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CANADA'S WASTEFUL PLAN TO REGULATE PLASTIC WASTE

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by Kenneth P. Green

Contents

Executive Summary

At the end of 2021, the government of Canada launched a regulatory campaign against plastic waste—Zero-Plastic Waste 2030 (ZPW2030)—that will, in the estimation of its own Regulatory Impact Assessment, impose costs on Canadian society exceeding projected benefits. This fails the first, and arguably most important, test of sound public policy.

Environmental Impacts

ZPW2030 will produce little or no environmental benefit because Canada's plastics economy poses a very small environmental risk either locally or globally. Only one percent of Canada's plastic wastes are ever released into the environment. The other 99% is disposed off safely from an environmental perspective: some incinerated, some recycled, but most discarded in landfills, an environmentally benign endpoint.

Canada's contribution to global aquatic plastic pollution, when assessed in 2016, was between 0.02% and 0.03% of the global total. If observed market trends were to continue in the absence of ZPW2030, the government's Regulatory Impact Assessment estimates plastic waste and plastic pollution could increase (from 2016 levels) by roughly one third by 2030. Thus, if ZPW2030 eliminated all the predicted increase, it would prevent an increase from 0.02%–0.03% to 0.023%–0.033% of the global total, an undetectable reduction of three thousandths of one percent.

Even that small reduction in environmental harm is likely to be offset by increased environmental harms stemming from replacements for the plastic products banned under ZPW2030. As government acknowledges, "the proposed Regulations are expected to increase the waste generated from substitutes by 298,054 tonnes in the first year of full policy stringency (2024) and by around 3.2 million tonnes over the analytical period (2023 to 2032), almost all of which is driven by paper substitutes". And, the government observes: "The proposed Regulations would prevent approximately 1.6 million tonnes of plastics from entering the waste stream over the analytical period but would also add about 3.2 million tonnes of other materials to the waste stream from the use of substitutes".

The potential for this kind of regulatory "backfire" fails another important test of sound health- and environment-related public policy, which is "First, do no harm".

Economic impacts

As the government's Regulatory Impact Analysis shows, the monetized costs of the proposed single-use plastics regulations—CA$1.3 billion—will outstrip the monetized benefits—CA$619 million—by nearly 2:1. According to a report the government contracted Deloitte to produce, over the course of the initiative estimated benefits of the overall ZPW2030 regime are estimated to be up to CA$10.5 billion, but would require investment in new facilities of up to CA$8.3 billion to achieve it. Even then, in 2030, annual costs of the program are estimated to exceed benefits by CA$300 million per year.

These costs will ultimately be borne by consumers, as the government observes: the increased volume of wastes discussed above will "represent additional costs for municipalities and provincial authorities, as they are usually responsible for managing collection, transportation, and landfilling of plastic waste, and would assume most of the associated costs, which would ultimately be passed on to taxpayers".

Alternative policy options

Canada's policy makers should consider re-targeting and refocusing its ambitious plan to regulate Canadian plastic wastes, which are a very small environmental problem in Canada, and constitute only a vanishingly small contribution to the global plastic pollution problem. Instead, Canadian policy makers could examine ways to crack down on end-point improper disposal of plastic wastes, such as littering in general. To the extent the federal government is involved with solid waste management, they might look for incentives they could develop to improve street cleaning and municipal waste management and handling practices to prevent littered plastics from lingering in Canada's environment or leaving its bounds to become part of a global problem.

Introduction—Zero Plastic Waste 2030

In 2021, the Canadian government established an "ambitious" policy agenda of driving Canada's plastic wastes to zero by the year 2030 (PMO, 2021). This policy, Zero Plastic Waste 2030 (ZPW2030) reflects growing global concerns over the environmental impacts of the production, use, and disposal (both proper and improper) of plastics around the world.

The news coverage of the ZPW2030 policy agenda has focused on only one aspect of the plan—the banning of single-use disposable plastic products such as plastic grocery bags, plastic drinking straws, and plastic cutlery— but ZPW2030 is more far-reaching, and is intended not only to end the release of plastic wastes to the environment, but to end the disposal of plastic wastes in conventional landfills, which has traditionally been the destination for most plastic wastes in Canada.

Because ZPW2030 applies to the entire Canadian plastics economy, and the overall life-cycle of plastic in the environment, it will have far-reaching implications for Canada's overall economic health, the health of Canadian private-sector businesses, Canada's imports and exports, and Canadian consumer choice (both domestic and international) (Rabson, 2021).

Canada's leaders have been eloquent about Canada's need to reduce plastic wastes. From a news release on the Government of Canada's website, we learn that this is how the Prime Minister and his government leaders characterize the initiative:

> "Canadians know first-hand the impacts of plastic pollution, and are tired of seeing their beaches, parks, streets, and shorelines littered with plastic waste. We have a responsibility to work with our partners to reduce plastic pollution, protect the environment, and create jobs and grow our economy. We owe it to our kids to keep the environment clean and safe for generations to come."

—*The Rt. Hon. Justin Trudeau, Prime Minister of Canada*

> "We've all seen the disturbing images of fish, sea turtles, whales, and other wildlife being injured or dying because of plastic garbage in our oceans. Canadians expect us to act. That's why our government intends to ban harmful single-use plastic products where science warrants it, and why we're working with partners across

> Canada and around the world to reduce plastic pollution. Taking these steps will help create tens of thousands of middle-class jobs and make our economy even stronger—while protecting fish, whales, and other wildlife, and preserving the places we love."

—*The Hon. Catherine McKenna, Minister of Environment and Climate Change*

> "The health of our oceans is vital to the economic, cultural, and social well-being of Canada's coastal communities. We know plastic pollution harms Canada's oceans, wildlife, communities—and our economy. It's a problem we simply can't afford to ignore. We are working with industry to prevent and remove ghost fishing gear, to protect marine animals and the marine environment now and for future generations."

—*The Hon. Jonathan Wilkinson, Minister of Fisheries, Oceans and the Canadian Coast Guard*

(Office of the Prime Minister of Canada, 2019)

Public discourse over the plan has also been reasonably robust. In 2020, for example, the *Toronto Star* published a pro-and-con debate over the idea of banning single-use plastics (SUP) in which Sarah King, of Greenpeace Canada, debated Angela Logomasini, a policy analyst with the Competitive Enterprise Institute (a US environmental policy think tank), focused on the single-use plastics aspects of the ZPW2030 idea. (King and Logomasini, 2020).The *Star* debate neatly encapsulated the major arguments on both sides of the issue over the idea of banning single-use plastics. The two sides to the debate essentially come down to this:

pro-ban—pollution by plastics is a global problem and, because Canada is a part of that problem, Canada should eliminate its plastic wastes, as well as its contribution to the global plastics problem, through changes to its overall use of plastics in society;

anti-ban—over 99% of the plastic materials that pass through Canada's economy are disposed of safely, mostly in landfills, partly via recycling and combustion; Canada is an insignificant contributor to the global plastics problem but banning single-use plastics will harm consumers.

The contours of the public debate are much the same at the time of this publication.

The current status of ZPW2030

In the near term, the Canadian framework focuses on single-use plastics, and "propose[s] to prohibit the manufacture, import and sale of single-use plastic checkout bags, cutlery, food-service ware made from or containing problematic plastics, ring carriers, stir sticks, and straws. Exceptions to the Regulations will allow single-use plastic flexible straws to remain available for sale in stores, under certain conditions, so that people who need them will still have access" (Government of Canada, 2021a). [1] In the longer term, however, ZPW2030 goes well beyond these sorts of single-use disposable plastics and also includes the reduction of plastic wastes from packaging materials, recycling mandates, recycled-plastic-content mandates, labeling rules for recyclable plastics, reducing and/or ending disposal of plastic wastes in landfills, and more.

In the government's policy framework, "plastic waste" is defined broadly, as including essentially all plastic materials that might wind up buried in landfills, burned for energy production, or released to the environment. In this framework of analysis, any plastic material not part of a closed loop of complete recycling—from plastic precursors back to plastic precursors—are considered waste, and the existence of those wastes is considered a cost to society, and detrimental to wildlife and the environment. [2]

Legislative / regulatory history

In December 2021, the Trudeau government published the Prime Minister's "*Minister of Environment and Climate Change Mandate Letter*", which set out a long list of policies the government would pursue to reduce Canada's negative environmental impacts, primarily related to climate change and greenhouse gas emissions (Trudeau, 2021).

The Prime Minister's mandate calls for the achievement of "Zero Plastic Waste by 2030", specifying the following actions:

> - continue to implement the national ban on harmful single-use plastics;
> - require that all plastic packaging in Canada contain at least 50 per cent recycled content by 2030;

[1] On Monday, June 20, 2022, the federal government announced specifics of the first phase of Zero-Plastic Waste 2030, including a time line for a ban on the manufacturing, importation, and exportation of straws, takeout containers, grocery bags, cutlery, stir sticks, and plastic rings used to hold cans or bottles together (ECCC, 2022).

[2] There are several interesting philosophical questions that we lack space to address here but should probably be considered as the reader advances through this paper, as they are fundamental issues that underlie the deep rationale for the entire policy framework of ZPW2050. Among these questions are the following. Is there some particular benefit in not disposing of a waste in one generally safe way (landfilling) but rather, in disposing of it in some other way that may or may not be more costly, or have other offsetting problems? Is anything that is not either completely "used up" until it is either unreclaimable heat energy or inert matter legitimately considered to be "waste"? Is a "circular economy" not an inherently diminishing economy, due simply to the effects of entropy, and the loss of energy to systems over time? It is unclear to the author that locking society into a diminishing spiral of material-use reduction is not itself a rather massive waste of human potential. But, again, we lack space for such discussion here.

> - accelerate the implementation of the zero plastic waste action plan, in partnership with provinces and territories;
> - continue to work with provinces and territories to ensure producers, not taxpayers, are responsible for the cost of managing their plastic waste;
> - work with provinces and territories to implement and enforce an ambitious recycling target of 90 per cent—aligned with Quebec and the European Union—for plastic beverage containers;
> - introduce labelling rules that prohibit the use of the chasing-arrows symbol unless 80 per cent of Canada's recycling facilities accept, and have reliable end markets for, these products; and
> - support provincial and territorial producer responsibility efforts by establishing a federal public registry and requiring producers to report annually on plastics in the Canadian economy.
>
> (Trudeau, 2021)

The Prime Minister's *Mandate Letter* has been implemented in the form of *Zero Plastic Waste: Canada's Actions* (Government of Canada, 2021b), which consists of two main components: first, promulgating an *Ocean Plastics Charter*, to address global plastics pollution; and second, implementing the *Canada-wide Strategy on Zero Plastic Waste* (Government of Canada, 2021a). As Canada's plastic-pollution profile only minimally affects plastics pollution of the ocean (as will be discussed below), the details of the *Ocean Plastics Charter* will not be further discussed here and this policy analysis will focus on the *Canada-wide Strategy on Zero Plastic Waste*.

According to the website of *Zero Plastic Waste: Canada's Actions* (as of February 1, 2022) after a several-year period of policy development, the government of Canada first added a category of materials called "plastic manufactured items" to Schedule 1 of the Canadian Environmental Protection Act of 1999 (CEPA) in May 2021 (Government of Canada, 2021b). This action, according to the Canada-wide Strategy, enabled the government to "take regulatory and other action in support of reaching Canada's zero plastic waste goal and setting the conditions for a plastics circular economy".

Subsequently, on December 25, 2021, the Government of Canada published the proposed *Single-Use Plastics Prohibition Regulations*, in the Canada Gazette, Part I, and a *Guidance for Selecting Alternatives to the Single-Use Plastics in the Proposed Single-Use Plastics Prohibition Regulations* (Canada Gazette, 2021; ECCC, 2021b). The detailed regulations themselves were published in the Canada Gazette on December 25, 2021 (Canada Gazette, 2021), along with an extensive Regulatory Impact Analysis Statement, which will be discussed further below.

Plastics in Canada—a Brief Overview

As in most developed societies, plastic materials in Canada are virtually omnipresent: it is difficult, if not impossible, to look around oneself in an indoor environment without seeing innumerable objects that are partially composed of plastic materials. Some of those plastics, in fact, make up the composition of the rooms we inhabit, up to and including some of the structural materials that form the entire indoor environment itself. Some of them are inside our bodies themselves or may be the thin film of a contact lens on the front of your eyes.

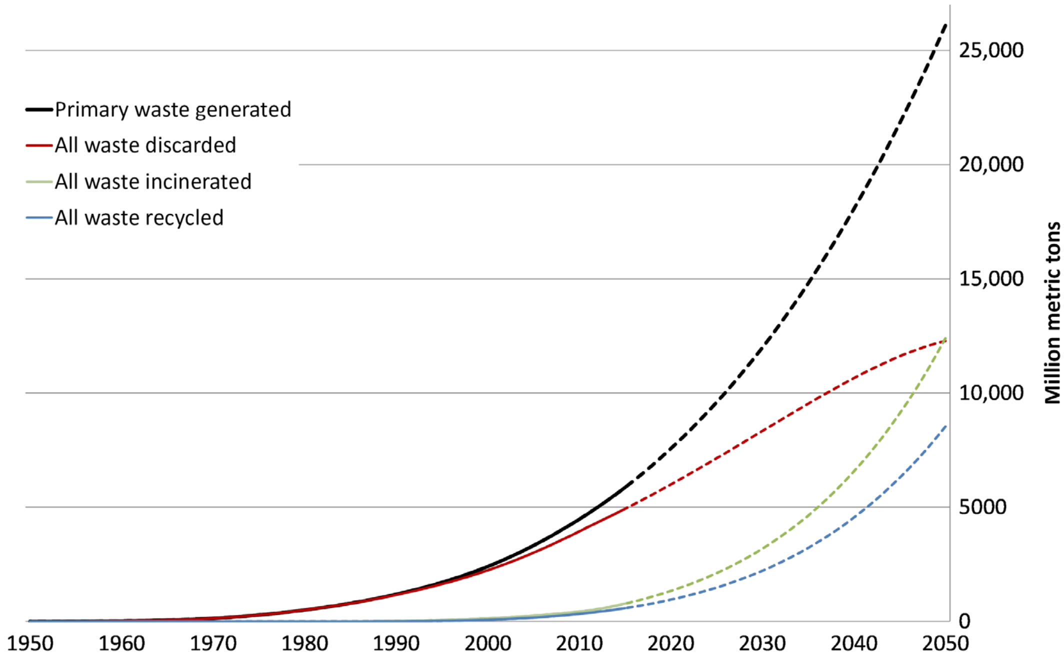
Today, plastic and plastic-bearing materials are used especially intensively in the packaging, preserving, protecting, and transportation of a vast array of goods including foods and beverages. Plastic wrapping materials compose 48% of Canada's plastic wastes (ECCC, 2020b), and plastic materials also play a major role in the production, distribution, and use of chemicals, medicines and medical supplies, as well as health protection and medical technologies.

Figure 1 shows the historic growth of plastic waste generation and disposal since the 1950s (when plastics were first developed). The dashed lines are modeled extrapolations from a historical study of plastics (Geyer, Jambeck, and Law, 2017). As Geyer and colleagues observe:

> The growth of plastics production in the past 65 years has substantially outpaced any other manufactured material. The same properties that make plastics so versatile in innumerable applications—durability and resistance to degradation—make these materials difficult or impossible for nature to assimilate. Thus, without a well-designed and tailor-made management strategy for end-of-life plastics, humans are conducting a singular uncontrolled experiment on a global scale, in which billions of metric tons of material will accumulate across all major terrestrial and aquatic ecosystems on the planet. The relative advantages and disadvantages of dematerialization, substitution, reuse, material recycling, waste-to-energy, and conversion technologies must be carefully considered to design the best solutions to the environmental challenges posed by the enormous and sustained global growth in plastics production and use. (Geyer, Jambeck, and Law, 2017)

As Geyer and colleagues note, the unique characteristics of plastic not commonly found together in natural materials—including their non-reactivity, non-conductivity,

Figure 1: Global cumulative plastic waste generation and disposal, 1950–2050 (projected)



Note: Solid lines show historical data from 1950 to 2015; dashed lines show projections of historical trends to 2050.
Source: Geyer, Jambeck, and Law, 2017: figure 3.

flexibility, conformability, malleability, durability, impermeability, foaming capacity, textural variability, and colorization—make plastic materials uniquely useful in a broad range of human endeavours, a utility that is reflected in consistently strong market demand for plastic-bearing materials.

Though ubiquitous now, plastics constitute a novel form of structural material in the history of the Earth, a material not provided by nature. It has critical characteristics that facilitate the production, maintenance, and use of innumerable vital goods: whether it is the plastic housing on an MRI machine; the plastic panels on the ambulance that transports us to hospital; the plastic components in refrigeration systems, plumbing systems, electrical systems, transportation systems, and food containers; and plastic-containing fabrics of all sorts. And as the COVID-19 pandemic has highlighted, plastics are used widely in the manufacturing (and implantation) of medical devices and prosthetics. Some examples of medical implants that use plastics include hip joints, cardiovascular implants, drug delivery devices, vascular grafts, bone cement for orthopedic implants, dental cement, heart valves, pacemakers, artificial materials for ear, chin, and nose reconstruction, sutures, and of course breast implants and other cosmetic implants. Some of the more familiar plastics used in medical implants include polyethylene, polypropylene, polyvinyl chloride (PVC), polyethylene glycol, cellulose acetate, and the ubiquitous nylon. But those same characteristics, particularly durability, non-reactivity, and low-density pose particular challenges for the management of plastic wastes (Nag and Banerjee, 2012).

In July 2018, Environment and Climate Change Canada (ECCC) published an *Economic Study of the Canadian Plastic Industry, Markets, and Waste,* produced by a consortium of the firms Deloitte and Cheminfo Services, Inc. (ECCC, 2019; the publication is referred to here as *Deloitte 2019* for simplicity). The project was "overseen, funded, and coordinated" by Environment and Climate Change Canada.

As *Deloitte 2019* documents, Canada's plastics problem is not, in fact, primarily one of environmental pollution: as will be discussed in greater depth, only one percent of the flow of plastic materials through Canadian society is actually released to the environment via "unmanaged dumps or leaks". Of the other 99% of plastics that flow through the Canadian economy and society, 9% is recycled completely (that is, broken down to the chemical constituents of plastics that can be reused), 4% is incinerated to produce energy, and 86% is disposed of in landfills (presumably in accordance with environmental safety regulations that govern land disposal of wastes in Canada.)

Canada's intense use of plastics does pose challenges to environmental protection, both in Canada and internationally. The production and use of plastics in society carries a range of potential environmental harms: these include contributing to the atmospheric concentration of greenhouse gases; contaminating the environment and ecosystems with long-lived plastic materials (that is, litter); and harming wildlife (primarily aquatic) including aquatic mammals and the fish we consume. Though the conventional pollutant and greenhouse-gas emissions attendant upon plastics production, use, and disposal are not insignificant, the global plastics problem is primarily one of relatively crude environmental contamination, through plastics production, use, and disposal, hence the focus of Canada's ZPW plan on the "W"—the waste.

By virtue of their physical and chemical durability (as well as their low density), plastic wastes can persist in the environment almost indefinitely, posing physical hazards to wildlife, especially aquatic wildlife, as much of the world's plastic waste is either dumped directly into the world's rivers and oceans, or makes its way there after being improperly disposed of on land—as litter, for the most part. Table 1 tabulates the proportion of plastic wastes generated in Canada, by industrial/usage sector.

However, based on *Delloite 2019*'s accounting of plastics use in Canada, the primary problem Canada has with plastics is not one of environmental *contamination*, it is one of perceived economically inefficient (or otherwise undesirable) *disposal*:

Table 1: Main industrial sectors generating plastic waste in Canada in 2016

Sector	Proportion of total plastic waste	Sector	Proportion of total plastic waste
Packaging	47%	Construction	5%
Automotive (vehicle parts and components, excluding tire wear)	9%	White goods (e.g., large and small appliances)	4%
Textiles	7%	Agriculture	1%
Electrical and electronic equipment	7%	Other	19%

Source: ECCC, 2019: table 3-1.

> The Canadian plastics economy is mostly linear, with an estimated nine percent of plastic waste recycled, four percent incinerated with energy recovery, 86 percent landfilled, and one percent leaked into the environment in 2016 … *Thus, plastics material not recovered (i.e., 2,824kt of resins **sent to landfill or leaked into the environment**) represented a lost opportunity of CA$7.8 billion for Canada in 2016, based on the value of virgin resin material*. (ECCC, 2019: ii; emphasis mine).

To assess the potential benefits of addressing this undesirable linearity in Canada's plastics economy, *Deloitte 2019* developed a scheme for a "Zero Plastic Waste Economy" for Canada in 2030 (figure 2 and figure 3). In this scenario, *Deloitte 2019* envisions a world in which 90% of the waste that is currently sent for environmentally safe disposal in landfills would be largely recycled (and partly incinerated) instead, and the amount of plastic actually released to the environment would decrease from one percent to "< one percent".

Of note in this projected future scenario of plastics management is that, while recycling of plastic wastes to chemical precursors grows to 15%, *the biggest growth in recycling is the result of a reduction in landfilling*, which drops from taking 86% of plastic wastes (2016) to only 10% in 2030. The percentage of plastic wastes prevented from environmental release is extremely small. An additional 21% of the plastics to be recycled in 2030 come from "diverted waste" and another 27% from mechanical recycling of solid plastic wastes gathered in recycling programs. Incineration, with energy recovery grows from 4% (2016 data) to 22% in 2030.

Economic impacts

As the government's economic impact analysis shows, the monetized costs of the proposed single-use plastics regulations will outstrip the monetized benefits by nearly 2:1:

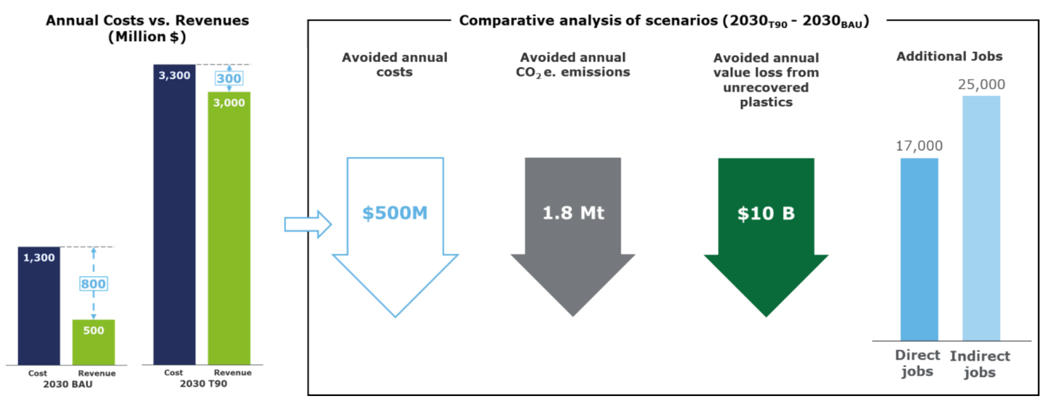
> [T]he proposed Regulations are expected to result in $65 million in monetized benefits in the first year of full policy stringency (2024), or $619 million in monetized benefits over the analytical period (2023 to 2032), stemming mainly from the avoided cost of terrestrial litter clean-up … the costs and monetized benefits of the proposed Regulations would total $140 million in net cost in the first year of full policy stringency (2024), or $1.3 billion in net cost over the analytical period (2023 to 2032).

> While the proposed Regulations are expected to result in a total net cost with respect to monetized impacts, the most significant benefit is non-monetized; namely, the reduction in risk of harm to wildlife and their habitats from less plastic pollution. (Canada Gazette, 2021)

The government's detailed cost-benefit analysis is broken out in **table 2**:

Deloitte 2019 also estimated the economic costs and benefits of implementing Canada's ZPW2030 plan as a whole (beyond single-use plastic bans) by calculating the change in costs and revenues in 2030 from the ZPW scenario to one of "business as usual". **Figure 2** summarizes the economic findings of the study. As we see, projected in 2030, moving from a "business as usual" scenario to one of Zero Plastic Waste would see Canadian society avoiding CA$500 million in costs (primarily of waste management), and avoiding annual "lost value" from the unrecovered and not-recycled (mostly landfilled) plastics of CA$10 billion.

Figure 2: Comparative analysis of scenarios used in the Deloitte 2019 study



Source: ECCC, 2019: figure 3.

However, these savings will come at a significant cost. *Deloitte 2019* estimates that achieving the Zero Plastic Waste scenario would require major investment in new facilities: "The model projects the need to add 167 facilities for a total estimated investment

Table 2: Cost benefit analysis of single-use plastic regulations

Cost-benefit statement

Number of Years: 10 years (2023 to 2032)

Base year for costing: 2020

Present value base year: 2021

Discount rate: 3%

Monetized costs, discounted (in millions of dollars)

Impacted stakeholder	*Description of cost*	*2023*	*2024*	*2032*	*Total (2023–2032)*	*Annualized value*
Canadians	Substitution (for all items except checkout bags)	$130	$185	$180	$1,770	$207
Canadians	Subsitution and secondary use (for checkout bags)	Break-even	Break-even	Break-even	Break-even	Break-even
Canadians	Waste management	$11	$18	$16	$163	$19
Certain manufacturers, importers, and retailers	Administrative	$0.70	$0.40	$0.0020	$1.10	$0.10
Government	Compliance and enforcement	$1.40	$2.10	$0.90	$13.40	$1.60
All stakeholders	Total costs	$143	$205	$197	$1,948	$228

Monetized benefits, discounted (in millions of dollars)

Impacted stakeholder	*Description of cost*	*2023*	*2024*	*2032*	*Total (2023–2032)*	*Annualized value*
Canadians	Avoided terrestrial litter clean-up cost	$42	$61	$59	$583	$68
Canadians	Avoided marine pollution cost	$2	$4	$4	$36	$4
All stakeholders	Total benefits	$44	$65	$63	$619	$72

Summary of monetized costs and benefits (discounted)

Impacts	*2023*	*2024*	*2032*	*Total (2023–2032)*	*Annualized value*
Total costs (in millions of dollars)	$142	$205	$197	$1,948	$228
Total monetized benefits (in millions of dollars)	$44	$65	$63	$619	$72
Net monetized impact— net cost (in millions of dollars	$98	$140	$134	$1,329	$156
Quantified reduction in plastic waste (tonnes avoided)	78,096	132,242	163,898	1,405,789	140,579
Net non-monetized impact: benefits to wildlife and humans in the form of reduction in plastic pollution (tonnes avoided)	1,293	2,196	2,744	23,432	2,343

Sources: Canada Gazette, 2021: tables 18, 19, 20.

of between CA$4.6 billion and CA$8.3 billion for [the 2030 scenario], broken-down by facility types" (ECCC, 2019: 19; see **figure 3**). Even in 2030, then, the annual costs of the program are estimated to exceed benefits by CA$300M.

Figure 3: Additional capacity and investment estimates needed to implement the 2030 scenario

Source: ECCC, 2019: figure 14.

The economic impacts of ZPW2030, however, will transcend both the national-level environmental cost/benefit balance, and impacts to consumers, because Canada has a robust plastics industrial economy of its own, and the uses of plastics are in highly dispersed aspects of the economy: [3]

> With total sales estimated at CA$35 billion, plastic resin (CA$10 billion) and plastic product (CA$25 billion) manufacturing in Canada accounts for over five percent of the sales in the Canadian manufacturing sector and employs 93,000 people across 1,932 establishments. Present in almost every modern product, global demand and production of plastics is growing. In Canada, plastic products are in demand in most sectors of the economy, with approximately 4,667 kilotonnes (kt) of plastics introduced to the domestic market on an annual basis (more than 125 kg per capita). Three categories (packaging, construction and automotive) show a particular appetite for plastic, accounting for 69 percent of plastic end-use. (ECCC, 2019: i)

One important aspect of Canada's plastics economy that receives little coverage in public debate over the question of plastic waste is the industries' input sources. As *Deloitte 2019* explains: "Virgin plastic resin production is dependent primarily on oil or natural gas for its source of chemical raw materials. The abundance of new, inexpensive energy sources resulting from shale gas development has precipitated unprecedented investment in new virgin resin production capacity" (ECCC, 2019: 4).

[3] Plastic *resin* refers to the chemicals that are combined to make solid plastics (these are usually liquids, and usually derived from fossil fuels). Examples of plastic resins readers will likely be familiar with include vinyl, polyvinyl chloride, polyethylene, polystyrene, polyurethane, and acrylic. Plastic products are the solid (and semi-solid) materials made by combining plastic resins in different ways.

Plastic precursor chemicals

Canada also has a significant economic presence in the production of plastic precursor chemicals, such as ethylene and propylene, which are used to produce plastics such as polyethylene and polypropylene. In *Examining the Expansion Potential of the Petrochemical Industry in Canada,* the Canadian Energy Research Institute (CERI) details those activities (as of 2015) with a look ahead at potential development of the sector. According to CERI, the Chemical Manufacturing Sector made the following GDP contributions to the Canadian economy for the year 2014.

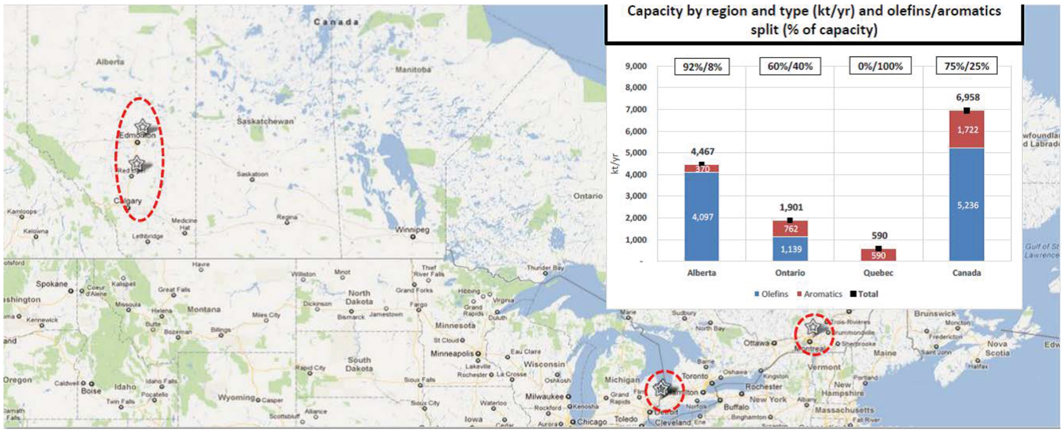
> - Manufacturing = $174 billion
> - Real estate & rental & leasing = $205 billion
> - Mining, quarrying, oil & gas extraction = $138 billion
> - Construction = $117 billion
> - Finance & insurance = $111 billion
> - Health care & social assistance = $110 billion
> - Public administration = $110 billion
> - Wholesale trade = $91 billion
> - Retail trade = $88 billion
> - Professional, scientific & technical services = $87 billion
> - Educational services = $84 billion
> - Transportation & warehousing = $68 billion

(CERI, 2015: 17)

Per CERI, petrochemical production is concentrated in Alberta (Joffre and Ft. Saskatchewan), Ontario (Sarnia-St. Clair), and Québec (East Montreal). Plastic precursor chemicals such as ethylene and polypropylene (called *olefins*), however, are produced only in Alberta and Ontario. Figure 4 shows the locations and products of the petrochemical clusters in Canada. As can be seen from the figure, In Alberta, 92% of the petrochemical industry's output are plastic-precursor olefins. In Ontario, according to CERI, about 60% of the province's petrochemical capacity is based on olefins and 40% on aromatics (other petrochemicals such as toluene and benzene used for various industrial purposes).

As CERI notes, the plastic precursor feedstocks have primarily been sources from Western Canada (natural gas liquids and crude oil/condensates) and from local refineries: "In the Canadian context, the main sources of petrochemical feedstock include NGLs from processing plants and off-gas plants as a feedstock for olefin or ethylene crackers in Alberta and Ontario. Crude bitumen, crude oil, and condensates processed at refineries are another feedstock, which yield LPGs, as well as refinery naphtha and gas oils for steam crackers" (CERI, 2015: 11).

Figure 4: Petrochemical manufacturing regions and their olefin and aromatic production (kt/yr)



Source: CERI, 2015; figure 1.2 (image from GoogleMaps; modified by CERI).

CERI concludes: "The petrochemical sector in Canada is cost competitive with other regions globally. The main reason is the access to cheap feedstock" (CERI, 2015: 57) However, CERI observes that market access remains a challenge if expansion is to occur in Canada, but notes that Canada also faces numerous challenges in export markets for petrochemicals: "The challenges of the export market and in particular the transportation infrastructure to tidewater remain" (CERI, 2015: 58).

By artificially lowering the costs of using plastic precursor chemicals recycled from plastics currently destined for landfills, ZPW2030 would likely displace some market demand for both newly synthesized resins and newly synthesized plastic precursor chemicals such as ethylene, polyethylene, and polypropylene, which are growing markets both in Canada and abroad. This could disproportionately harm the centers in Canada (figure 4) that produce plastic precursor chemicals from raw petroleum inputs. How much harm ZPW2030 would impose on those precursor industries and regions could not be quantified at the time of writing.

ZPW2030—Environmental Impacts

The ZPW2030 initiative involves several environmental considerations, some direct, and some less so. These include:

- potentially reduced emissions of greenhouse gases and other air pollutants;
- potentially reduced contamination of the environment by plastic materials that are both unsightly and pose risks to wildlife;
- reduced use of landfilling—the disposal of solid wastes into land impoundments; and
- potentially more (or less) energy production and consumption via the combustion of plastic wastes to generate energy.

It is relatively straightforward to understand the connection of the first, *emissions of greenhouse gases and conventional air pollutants*, to environmental protection: these are empirically detectable and quantifiable emissions of substances that pose risks to the ecosystem and, thereby, human health and welfare. As a result of the actions planned to achieve ZPW2030, *Deloitte 2019* projects a reduction in Canada's annual greenhouse-gas emissions of 1.8 Megatonnes (Mt/yr) by 2030 (measured as Carbon Dioxide equivalents). For reference, in 2018, Canada's greenhouse-gas emissions were estimated at 729 Megatonnes of CO_{2e} (ECCC, 2020a), while Canada's estimated greenhouse-gas emissions in 2030 (under Canada's Climate Plan) are projected to be 588 Mt, a reduction of 28% compared to a scenario without Canada's Climate Plan (ECCC, 2021c). Accordingly, Canada's Zero-Plastic-Waste policies, should they achieve the scenario developed in the *Deloitte 2019* study, would achieve a reduction of 1.8 (Mt)/(729–588) Mt, or about ***0.01%*** of Canada's projected emissions.

The second aspect of environmental impact on *Deloitte2019*'s list is *quantification of the volume and impacts of plastic materials that are released into the environment,* particularly environments where they are likely to harm wildlife. The primary harm from plastic wastes is that affecting aquatic environments. In fact, plastics constitute the most prevalent type of litter found in the oceans, estimated to make up at least 80% of total marine debris (from surface waters to deep-sea sediments), plastic bags being among the most prevalent littered items (Canada Gazette, 2021). The scale of the global problem with aquatic plastic pollution (from land sources) can be seen in **table 3** (UNEP, 2020b).

Table 3: Estimated emissions of plastic waste (million metric tonnes/yr), 2016

Estimated emissions of plastic waste	Source-to-sea aspect	Projected emissions of plastic waste under certain conditions	Approach used
19–23 Mt/yr	Entered aquatic eco-systems in 2016	53 Mt/yr by 2030	Integrating expected population growth, annual waste generation per capita, the proportion of plastic in waste; incorporating an increase in plastic materials associated with predicted production increases, and the proportion of inadequately managed waste by country
9–14 Mt/yr	Entered aquatic eco-systems in 2016	23–37 Mt/yr by 2040 (equivalent to 50 kg of plastic per meter of coastline worldwide)	Modeled stocks and flows of municipal solid waste and four sources of microplastics through the global plastic system, using five scenarios (2016–2040) and assuming no effective action is taken
0.8–2.7 Mt/yr	Entered the oceans from global riverine systems in 2015		Based on >1,000 rivers, calibrated using field observations

Source: UN 2020: table 1.

Plastic pollution of Canada's environment is also a detectable, and quantifiable harm, though a relatively small one. As mentioned earlier, at present only approximately one percent of Canada's plastics materials (some 29,000 tonnes) end up being released into the environment, 2,500 tonnes of which became marine plastic pollution. For context, then, per the government's Regulatory Impact Assessment, at the 2016 level of plastic waste Canadians produced around 800 grams of plastic pollution per capita. At Canada's 2022 population level of about 38 million, this would add up to approximately 15,200 tonnes of plastic waste. [4] Internationally, academic studies have estimated the total amount of plastic pollution entering oceans globally at between 8 million tonnes and 13 million tonnes per year. Thus, Canada's contribution to global aquatic plastic pollution at 2016 levels was between ***0.02% and 0.03% of the global total***.

If observed market trends were to continue, without ZPW2030 the Regulatory Impact Analysis Statement estimates that the 2016 figures for plastic waste and plastic pollution could increase by roughly one third by 2030 (Canada Gazette, 2021), thus, to ***0.023% and 0.033% of the global total***. Thus ZPW2030, if it completely avoided the growth in plastic wastes over its implementation period, would reduce Canada's share of global plastic waste contamination by ***three one-thousandths of one percent***.

And even that small reduction will come with offsetting negative consequences:

[4] Calculation by author based on data from the Regulatory Impact Analysis Statement (Canada Gazette, 2021) and publicly available national population data.

> [T]he proposed Regulations are expected to ***increase*** the waste generated from substitutes by 298,054 tonnes in the first year of full policy stringency (2024) and by around 3.2 million tonnes over the analytical period (2023 to 2032), almost all of which is driven by paper substitutes. In the case of [single-use plastic] checkout bags, SUP food-service ware made from or containing problematic plastics, and SUP ring carriers, some of their substitutes would themselves be made of plastics, though they would represent inherently less risk to the environment … substitutes made of plastics would represent an additional 21,519 tonnes of plastic waste in the first year of full policy stringency (2024), 229,101 tonnes over the analytical period (2023 to 2032). (Canada Gazette, 2021)

The Regulatory Impact Analysis Statement goes on to find that:

> The proposed Regulations would prevent approximately 1.6 million tonnes of plastics from entering the waste stream over the analytical period but would also add about 3.2 million tonnes of other materials to the waste stream from the use of substitutes, due to their increased unit weights relative to SUPs. This increase in tonnage of waste would represent additional costs for municipalities and provincial authorities, as they are usually responsible for managing collection, transportation, and landfilling of plastic waste, and would assume most of the associated costs, which would ultimately be passed on to taxpayers. (Canada Gazette, 2021)

Understanding the Challenge of Trade-Offs

One of the challenges policy makers face in attempting to reduce the use of plastics is that people use these materials for a reason. The use of disposable plastics fills a perceived need of the people who use them, which is self-evident. If policy makers seek to prevent consumers from using plastics, people are confronted with a choice: simply stop doing the things that plastics enable them to do (which, given the rapidity with which plastics were adopted, seems unlikely), or they can use substitute materials to accomplish the same things previously done with plastics, multiple-use, single-use, or lifetime use.

Understanding those trade-offs, and their economic and environmental implications, is achieved—when it is performed, which has been too rarely—by comparing the life-cycle environmental impacts of plastic goods with the life-cycle environmental impacts of whatever goods would replace them. Comparative life-cycle assessment is a growing field of study that offers a rigorous method of computing the trade-offs of replacing one material with another.

All life-cycle analyses, however, are not equally reliable. A critical issue for life-cycle analyses is the question of where one draws the boundary of the life cycle to be analyzed. That is, what one includes and excludes from the framework of analysis of a life cycle in both time and space, in human and non-human ecosystems, and in economic and intergenerational perspectives. Without proper caution, these boundaries can sometimes be drawn too narrowly or too broadly, too inclusively or not inclusively enough, leading to inappropriate comparisons—the dreaded apples-to-oranges.

Life-cycle analysis, as the name implies, is an attempt to estimate the impacts of a material over the full life cycle of its existence, and like sustainability, the concept seems simple enough on first consideration. A deeper look at what the life cycle of an object (or an activity, for that matter) entails over the course of its production, use, and disposal, however, reveals that the issue is far more complex than it would appear. While it can be complex and quantitative in execution and presentation, environmental life-cycle analysis is still fundamentally a subjective framework of analysis, requiring numerous judgments about what is included in the analysis, the time frame, scope, scale, and even the definition of environmental harms. However, life-cycle analysis is the best tool we have to assess and compare in a logical way the sort of impact materials may have.

Several high-resolution, comparative life-cycle analyses (LCA) have been performed in recent years, and the findings to date suggest that replacing plastics with other materials can have perverse consequences that themselves cut against the concept of environmental sustainability. Following are a few examples of such comparative LCA studies, presented to help the reader understand some of the intricacies of product-substitution decisions, and the likelihood of adverse consequences as a result of the substitution.

Franklin Associates (2018)—plastic packaging compared to alternatives

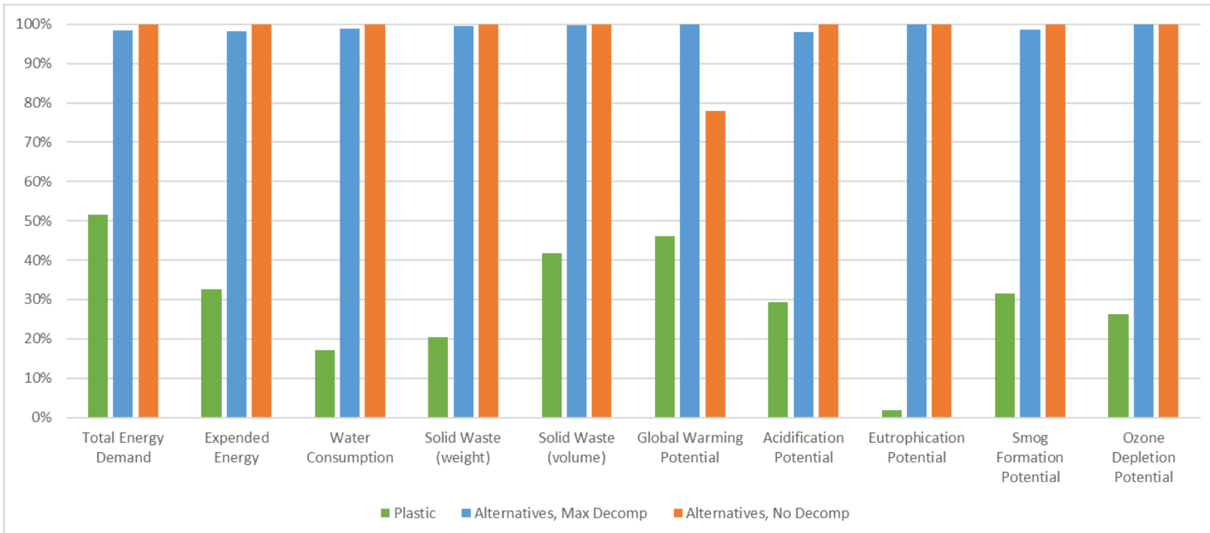
A comparative life-cycle analysis conducted by Franklin Associates (2018) for the American Chemistry Council, asked the question: "If plastic packaging were replaced with alternative types of packaging, how would environmental impacts be affected?" This is a critical issue for Canada, because, as mentioned earlier, plastic packaging is a major component of Canada's plastic waste, at 47% of the total plastic waste generated in the country.

Franklin Associates examined a broad range of environmental metrics including: energy demand; water consumption; solid waste; global warming potential; acidification potential (of water bodies); eutrophication potential (of water bodies); smog formation potential; and ozone depletion potential. Figure 5 illustrates the findings of the Franklin study at a glance. As one can see, the counter-intuitive findings are stark: on the 10 metrics of environmental degradation studied, plastics were the least detrimental, followed by alternative materials that had been maximally decomposed (Max Decomp), which were only slightly better than alternative materials (except in the case of global warming potential) disposed of with "No Decomp," that is, in landfills.

Table 4 breaks out the findings of the Franklin study for the United States and Canada in more detail. As a point of reference, the population of Canada is approximately one tenth that of the United States; as of this writing, there were approximately 330 million people living in the United States and about 38 million Canadians. Notice that, if you divide the US values by 10, they are very much in line with the Canadian values, implying that plastic-waste management in the United States is not all that dissimilar from that in Canada.

Table 5, from Franklin Associates (2018), puts the findings in a more intuitively understandable perspective, comparing the annual environmental impact "savings" of plastic-materials use in more colloquially familiar terms such as miles driven by vehicles, or the number of Olympic-swimming-pool volumes of water consumed. Again, a scaling factor of 10 indicates that the use of plastic packaging per person is similar in the two countries.

Figure 5: Environmental performance of plastic packaging and alternatives



Note: In this chart, "100%" represents the highest environmental impact within the particular metric listed across the bottom. So, for Total Energy Demand, "Alternatives, No Decomposition" consumed the greatest amount of energy (considered a negative environmental impact) compared to either Alternatives with Maximum Decomposition, or Plastics.
Source: Franklin Associates, 2018; figure ES-3.

Table 4: Summary of savings for plastic packaging compared to substitutes

Results category	Units	US saviings, compared to:		Canadian savings, compared to:	
		substitutes with maximum decomposition	substitutes with no decomposition	substitutes with maximum decomposition	substitutes with no decomposition
Total energy demand	billion MJ	1,196	1,235	121	123
Expended energy	billion MJ	1,396	1,435	143	145
Water consumption	billion liters	1,106	1,121	130	133
Solid waste by weight	thousand metric tons	52,887	53,162	4,044	4,050
Solid waste by volume	million cubic meters	55.1	55.4	3.73	3.74
Global warming potential	million metric tonnes CO_2 eq.	67.1	39.5	8.66	3.65
Acidification potential	thousand metric tonnes SO_2 eq.	526	541	52.3	52.7
Eutrophication potential	thousand metric tonnes N eq.	340	341	37.4	37.4
Smog formation potential	thousand metric tonnes O_3 eq.	6,549	6,682	666	670
Ozone depletion potential	metric tonnes CFC-11 eq.	1.15	1.15	0.13	0.13

Source: Franklin Associates, 2018: table ES-4.

Table 5: Savings equivalents for plastic packaging compared to substitutes

Results category	Equivalence factor	US saviings, plastics compared to: substitutes with maximum decomposition	US saviings, plastics compared to: substitutes with no decomposition	Canadian savings, plastics compared to: substitutes with maximum decomposition	Canadian savings, plastics compared to: substitutes with no decomposition
Total energy	Million passenger vehicles per year	18	18	1.8	1.8
	Thousand tanker trucks of gasoline	1073	1108	108	110
Global warming potential	Million passenger vehicles per year	14	8.5	1.9	0.8
	Thousand tanker trucks of gasoline	889	523	115	48
Water consumption	Thousand Olympic swimming pools	461	467	54	55
Solid waste by weight	Thousand 747 airplanes	290	291	22	22
Solid waste by volume	US Capitol rotundas	1496	1505	101	102
Acidification	Thousand rail cars of coal	292	301	29	29

Source: Franklin Associates, 2018: table ES-5.

United Nations Environmental Programme (2020b)—plastic bags compared to alternatives

In *Single-Use Plastic Bags and Their Alternatives: Recommendations from Life Cycle Analysis,* the United Nations Environment Programme (UNEP, 2020b) conducted a meta-analysis of seven (English-language) life-cycle analyses of single-use plastic bags and their alternatives. The findings of the UNEP report were quite mixed with regard to the trade-offs involved in using plastic bags and their substitutes. **Table 6** shows the summary findings of the seven LCAs examined.

Some key findings from the UNEP's report on environmental trade-offs of single-use plastic bags (SUPB) as opposed to alternatives included (selected for relevance):

> - Considering the impacts from all life cycle stages, the environmental ranking of bags varies between different environmental categories. The SUPB is a poor option in terms of litter on land, marine litter and microplastics, but it scores well in other environmental impact categories, such as climate change, acidification, eutrophication, water use and land use. The overall environmental ranking will depend on what environmental aspects are given the highest priority. In this context it might be important to note that bags are responsible for a significant share of the litter, but a very small share of the total climate change when compared with other products and commodities.
>
> …

Table 6: Summary from all studies considered in Single-Use Plastic Bags and Their Alternatives, by different environmental impact categories

	Environmental impact category in the life cycle of the bags			
	Climate change	Acidification, eutrophication, and photochemical ozone	Land use change	Littering potential
Conditions or other observations	※ In the majority of reviewed studies, PE based plastic bags were found to have the lowest climate impact. ※ Single-use PE bags from recycled or bio-based materials were found to have a lower climate impact than their fossil PE alternative. ※ Durable PP and reusable PE bags need to be reused 10–20 and 50–10 times, respectively, before they can compete on the basis of climate change with single-use bags. This is due to their higher weight and the related material consumption. ※ Paper bags can be better for the climate if produced in integrated mills using renewable energy and if bags are reused and recycled or incinerated. Forestry can affect the carbon stocks above and below ground. This effect can be considerable, potentially leading to a high climate impact or a climate benefit, depending on the forest management. ※ Cotton bags need to be reused 50–150 times followed by incineration or recycling before their climate impact is comparable to single-use plastic bags.	※ While all reviewed studies assessed climate impact, the assessment for other impacts such as acidification, eutrophication and ozone-related impacts varied between studies. ※ For the studies that assessed acidification, eutrophication and ozone-related impacts, fossil PE-based alternatives (HDPE/LDPE) were found to be the best options. There is no clear "worse" alternative, though the studies point towards bio-based alternatives. ※ Bio-based LDPE was found to perform worse than fossil LDPE. ※ For durable and reusable LDPE and PP bags, as well as cotton and paper bags, the same findings as for climate change apply; whether they can compete with the single-use alternatives depends on the number of reuses. ※ Starch-based bags were found to have no environmental benefit compared to conventional single-use bags.	※ Though not assessed in detail, it is important to consider that bio-based and paper bags require a certain amount of land for feedstock cultivation. ※ In addition to land use, there is also the possibility of land-use change, which can lead to impacts on biodiversity, etc.	※ There are several impacts of littering: visual impacts, physical impacts on animals, and the impacts of microplastics. ※ The assessment of littering potential in LCA is still under development. A minority of the reviewed studies addresses impacts of littering and even these account for visual impacts only. ※ Littering potential is a challenge for non-degradable bags (fossil- and bio-based) and for bags labeled as degradable. ※ Bio-degradable plastics should not just be left in the environment; handling in managed sites is needed. ※ The degradation rate depends on the local conditions. Exposure to UV light, availability of oxygen, temperature, and humidity to influence the degradation process of degradable plastics, paper, and cotton. ※ Oxo-degradable plastics seem to only partially fragment; i.e., they leave residues behind.

Note: PE = polyethylene; PP= polypropylene; HDPE = high-density polyethylene; LDPE = low-density polyethylene.
Sources: UNEP, 2020b..

> - Paper bags contribute less to the impacts of littering but in most cases have a larger impact on the climate, eutrophication and acidification, compared to SUPBs. However, they can be better for the climate if the SUPB is heavy, the paper mills use renewable fuel, the paper bags are reused multiple times, and/or the waste bags are incinerated rather than deposited at landfills.
> - Single-use polyethylene bags based on renewable resources are better for the climate, compared to conventional SUPBs; however, they cause the same problems related to impacts of littering and are likely to cause more acidification and eutrophication.
> - Biodegradable bags decompose and contribute less to the impacts of littering, compared to conventional SUPBs; however, the LCA results indicate they might be the worst option when it comes to climate impacts, acidification, eutrophication, and toxic emissions.

… (UNEP, 2020b: 2–3)

Environmental Agency of England (2011)—plastic bags compared to alternatives

A study released in February, 2011, by the Environmental Agency of England, entitled *Life Cycle Assessment of Supermarket Carrier Bags*, provided a "cradle-to-grave" review of seven types of grocery store bags: conventional lightweight bags made of high-density polyethylene (HDPE); an HDPE bag doped with a chemical to speed its degradation; a lightweight bag made from a biodegradable starch-polyester blend; a regular paper bag; a heavy-duty "bag for life" made from low-density polyethylene (LDPE); a heavier duty polypropylene bag; and a cotton bag. Environmental end points assessed included global warming potential; abiotic depletion; acidification; eutrophication; human toxicity; freshwater aquatic ecotoxicity; marine aquatic ecotoxicity; and petrochemical oxidation. The key findings were:

- The conventional HDPE bag had the lowest environmental impacts of the lightweight bags in eight out of nine impact categories;
- the biodegradable HDPE bag had larger environmental impacts than the regular kind;
- the starch-poly bag (similar to HDPE bags, but made of a mixture of starch and polyethylene) was worse yet, with the highest environmental impact rankings on seven of the nine categories examined;
- the heavy-duty LDPE bag must be used five times in order to get its global-warming potential below that of a conventional HDPE bag;
- the non-woven polypropylene "bag for life" had to be used 14 times to get its global warming potential down to that of HDPE;

- paper bags performed poorly on the environmental impact tests, and must be used four or more times to match the global-warming potential of the HDPE bags; and, finally,
- cotton bags were found to have greater environmental impacts than the conventional HDPE bag in seven of nine categories, even when used 173 times, which is needed for their global-warming potential to drop down to that of HDPE.

(EAE, 2011: 58)

Table 7 shows how many times non-HDPE bags needed to be reused in order to bring their global-warming potential down to that of an HDPE bag under a range of assumed reuse rates. The first column, for example, shows that one has to reuse a paper bag three times to reduce its global warming potential to that of the HDPE bag, while one would have to use an LDPE bag four times, a non-woven polypropylene bag 11 times, and a cotton bag 131 times to achieve the same end.

Table 7: Number of reuses of alternatives to high-density polyethylene bags needed to equalize global-warming potential

Type of carrier	HDPE bag—no secondary reuse	HDPE bag—40.3% reused as bin liners	HDPE bag—100% reused as bin liners	HDEP bag—used 3 times
Paper bag	3	4	7	9
LDPE bag	4	5	9	12
Non-woven PP bag	11	14	26	33
Cotton bag	131	173	327	393

Source: Environmental Agency of England, 2011: table 8.1.

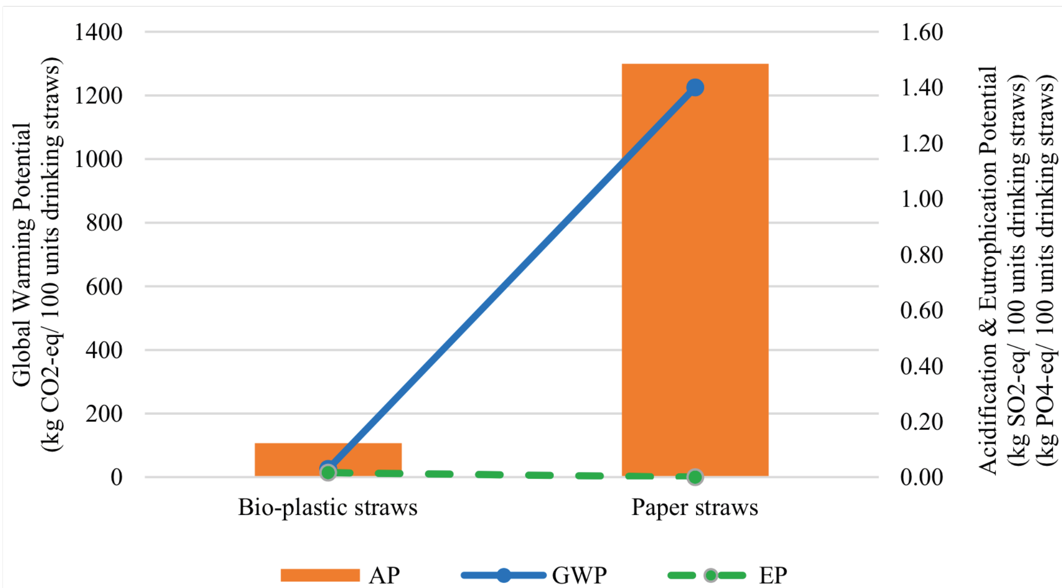
Moy, Tan, Shoparwe, Shariff, and Tan (2021)—plastic drinking straws compared to alternatives

Finally, although detailed research on the subject is relatively scant compared to the literature on plastic bags, several recent studies illuminate the "tip of the spear" in the modern debate over disposable plastics, and ground zero of Canada's ZPW2030 plan, the battle to ban disposable plastic drinking straws.

In the Malaysian open-access journal, *Processes*, a research team based out of Monash University in Malaysia, published a study comparing the life cycle impacts of two types of drinking straws: bio-plastic polymers and paper drinking straws. Plastic waste is a matter of serious concern in Malaysia, which "has been listed as the eighth-worst country worldwide for the mismanagement of plastic waste. It was estimated that there were almost one million tons of mismanaged plastic waste in Malaysia, of which 0.14 to 0.37 million tons may have been washed into the oceans in 2010" (Moy, Tan, Shoparwe, Shariff, and Tan, 2021: 1).

Moy and colleagues focused on three metrics of sustainability, global warming potential, eutrophication potential, and acidification potential. Global warming potential was assessed as emissions of carbon dioxide equivalents; eutrophication potential was assessed in terms of phosphate emissions; and acidification was assessed in emissions of sulfur dioxide. As **figure 6** shows, they found that bio-plastic straws outperformed paper straws on the environmental metrics of global warming potential, air pollution, and eutrophication potential.

Figure 6: Comparison of global warming potential (GWP) acidification potential (AP), and eutrophication potential (EP) of paper compared to bioplastic straws



Source: Moy, Tan, Shoparwe, Shariff, and Tan, 2021; figure 7.

Denmark Environmental Protection Agency (2019)—single-use plastic straws, stirring sticks, and cutlery.

The Danish Environmental Protection Agency commissioned a report, *LCA of Single Use Plastic Products in Denmark* (Takou, Boldrin, Astrup, and Damgaard, 2019), to study the implications of a plan by the European Commission to ban certain single-use plastics, as Canada is planning to do. The EU Commission's plan studied would ban cotton buds (swabs), cutlery, food containers (clamshells), straws, and beverage stirrers. As in the previous studies discussed, the Danish study found mixed evidence on the benefits of replacements for single-use plastics. Paper and wood alternatives to cotton buds, cutlery, and stirrer sticks performed better on environmental metrics than did single-use plastics. For food containers, however, paper options performed mostly more poorly than single-use plastics, and drinking straws were essentially a toss-up, with equal performance for environmental impacts.

Key findings (simplified) from the Danish study were as follows:

- ***Cotton Buds***: Paper cotton buds (SUNP) performed in average better than plastic cotton buds made out of polypropylene (SUP) in all scenarios studied.
- ***Cutlery***: Wooden cutlery (SUNP) performed in average better or at least at the same level as plastic cutlery (SUP) made out of polypropylene in most scenarios.
- ***Food Containers***: For food containers (plates or clamshell), the paper option (SUNP) was found to perform worse or at best the same as the polystyrene option (SUP) considering all the sensitivity scenarios assessed.
- ***Straws***: The paper straws (SUNP option) were found to perform better or on the same level with polypropylene (PP) straw, in all the scenarios tested.
- ***Stirrers***: The wooden stirrers (SUNP) performed in average better or at least the same as plastic stirrers (SUP).

Tetrapak, 2019—plastic straws compared to paper straws

Tetrapak, a manufacturer of portion-sized drinking cartons (also referred to as "drink boxes" in North America) commissioned a life-cycle analysis when it was considering changing the drinking straws used in such cartons from single-use plastic to paper straws (Shonfield, 2019). The LCA examined three cradle-to-grave scenarios for: plastic straws with plastic wrapping, paper straws with plastic wrapping, and paper straws with paper wrapping.

The Tetrapak study found that, in some cases, the switch to paper had beneficial environmental impacts in life-cycle analysis, but some environmental metrics were negatively affected by replacement of plastic with paper alternatives.

Increased environmental burdens

> The impact categories where burdens are seen to *increase* with increasing paper content are generally those that have dominant contributions from specific polluting emissions (particularly NO_x but also SO_2), which are produced in greater amounts during paper production than polymer production and are also associated with energy consumption required for manufacturing straws. As paper straws are produced less efficiently than plastic straws, this results in higher burdens for the paper option. Water scarcity also increases with increasing paper content and

> this is partially due to the higher burdens from paper production (although the data here are less reliable) but, again, is mainly a result of the much higher energy consumption associated with straw manufacture. (Shonfield, 2019: 10–11)

Decreased environmental burdens

> Those impact categories where burdens *decrease* with increasing paper content are both strongly correlated with use of fossil fuels. Polymer production uses a lot of fossil fuel both for process energy during manufacture and as feedstock within the finished product. In contrast, paper production uses much less fossil fuel as most of its energy requirements are sourced from biomass (wood chips, bark and black liquor) derived from the same forestry operations that supply the raw material for pulping. (Shonfield, 2019: 12)

The Tetrapak study concludes that: "On this basis alone, it is difficult to make recommendations about which material is preferable to use for straws and wrapping. There are trade-offs associated with each choice" (Shonfield, 2019: 12).

Gao and Wan, 2022—disposable drinking straws

The authors of a recently published article, Life Cycle Assessment of Environmental Impact of Disposable Drinking Straws: A Trade-Off Analysis with Marine Litter in the United States (Gao and Wan, 2022) found that overall, paper straws were superior to plastic straws in that they had lower impacts on the environment.

> While category specific comparison identifies the absolute value of each impact category among PP [polypropylene], PLA [polylactic acid (bio-plastic)], and PA [paper] straw LCA, the composite REI [relative environmental impact] combining all eight categories as a single score allowed for more direct comparison of the relative environmental impacts among the three types of straws. The REI values were 2.4 for PP straws, 6.4 for PLA straws, and 5.1 for PA straws with landfill and 3.2 for PP straws, 6.8 for PLA straws, and 4.9 for PA straws with incineration, indicating that the environmental impacts for PP straws are substantially less than that for PLA and PA straws no matter whether the end-of-life disposal option is landfill or incineration. (Gao and Wan, 2022: 5)

> Between the two candidates for replacing plastic drinking straws, the LCA analysis demonstrates that REI value for PLA straws was about 30–40% more than for PA straws. This suggests that PA straws should be a better candidate for consideration if PP straws are indeed to be phased out. This could also be the case for other single-use plastic items such as disposable cups and take-out containers. (Gao and Wan, 2022: 5)

Despite this finding, Gao and Wan conclude:

> The results show that US daily consumption of disposable drinking straws (500 million straws daily) *may carry significant environmental burdens regardless of straw types*, with the feedstock manufacture stage of the life cycle creating most of the contribution. The REI index values were 2.4 for PP straws, 6.4 for PLA straws, and 5.1 for PA straws with landfill and 3.2 for PP straws, 6.8 for PLA straws, and 4.9 for PA straws with incineration. A sensitivity analysis did not show much change in REI with increasing marine litter rate, demonstrating that replacing PP straws with PLA or PA straws for controlling marine plastic pollution would come with environmental costs in other categories. The trade-off can be quantitatively represented by the difference in REI between PP straws and PA or PLA straws. (Gao and Wan, 2022: 1; emphasis mine)

Zhangelini et al., 2020—plastic straws and alternatives

Zhangelini and colleagues (2020) looked at the environmental performance of conventional non-reusable plastic straws, and three types of reusable straws: glass, bamboo, and metal. They found that:

> Glass straws and Bamboo straws have similar environmental profiles, with glass being preferable to ozone depletion (OD), photochemical ozone formation (POF), water depletion (WD), land use (LU), eutrophication potential (EP) and cumulative energy demand (CED), while bamboo has shown better environmental performance for climate change (CC), respiratory inorganics (RI), resource consumption (RC) and acidification potential (AP). In either case, both have similar performance in terms of environmental indicators. Steel straws are also positioned in this group, however with considerably better environmental performance than the formers and lower impacts than Paper straws on climate change (CC), photochemical ozone formation (POF) and respiratory inorganics (RI). Lastly, the Paper straws, a "biomass-based without reuse" product system, represent the third group. Paper straws showed higher land use (LU) impacts over all other product systems but have better performance for other indicators if compared to group 2 (exception made for steel products in some categories). (Zhangelini et al., 2020: 7–8)

Conclusions

Canada has launched a regulatory campaign against plastic waste, Zero-Plastic Waste 2030, that will have a negative impact on Canada's overall economic health, the health of Canadian private-sector businesses, Canada's imports and exports, and Canadian consumer choice (both domestic and international). It could, via substitution effects, lead to increased environmental damages rather than their reduction.

Environmental impacts—ZPW2030 will produce little or no environmental benefit: an empirical understanding of Canada's plastics threat to the environment reveals that it is extremely small, from the perspective of Canada as a country acting alone, and vanishingly small from the perspective of Canada's contribution to the global burden of plastic-related environmental harms.

Economic impacts—As government's economic impact analysis shows, the monetized costs of the proposed single-use plastics regulations (CA$1.3 billions) will outstrip the monetized benefits (CA$619 millions) by nearly 2:1 (Canada Gazette, 2021). Over the course of the initiative, estimated benefits of the overall ZPW2030 regime are estimated to be up to CA$10.5 billion, but would require investment of up to CA$8.3 billion in new facilities to achieve it. Even then, in 2030, annual costs of the program are estimated to exceed benefits by CA$300 millions. Diverting plastic wastes from safe landfill disposal to total recycling of precursor chemicals will reduce the market need for freshly produced plastic precursor chemicals, to the detriment of Canada's robust (and potentially promising) petrochemical industries, currently located primarily in Alberta and Ontario, but with a significant presence in Quebec as well.

First, do no harm—"Backfire" environmental harms through substitution effects are likely, based on a number of life-cycle analyses discussed in this study. Replacement of banned single-use plastics with alternative materials such as paper, bio-degradable plastics, metal, string, cloth, and so on have been shown to pose threats as great, or greater, than the plastic products they replace.

Alternative policy options—Canada's policy makers should consider dropping the plan to regulate plastic wastes, a near-trivial environmental problem in Canada and as a share of our global contribution to the plastic-waste problem. Instead, policy makers could examine ways to crack down on end-point improper disposal of plastic wastes (littering, in general); and to improve street cleaning and municipal management and handling of waste to prevent littered plastics from lingering in the environment.

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