government and businesses for stronger responses.

On the other hand, critics argue that banning single-use plastics may create a false sense of complacency by creating the impression that remedial action has been taken and further efforts are unnecessary. Critics also express concerns about the environmental impacts caused by substitutes for single-use plastics. For example, there is some evidence that certain alternatives to single-use plastic bags (e.g. cotton bags or thicker "reusable" plastic bags) may have larger footprints, based on life-cycle analysis.

Another potential difficulty is that plastic bag bans can be politically controversial, consuming the political capital available to address the problem. Lawsuits filed in 2012 against a proposed bag ban in Toronto succeeded in convincing politicians not to proceed with the ban. Six years later, Toronto is still in a state of policy paralysis on this issue. A lawsuit was filed against the City of Victoria's single-use plastic bag ban, but opponents lost their case and the ban is now in effect.

Bans on single-use water bottles have been proposed by a number of private institutions and local and state governments,[45] especially in jurisdictions with ineffective existing waste management systems where bottles become litter. As discussed in the next section, economic instruments such as avoidable single-use plastic taxes can induce collection and recycling outcomes that are equivalent to a ban.

6.4.1 Single-use plastic taxes as an alternative to bans

As an alternative to bans, taxes imposed on single-use plastic bags have had comparable effects to bans as measured in England, Ireland, Portugal, and Denmark.

The UK is considering a single-use plastics tax on single-use plastics such as "bottles, single use cutlery, drinking straws, takeaway packaging, fruit netting, cling film, crisp packets and plastic wrap."[46]

Taxing or pricing single-use plastic items to discourage their wasteful use and mitigate the externalities associated with their production, discharge to the environment and the challenges they pose to recycling systems[47] is generally a more economically efficient approach than bans. However, if the level of tax is set too low, it will be less effective in achieving the intended outcome than a regulatory ban.

As an example of effectiveness, Norway's single-use bottle tax has generated the same waste reduction outcome as a ban. In Norway, beverage producers are subject to an environmental tax on plastic bottles that is suspended once producers collectively exceed a 95% recycling target.

In response to the tax, producers introduced a deposit-refund system that results in the recycling of 97% of containers sold, with 92% of containers sold recycled into new bottles.[48] In addition, the stringent recycling target has driven the standardization of bottle and cap plastics to two resin types as well as consistent design for label and glue to increase recycling efficiency.

Norway is in the process of also introducing a sliding scale recycled content tax that would decrease to zero when a recycled content performance standard is met. The collection tax and the recycled content tax are seen as complementary policies to drive a circular economy for beverage packaging[49].

FIGURE 3 NORWAY'S APPLICATION OF SCALABLE TAXES TO DRIVE A CIRCULAR ECONOMY FOR BEVERAGE PACKAGING

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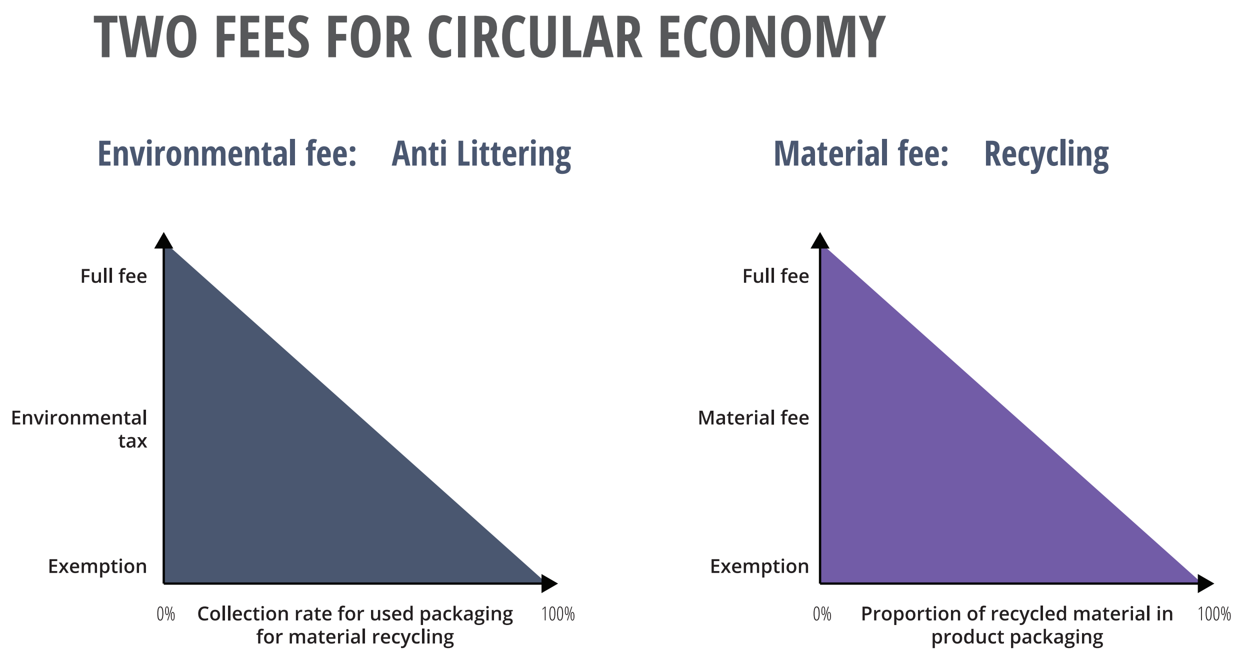

Taxes can be set in a manner that prices the externalities associated with the plastic product or package. They also serve as an economic instrument to reduce demand by changing consumer behaviour. Taxes give people an incentive to avoid or reduce the wasteful use of single-use plastic products, while providing them with flexibility in circumstances where there are no alternatives (e.g. use of bottled water during an emergency when municipal water supplies are deemed unsafe).

Finally, it is important to ensure that the tax revenue generated by single-use plastic pricing is used to mitigate the discharge of plastics to the environment. Given such discharges typically occur in a manner that is best addressed by local governments, it is important that whatever order of government administers the tax ensures local governments are allocated the revenue for the purpose of addressing plastic pollution.

6.5 Bans on the disposal of plastic products and packaging

A ban of the disposal of plastics is implemented at the disposal site located within the jurisdiction applying the ban (e.g. at an energy from waste facility or a landfill) and at transfer facilities where wastes are aggregated if they are to be exported.

Bans on landfilling or incinerating recyclable plastics are designed to prevent the flow of materials that have value for recycling from being disposed of. They can act as an important complement to supply-side plastics policies such as EPR[50].

Disposal bans are administered at the facility level. When a waste hauler is found to have "tipped" wastes for disposal that contain banned materials, enforcement of the ban (typically a financial penalty or outright rejection of the offending load) is intended to induce the hauler to discourage generators from discarding banned materials.

As such, disposal bans require ongoing onsite enforcement at disposal sites and transfer facilities, which is resource and administratively intensive. They also require sufficiently punitive sanctions to be effective.

Such bans can be imposed by municipalities, provinces or territories. Bans on the disposal of materials such as plastics should be implemented after systems are in place to collect and recycle the banned materials[51].

Bans on disposal of recyclable materials have proven to be effective at increasing the recycling of materials[52]. However they are most effective when applied in concert with disposal levies applied on each tonne of material sent to landfill[53].

Bans on disposal of recyclable materials have proven to be effective at increasing the recycling of materials. They are most effective when applied in concert with disposal levies.

6.5.1 Disposal levies as a supplement to disposal bans for plastics

Disposal levies are applied to each tonne of waste sent for disposal and can be applied to both IC&I and residential waste streams. These levies are in addition to tipping fees charged by landfill operators.

In the case of IC&I generators, since both the tipping fees and disposal levies are borne by waste generators there is a direct financial incentive to reduce the amount of waste sent to disposal. Where a recycling alternative exists (say through services provided by producers under EPR) there is thus an incentive to pre-sort waste to divert recyclable materials from disposal. As such, disposal levies have proven to be effective in increasing recycling rates.[54]

Disposal levies borne by municipalities may result in those municipalities encouraging residents to divert more waste for recycling through promotion and education efforts. In addition, disposal levies may cause municipalities to implement Pay As You Throw (PAYT) charges for waste disposal (typically applied on per garbage bag basis). The results of PAYT in driving residential recycling has been mixed.[55]

Plastics disposed of as fuel should be treated as any other fossil fuel under federal, provincial and territorial greenhouse gas mitigation policies.

Disposal bans for recyclable plastics and disposal levies may help in address barriers to a circular economy for plastics. Specifically:

1. In concert they help overcome the overall economic disparity between the linear and circular economies for plastics by preventing disposal (ban) or increasing the costs of disposal (levy);
2. They address (in part) un-priced externalities by mitigating the discharge of plastics to the environment; avoiding emissions associated with burning plastics for energy from waste; and energy use and emissions associated with virgin resin production;
3. They incentivize IC&I generators to divert plastics away from disposal and into recycling systems; and
4. They incentivize municipalities to encourage residents to use recycling, especially where recycling programs are operated and financed by producers under EPR.

Disposal bans for recyclable materials and disposal levies should be introduced concurrent to their being recycling capacity available to generators of those materials.

Given the geographic and socio-economic differences between Canadian jurisdictions, the application of disposal bans on transfer and disposal facilities will differ between locations as will the quantum of the disposal levies. As such, disposal bans for recyclable plastics and disposal levies should be developed and administered provincially and territorially.

6.6 Pricing the burning of plastics for energy

As discussed earlier, burning mixed plastics for energy is a shortcut to dealing with plastics that fails to avoid emissions and to recover the full energy embodied in fossil-derived plastics.

While it is inevitable that plastics will need to be disposed of during the transition to a circular economy, plastics disposed of as fuel should be treated as any other fossil fuel under federal, provincial and territorial greenhouse gas mitigation policies. Specifically,

1. Where the federal government, the provinces or the territories adopt life-cycle clean fuel intensity standards (CFS), chemical recycling processes that produce fuels (e.g. to replace diesel fuel) from fossil-derived plastics should be subject to those standards. Subjecting these fuels to the CFS will ensure that they either confer real greenhouse gas reductions when blended with other fossil fuels or their use (and hence production) is discouraged where they do not; or

2. Where jurisdictions adopt carbon pricing (or are covered by the default pan-Canadian approach to pricing carbon pollution) the fuels produced by the chemical recycling of fossil-derived plastics should be subject to carbon pricing in the same manner as other fossil fuels. Application of the carbon tax in this manner will encourage chemical recyclers towards plastics-to-plastics recycling while discouraging the conversion of fossil based plastics to fuel (that are converted to greenhouse gases once the fuel is burned); and

3. Fossil-derived plastics that are sent directly to energy recovery should be subject to carbon pricing in a manner consistent with the pricing of waste-related emissions under the pan-Canadian approach to pricing carbon pollution.This will discourage the use of plastics as fuel and encourage plastics-to-plastics recycling.

CONCLUSION

The economic and environmental costs of the current take-make-waste, linear approach to plastics are too great. Canada has an opportunity to set an economic growth trajectory that evolves from the current linear economy for plastics to a circular economy for plastics. This closed loop approach can engineer renewable plastics and establish systems to recirculate plastics in a productive economy rather than squandering these resources as waste in our landfills, air and water.

Smart policies and market interventions designed to drive efficiency and innovation can kick-start a reverse supply chain for plastics, setting us on a trajectory towards a circular economy for this ubiquitous material.

Extended producer responsibility, renewable and recycled content performance standards, government procurement against those standards and a harmonized set of Canadian definitions, standards and performance objectives will, in concert, serve to overcome many of the barriers facing the development of a circular economy for plastics in Canada. These three policy strategies not only support existing plastic recycling commitments made by many Canadian consumer products companies, but will also drive innovation in the renewable plastic chemistry and plastics recycling sub-sectors of the Canadian chemical industry. With other packaging materials, such as glass, card stock, and metals, producers of “virgin materials” have also become the major recyclers. This opportunity also exists for Canada’s chemical industry.

Supplementing these initial policy actions with policies to price or ban disposal of plastics and mitigate greenhouse gas emissions will ensure continued progress towards a plastics circular economy.

A circular economy will take time to build, is path dependent and requires effort and investment by market actors throughout the plastics life-cycle. Canada’s economy has exactly the right expertise and capacity to evolve the plastics economy from one that is linear and wasteful to one that offers economic growth without waste.

ANNEX A

Raw materials extraction and resin production

Issue / externality	Barriers to circular economy
1. The environmental damage (e.g. greenhouse gases, air pollution, water pollution etc.) associated with the extraction and shipment of fossil raw materials for the production of resin acts as an effective subsidy to the price of virgin plastics over plastics sourced from renewable or recycled feed-stocks.	• Unlevel playing field: un-priced externalities in fossil feedstock production
2. Direct subsidies for fossil resource development and extraction lowering the relative cost of fossil feedstock relative to plastics sourced from renewable or recycled feedstocks[59].	• Fossil feedstock production subsidies[60],
3. Impacts from agricultural production on biodiversity, water quality and other environmental externalities associated with the production of bio-plastics.	• Unpriced externalities in bioplastics feedstock production • Agricultural fuel subsidies[61]
4. The use of additives that hinder effective recycling of plastics by compromising physical, chemical or visual characteristics of recycled plastics (for example, affecting brittleness, flame retardancy, oxidation)."[62] The effect is to raise the cost of recycling at end-of-life or to prevent it entirely, thus requiring plastics to be disposed of.	• Information asymmetries • Technological barriers • Regulatory inconsistency

Plastic packaging or plastic product design and production

Issue / externality	Barriers to circular economy
5. Product or packaging design choices are divorced from the realities of end-of-life resource recovery e.g. [63]; • Blending of plastics as composites or laminates for better product or package performance but making separation of polymers and monomers for recycling costly or technically infeasible under current recycling practices. • Products that have small removable plastic parts (e.g. bottle caps) or shed microfibers during use (e.g. textiles);	• Information asymmetries • Technological barriers • Regulatory inconsistency and/or unintended regulatory outcomes
6. Virgin and recycled plastics are treated as substitutes, with no separate demand for recycled plastics – i.e. virgin and recycled markets are "undifferentiated". This leaves markets for recycled plastics exposed to the price of fossil feedstock used in primary markets. Therefore, the price of recycled plastics is largely driven by the price of oil, rather than the cost of collecting, sorting and processing plastic waste. Recycled plastics are only price competitive when the price of fossil fuels is high.	• Undifferentiated market for recycled content

7. A consequence of the market failures described above is a volume of recycled plastics that is too small to meet demand for recycled plastic content at scale and to specification. Current recycling practices do not collect enough plastic of sufficient quality to meet such demand. Recyclers will not make investments to meet such demand as it remains subject to the price volatility of virgin resins discussed in the previous bullet. This issue has been exacerbated by the reliance on Asian markets to absorb plastics collected in Canada and has served to undermine domestic economies of scale for plastics recycling[64];	• Undifferentiated market for recycled content • Past and current waste management regulations/ practices

In use – e.g. plastic products and packaging used by producers to market products

Issue / externality	Barriers to circular economy
8. Producers lack information regarding alternative circular product and packaging and systems that can meet the same product and packaging delivery performance. There is also institutional resistance to changing longstanding production choices in favour of circular options. As noted by the EU there is, "Resistance to change among product manufacturers and a lack of knowledge of the additional benefits of closed-loop recycled plastics have also emerged as barriers to the higher uptake of recycled content."[65]	• Information asymmetries
9. Institutional barriers posed by status quo one-way systems for the distribution and sale of products and packaged goods that must be reconfigured to returnable, reusable or recyclable circular product and packaging delivery systems	• Information asymmetries • Technological barriers • Invested capital in the status quo

End-of-life

Issue / externality	Barriers to circular economy
10. Jurisdictions do not price solid waste disposal for plastics as a disincentive to disposal: • No incentive for local governments to collect and manage plastics facing high collection and sorting costs and low market demand for recycled plastics; • No incentive for IC&I generators to source separate plastics nor for IC&I service providers to separate and recycle plastics collected from generators	• Past and current waste management regulations/ practices
11. "The plastics recycling sector is smaller and more fragmented than the primary industry, leaving it at a significant disadvantage in terms of economies of scale and its ability to absorb market shocks;[66]"	• Market for recycled content undifferentiated from virgin resin markets

12. High contamination rates of plastics collected in municipal and IC&I recycling systems; • Reliance on Asian recycling markets that have traditionally accepted mixed plastics with high contamination rates has entrenched poor collection practices, thus constraining domestic recyclers that require higher quality feedstock	• Past and current waste management regulations/ practices
13. The increasing use of bioplastics entering systems designed to collect and recycle fossil based plastics; • Bioplastics collected in status quo recycling systems act as a contaminant in recycling of fossil based plastics • Status quo municipal composting systems are not designed to effectively compost bioplastics	• Information asymmetries • Policy/regulatory-induced market failures
14. The end of life consequence of using additives (*barrier #4*) is that recycling downgrades the quality of recycled plastics, limiting their long-term use in a circular economy;[67]	• Information asymmetries
15. The competition for demand for collected plastics between recycling and energy from waste	• Unpriced externalities • Past and current waste management regulations/ practices
16. The price competition between plastic-to-plastic recycling and diversion of plastics to secondary materials markets with low or no environmental standards	• Unpriced externalities
17. Low or no incentives for consumers to participate in material recovery systems and reduce contamination	• Information asymmetries • Reliance on voluntary source separation

In addition, there are factors that may act as barriers to the transition to circular economy for plastics that cut across all four of the life-cycle stages described above:

18. *Mis-assigned property rights for end-of-life plastics:* Provincial "product stewardship or "producer responsibility" policies do not assign[68] the responsibility for the collection and management of end-of-life plastics to producers. This leaves the core technical and operational issues associated with collecting and recycling of plastics to be borne by society at large (via municipal waste management systems) or by the environment where plastics are disposed of. Overcoming this barrier will require replacing these policies and unraveling consequent practices (e.g. the collection, consolidation, movement and recycling of post-consumer wastes) established under those policies.	• Unpriced externalities • Past and current waste management regulations/ practices • Information asymmetries

19. *Mis-identification of recyclables as waste:* Provincial policies and definitions that define materials destined for recycling as waste thereby requiring additional regulatory approvals and financial assurance thus adding regulatory and cost burden to recycling operations;	• Past and current waste management regulations/practices • Information asymmetries
20. *Policies lagging technological progress: Provincial policies and definitions that do not recognize evolving recycling technologies (e.g. confuse thermal pyrolysis of plastics for monomer recovery for recycling with incineration or energy from waste);*[69]	• Past and current waste management regulations/practices • Information asymmetries
21. *Absence of nationally harmonized definitions & policies:* Different jurisdictions have chosen to adopt varying definitions for key elements of policy design (i.e. of materials, reuse, remanufacturing, recycling, circular economy, extended producer responsibility etc.), and varying performance standards and measurement protocols for assessing progress towards a circular economy. The effect is to undermine scale and efficiencies that could be derived from a Canada-wide plastics reverse supply-chain for the processing and recycling of collected plastics. A national system can only emerge under a consistent set of regulatory rules and definitions;	• Past and current waste management regulations/practices • Information asymmetries
22. *Powerful incumbents: High rates of plastics recycling and renewable resin manufacturing will displace demand for virgin resins produced by the Canadian oil and gas sector. This sector will undoubtedly act vigorously to resist policies threatening the status quo*[70].	23. Political economy

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4 The biggest source of ocean plastic may not be what you think Evgeni Matveev, Canadian Broadcasting Corporation News. July 2nd 2018

5 Levi, P.G., Cullen, J.M., 2018 *Mapping Global Flows of Chemicals: From Fossil Fuel Feedstocks to Chemical Products* Environmental Science & Technology 2018 52 (4), 1725-1734

6 Raugei, M. [et al.]. 2009. *Single-use vs reusable transport packaging: a comparative life cycle analysis*. Packaging Technology and Science", 2009, vol. 22, num. 8, p. 443-450.

7 Franklin Associates. 2011. *Revised Final Report: Life Cycle Inventory of 100% Postconsumer HDPE And PET Recycled Resin From Postconsumer Containers and Packaging*. Prepared For The Plastics Division of the American Chemistry Council, Inc. The Association Of Postconsumer Plastic Recyclers (APR), The National Association For PET Container Resources (NAPCOR), And The PET Resin Association (PETRA)

8 No time to waste: What plastics recycling could offer McKinsey & Company. September 2018

9 "The production of plastic bottles from raw materials requires about 80 MJ/kg (energy per kilogramme). Incineration can generate about 3 MJ/kg of electricity and about 10 MJ of process steam from the recovered energy. *Life Cycle Thinking and Assessment for Waste Management.* European Union. http://ec.europa.eu/environment/waste This is true for plastics general. See: Bernardo, C., C. Simões and L. Pinto (2016), *Environmental and economic life cycle analysis of plastic waste management options*, China Journal of Renewable and Sustainable Energy, Vol. 10, pp. 140001-140002.

10 Rahimi, A.R., Garcia J.M. 2017 *Chemical recycling of waste plastics for new materials production.* In Nature Reviews Chemistry volume 1, Article number: 0046 (2017) and Grigore, M.E. 2017. *Methods of Recycling, Properties and Applications of Recycled Thermoplastic Polymers* in Recycling 2017, 2(4), 24.

11 Conversely, open material lifecycles result when end-of-life products are not collected for recycling or enter recycling systems that are incapable of recycling the particular material efficiently. Open life-cycles involve disposal, inefficient recycling practices (e.g., manual sorting of contaminated, mixed plastic waste) whereby materials are only partially recycled and where the functionality of the materials (i.e., the physical and chemical properties) are lost or reduced. This sometimes also referred to as "downcycling". For a discussion of open and closed materials life-cycles and functional and non-functional recycling see: Graedel, T. E., Allwood, Julian, Birat, Jean-Pierre, Buchert, Matthias, Hagelüken, Christian, Reck, Barbara K., Sibley, Scott F. and Sonnemann, Guido. *What do we know about metal recycling rates?* Journal of Industrial Ecology 15.3 (2011): 355-366.

12 *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition* 2013. Ellen MacArthur Foundation

13 This is distinct from "finding a use" or downcycling of mixed waste plastic such as synthetic lumber which is a means to make some use of them where there is no ability to recycle the individual polymers in a manner such that they can be used to displace those same polymers made from raw materials. Evolving chemical recycling processes offer some promise in recovering the chemical constituents from downcycled plastics (i.e. upcycling) to displace raw materials.

14 Bazzanella, A. M. & Ausfelder, F. *Technology study: Low carbon energy and feedstock for the European Chemical Industry*. Dechema: Gesellschaft für Chemische Technik und Biotechnologie e.V. (2017). Available at: https://dechema.de/dechema_media/Technology_study_Low_carbon_energy_and_feedstock_for_the_European_chemical_industry-p-20002750.pdf

15 Bataille, C,. and Stiebert, S. June 2018. *The transition toward very low carbon heavy industry in the Canadian context: Detailed technical and policy analysis and recommendations for the iron & steel, chemicals, forestry products & packaging, and base metal mining & processing sectors.* Phase II of the Canadian Heavy Industry Deep Decarbonization Project. Final Report. Prepared for The Industrial Gas Users Association (IGUA).

16 Keith et al., (2018) *A Process for Capturing CO2 from the Atmosphere* Joule 2, 1573–1594

17 For example, Montreal based Enerkem uses gasification to convert carbon-based wastes into a pure synthesis gas (also called syngas) which is converted to chemicals such as methanol, ethanol or other chemicals using catalysts. In turn, methanol is a chemical building block for the production of secondary chemicals such as plastics. https://enerkem.com/about-us/technology/ Enerkem process also produces fuels which is not a circular economy outcome for fossil based plastics

18 *Designing the Death of a Plastic* "Decades ago, synthetic polymers became popular because they were cheap and durable. Now, scientists are creating material that self-destructs or breaks down for reuse on command." New York Times August 6th 2018. See: https://www.nytimes.com/2018/08/06/science/plastics-polymers-pollution.html

19 Hastings-Simon S., 2018. Breaking it down: how carbon pricing addresses climate change Pembina Institute.

20 Posen, D., Jaramillo, P., Landis A., Griffin, M. 2017. *Greenhouse Gas Mitigation for U.S. Plastics Production: Energy First, Feedstocks Later*. Environmental Research Letters 12 034024

21 "At the heart of the original vision for extended producer responsibility (EPR) was the desire for a policy strategy that could provide ongoing incentives for the incorporation of environmental concerns into the design of products. If producers were made responsible for end-of-life management (i.e., reuse, recycling, energy recovery, treatment, and/or final disposal) of products, they would find it in their self-interest to anticipate end-of-life costs and obligations and design their products to minimize those costs…

This vision also included other aspirations. One was that the resulting policy schemes would be dynamic—that is, as the product mix, production and processing technologies, or market and societal conditions changed, so too would the responses by the producers facing EPR requirements. Advocates of EPR hoped that when the task of meeting the goals of EPR was assigned to producers, business acumen would be mobilized to find the most clever and cost-effective means of reaching those goals, without detailed prescriptions by governments." Lifset, R., and Lindhqvist, T., 2008. *Producer Responsibility at a Turning Point?* In Journal of Industrial Ecology 12(2). p.144-147

22 Coglianese,C., Nash,J., Olmstead,T. 2002. *Performance Based Regulation: Prospects and Limitations in Health, Safety and Environmental Protection*. Regulatory Policy Program, Center for Business and Government. John F. Kennedy School of Government, Harvard University. Cambridge, MA, USA.

23 Valiante U.A. (2015) *The relative economic efficiency of shared responsibility versus the principled application of extended producer responsibility for printed paper and packaging*. CPG LLP Policy Brief

24 EU member States will be obliged to collect 90% of single-use plastic drinks bottles by 2025, for example through deposit refund schemes. Single-use plastics: New EU rules to reduce marine litter Brussels, 28 May 2018

25 Includes the population of local governments that agreed to the implementation of EPR in 2017

26 Personal communication with Tony Moucachen, CEO, Merlin Plastics

27 "No city in the province is facing a recycling crisis because B.C. put all recycling in the hands of a non-profit, Recycle BC, whose costs are covered by all businesses in the province that are deemed to create waste packaging or products. It doesn't export plastics because all plastics have been recycled in-province for the last three years, in part because Recycle BC guaranteed a supply of plastics to a local business. That allowed Merlin Plastics to invest in technology that helped it generate second-generation plastic products that are saleable." China's tough new recycling standards leaving Canadian municipalities in a bind

28 RecycleBC announces 116 Recycle BC Depots Collecting Other Flexible Plastic Packaging

29 While collecting a broad range of PPP, contamination of recyclable materials in British Columbian cities is lower than most Canadian cities. See: RecycleBC: What is contamination and Many Canadians are recycling wrong, and it's costing us millions.

30 "While not immune to global market forces, overall Recycle BC has been able to weather the January 1st 2018 closure of China's secondary plastics and fiber commodity markets while many other Canadian recycling programs continue to struggle to find markets for their collected fiber and mixed plastics." *Packaging and Paper Product Extended Producer Responsibility Plan: Revised July 2018* RecycleBC.

31 For example, in 2018 the Canadian Steward Services Alliance initiated the Material Cost Differentiation (MCD) Project "which seeks to develop a methodology that can differentiate the cost to manage each material in the recycling system" to the point that it can be repurposed. See: http://www.cssalliance.ca/mcd/

32 Plastics manufactured using renewable chemistries would need an alternate standard, which at the least would require the declaration of their composition and the sources of their resin substrates.

33 See: Companies take major step towards a New Plastics Economy

34 Given the exceedingly low (and in some cases no) recycling rates for and recycled content of many plastic products and packaging, increasing the recycled content by 50% will achieve little or nothing. The "applicability" of this objective will likely be interpreted very narrowly where recycling is already occurring at an appreciable rate (e.g. PET plastic beverage containers).

35 See: Charlevoix Blueprint for Healthy Oceans, Seas and Resilient Coastal Communities, Annex: Ocean Plastics Charter

36 France is proposing an alternate approach that sets a system of financial penalties and rewards based on recycled content in plastic packaging. France to set penalties on goods packaged with non-recycled plastic in 2019. The Telegraph August 12th 2018.

37 "…we find that government procurement rules produce spillover effects that stimulate both private-sector adoption of the LEED standard and investments in green building expertise by local suppliers. These findings suggest that government procurement policies can accelerate the diffusion of new environmental standards that require coordinated complementary investments by various types of private adopter." Simcoe, T., and Toffel, M.W., 2014. *Government green procurement spillovers: Evidence from municipal building policies in California* Journal of Environmental Economics and Management 68 (2014) 411–434

38 "By using their purchasing power to choose goods, services and works with a reduced environmental impact, governments can make an important contribution towards sustainability goals. High-impact sectors are: buildings, food and catering, vehicles and energy-using products." Green Public Procurement OECD

39 Government of Canada actions on plastic waste in federal operations

40 An overarching comment from producers that were consulted during the preparation of this report was the need for national harmonization of definitions and EPR policy requirements such that emerging provincial and territorial supply-chains can be integrated across jurisdictions to afford the same operational and administrative efficiencies producers achieve in the distribution and sale of their products.

41 See: Microbeads Government of Canada.

42 As President of the G7 nations for 2018, Canada led the ratification of the Charlevoix Blueprint for Healthy Oceans, Seas and Resilient Coastal Communities which includes the Ocean Plastics Charter annex which commits Canada to:

- Working with industry and relevant levels of government, to recycle and reuse at least 55% of plastic packaging by 2030 and recover [i.e. collect] 100% of all plastics by 2040;
- Using green public procurement to reduce waste and support secondary plastics markets and alternatives to plastic;
- Working with industry towards increasing recycled content by at least 50% in plastic products where applicable by 2030;
- Supporting secondary markets for plastics including using policy measures and developing international incentives, standards or requirements for product stewardship, design and recycled content; and
- Supporting secondary markets for plastics including using policy measures and developing international incentives, standards or requirements for product stewardship, design and recycled content.

43 Xanthos, D., Walker, T.R., 2017. *International policies to reduce plastic marine pollution from single-use plastics (plastic bags and microbeads): a review*. Maritime. Pollution Bulletin. 118 (1–2), 17–26.

44 T.R. Walker and D. Xanthos. 2018. *A call for Canada to move toward zero plastic waste by reducing and recycling single-use plastics*, Resources, Conservation & Recycling.

45 UNEP (2018). Single-Use Plastics: A Roadmap For Sustainability

46 The UK government's has stated the objective of the single-use plastic taxas, "Our primary interest is in how we can persuade the producers of plastic materials and the retailers to choose recycled materials wherever possible rather than new virgin plastics and to deter them from using those types of plastics which are extremely hard or impossible to recycle like black carbon plastic." Tax on 'bad plastic' expected to be signed off by Government to boost recycling The Telegraph 18 August 2018

47 Plastic bags contaminate paper recycling resulting in lower paper recycling and disposal of both paper and the contaminating bags as waste. See: Vancouverites are good at recycling — just not when it comes to plastic bags

48 Can Norway help us solve the plastic crisis, one bottle at a time? The Guardian July 12th 2018

49 Source: Kjell Olav A. Maldum CEO Infinitum AS

50 "Prior to the implementation of a landfill disposal ban, careful consideration should be given to the timing of implementation and the need for complementary policies and standards. As shown through the desktop review, the introduction of a levy, in the early stages of the policy (i.e. to transition to a landfill disposal ban), has proved to be integral to providing the necessary economic

signals to encourage additional investment in processing and recycling capacity. In the absence of a [disposal] levy, it is important the complementary policy settings (e.g. phase-in implementation periods, and producer responsibility measures) are appropriate, so as to ensure any adverse unintended consequences are minimised and industry is provided with sufficient time to invest and to develop a good understanding of the future policy settings, including anticipated feedstock levels." *Cost-benefit analysis of the implementation of landfill disposal bans in Queensland* November 2014. Synergies Economic Consulting Pty Ltd., Australia

51 For example, Metro Vancouver prohibits the landfill of recyclable plastics (resins 1, 2, 4 & 5) that are collected and managed under Schedule 5 of the BC Recycling Regulation as well beverage containers that are collected and managed under Schedule 1 of the same regulation. http://www.metrovancouver.org/services/solid-waste/bylaws-regulations/banned-materials/Pages/default.aspx

52 Six of the 11 countries with the highest prost-consumer recycling rates in Europe employ disposal bans. Source PlasticsEurope https://www.plasticseurope.org/en

53 Bio Intelligence Services. April 2012. Use of Economic Instruments and Waste Management Performances Final Report. Prepared for the European Commission (DG ENV) Unit G.4 Sustainable Production and Consumption

54 "…in addition to simply reducing the amount of waste sent to landfill, higher landfill charges tend to push waste towards recycling and composting, therefore moving waste treatment up the waste hierarchy" Ibid. Ref. 53

55 "…significant waste prevention cannot be achieved through PAYT implementation, but requires other policies developed at the national or regional level (e.g., product policies, waste prevention plans, and tax regulations and more targeted actions at the local level, such as awareness raising campaigns, reuse initiatives, second hand markets, repair cafes, etc." Morlok, J Et. Al. 2017. *The Impact of Pay-As-You-Throw Schemes on Municipal Solid Waste Management: The Exemplar Case of the County of Aschaffenburg, Germany* in Resources 2017, 6, 8;

56 Clean Fuel Standard. Government of Canada July 2018

57 Enerkem Inc. (www.enerkem.com), has produced bio-dimethyl ether (Bio-DME), a by-product of biomethanol to substitute for diesel fuel from municipal solid waste. See: Enerkem produces a new clean, renewable alternative solution to diesel fuel for the transportation sector Media release September 10th 2018.

58 Technical paper: federal carbon pricing backstop Government of Canada. January 5th 2018

59 See: Feds gave Nova Chemicals $35-million grant before urging G7 to reduce plastics and Why companies are looking to Alberta to produce plastic: "In 2016, Alberta's Petrochemical Diversification Program, which offered $500 million in royalty relief incentives, attracted 16 proposals worth $20 billion. Two were selected, including Inter Pipeline's [polyethylene]project", which will, "…begin turning propane into polypropylene — a high-value plastic used in things like chairs, piping, medical equipment and rugs."

60 "Canada subsidizes the search for and production of fossil fuels to the tune of more than $3 billion a year in various tax credits, deductions and grants, while Export Development Canada routinely provides financing to oil and gas companies" *Liberal government still plans to eliminate fossil fuel subsidies, McKenna says* Globe and Mail May 2018

61 A number of Canadian provinces provide fuel tax exemptions to the agricultural sector.

62 "A critical issue is that of degradability enhancers which can significantly affect the strength and durability of recycled plastics and, if they were to become widespread in primary plastics could potentially prevent plastics recycling entirely. Furthermore, the uncertainty around the presence and nature of additives that may be present in primary plastics can dis-incentivise plastics recycling because recyclers cannot be certain that their feedstocks are free from additives." OECD (2018). *Improving Markets for Recycled Plastics: Trends, Prospects and Policy Responses*, OECD Publishing, Paris. http://dx.doi.org/10.1Overseas Development Institute787/9789264301016-en Recyclers interviewed for this paper echoed this concern.

63 "Exploring the synergies between the two ends of the supply chain – upstream and downstream - enables informed changes on increasing material quality, efficiency and sustainability, to be made." Hahladakis, J.N., Iacovidou, E., 2018. *Closing the loop on plastic packaging materials: What is quality and how does it affect their circularity?* In Science of the Total Environment 630 (2018) 1394–1400

64 "Much of the global market for plastics waste has been concentrated in a few countries. This makes markets for recycled plastics vulnerable and slow to adjust to demand shocks such as the import restrictions implemented by China in early 2018 after China had accounted for roughly two thirds of waste plastics imports during the last decade." Ibid. Ref. 62

65 A European Strategy For Plastics in a Circular Economy

66 Ibid. Ref. 62

67 “(mechanical) recycling affords materials for uses different from those for which the original material was manufactured. Most reclaimed post-consumer materials are recycled through this process, the products of which are typically lower in value, such that the process is often called ‘downgrading’ or ‘downcycling’. Mechanical recycling involve, “…processes in which polymers are sorted, ground, washed and extruded. Such reprocessing causes varying degrees of polymer degradation, with applications of mechanical recycling being limited by the number of reprocessing cycles that a given polymer can endure.” Ibid. Ref. 10

68 Ibid.

69 Personal communication with Jocelyn Doucet, Eng., Ph. D.,CEO, Pyrowave Inc.

70 There has been a concerted effort in Europe, Canada and the United States to oppose policies that would tax virgin plastics, ban certain plastics and plastic products, require minimum recycled content and make producers responsible for paying for the management, or actually managing end-of-life plastics. See: A plastic bag lobby exists, and it’s surprisingly tough Washington Post March 3rd 2015, Government cut recycling targets after lobbying from plastics industry The Independent February 17th 2017 and Plastic promises: Industry seeking to avoid binding regulations Corporate Europe Observatory May 22nd 2018

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