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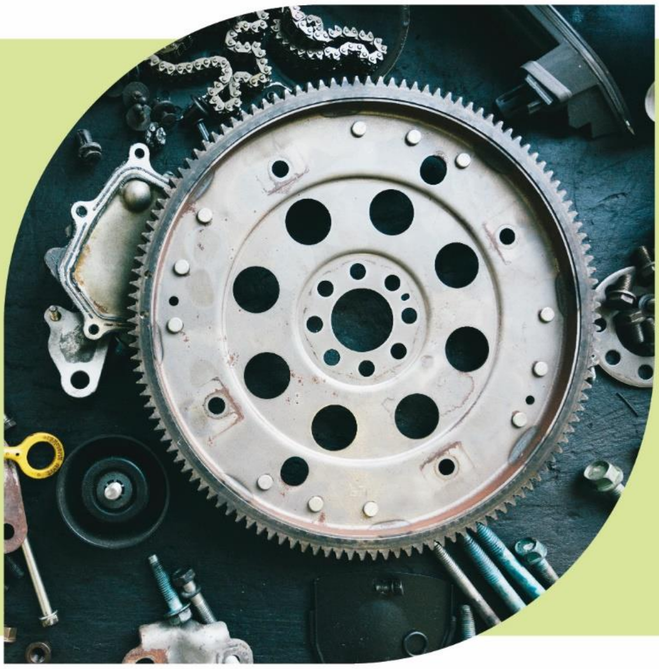

Socio-economic and environmental study of the canadian remanufacturing sector and other value-retention processes in the context of a circular economy

Canada

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Aussi disponible en français

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Glossary

ANSI	American National Standards Institute
B2B	Business-to-Business (marketing model)
B2C	Business-to-Consumer
C2C	Consumer-to-Consumer (also known as Peer-to-Peer)
CAGR	Compound annual growth rate
CE	Circular Economy
CERIEC	Centre d'études et de recherches intersectorielles en économie circulaire
CT	Computed tomography
CUSMA	Canada-United States-Mexico agreement
ECCC	Environment and Climate Change Canada
EoL	End of life
EoU	End of use
EPR	Extended Producer Responsibility
EU	European Union
EV	Electric vehicle
FTA	Free-Trade Agreement
FTE	Full-time equivalent employee
GDP	Gross domestic product
GHG	Greenhouse gas
GWP	Global Warming Potential (quantified as tonnes CO_2 equivalent)
HDOR	Heavy-duty and off-road
HS codes	Harmonized System codes
ICT	Information and communications technologies
IEDDEC	Institute for Environment, Sustainable Development and Circular Economy
IRP	International Resources Panel
LCA	Life cycle analysis
M&A	Mergers and acquisitions
MERA	Association for Sustainable Manufacturing (previously the Motor and Equipment Remanufacturers Association)
MRI	Magnetic resonance imaging
MRO	Maintenance, repair and overhaul
NAICS	North American Industry Classification System
OEM	Original equipment manufacturer
R&D	Research and development
RIC	Remanufacturing Industries Council
SME	Small and medium-sized enterprise
STEM	Science, technology, engineering and mathematics (jobs, training)
UN	The United Nations (assembly)
UNEP	United Nations Environment Program
UK	The United Kingdom of Great Britain and Ireland
US(A)	The United States (of America)
VMT	Vehicle miles travelled
VRPs	Value-retention processes
WEEE	Waste Electrical and Electronic Equipment
WRAP-UK	Waste & Resources Action Programme UK
WTO	World Trade Organization
$CAD	Canadian dollars

Units

Conventional International System of units (SI) and prefixes used throughout.

kt, Mt	Thousands, millions of metric tonnes mass (1 tonne = 2205 lb)
g, kg	Grams, kilograms mass (1 kg = 2.205 lb)

Definitions – related to end-of-life treatment

Core A product assembled from durable components suitable for recovery and remanufacture. Paraphrased from (Patterson, Ijomah, & Windmill, 2017)

Prevention Measures taken before a substance, material or product has become waste, that reduce the quantity of waste, including through the re-use of products or the extension of the life span of products. (The European Parliament and the Council of the European Union, 2008)

Recovery Any operation where the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfill a particular function, or waste being prepared to fulfill that function, in the plant or in the wider economy. (The European Parliament and the Council of the European Union, 2008)

Recycling Any recovery operation by which waste materials are reprocessed into products, materials, or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations. (The European Parliament and the Council of the European Union, 2008)

Re-use Any operation by which products or components that are not waste are used again for the same purpose for which they were conceived. (The European Parliament and the Council of the European Union, 2008)

Waste Any substance or object which the holder discards or intends or is required to discard. (The European Parliament and the Council of the European Union, 2008)

Definitions – related to Value-Retention Process (VRP) benefit metrics

Global Warming Potential (GWP) – the capacity of an emission to affect climate, quantitatively expressed as metric tons (tonnes) of carbon dioxide equivalent (CO_{2e}) emitted. 'Equivalences' accounts for the fact that the GWP of different emissions varies from that of CO_2 but has been scaled to be expressed as if it were CO_2.

Material Savings – If goods are disposed at end of life a certain fraction of their material will go to waste. Employing a VRP will result in some or all of that material not going to waste, a fraction we describe as Material Savings. This is material which does not need to be replaced by virgin material with all its associated impacts.

Waste Prevented – All processes are wasteful to some extent. The process of manufacturing a new item generates waste but, on the whole, remanufacturing (or other VRP) generates lower amounts of waste, largely because of the lower new material content. The difference between the wastefulness of the new versus VRP process we describe as Waste Prevented.

Plastics Re-used – ECCC has a particular interest in the recovery of plastics. A component of many goods is plastics and so may be amenable to re-use. 'Materials Savings' includes plastics re-use, but 'Plastics Re-used' makes this contribution explicit.

Transferable learning point	**Future research topic**	**Context information fragment**

1 Introduction

This document is a report on the work carried out under Environment and Climate Change Canada's (ECCC) bid solicitation 500 004 3872, Socio-Economic and Environmental Study of the Canadian Remanufacturing Sector and Other Value-Retention Processes (VRPs) in the Context of a Circular Economy (CE).

Remanufacturing and other VRPs have been identified as a way to reduce waste and other adverse environmental impacts through prolonging the useful life of a product or its components. In addition, these activities can have enormous economic and social benefits: they are generally labour-intensive and require skilled labour to perform. This study has been carried out, on behalf of ECCC, to quantify the potential benefits of VRPs in Canada; the costs associated with carrying them out; and to identify barriers to the growth of these activities in Canada.

The findings of this study will help inform the development of a national strategy to encourage the remanufacturing of products and other VRPs in Canada. This strategy might involve a mix of measures, such as regulatory or market interventions, to reduce the barriers identified and stimulate activity in industries that have a high potential for remanufacturing and VRP growth. This initiative is part of ECCC's ongoing work to support a circular economy approach for the management of products and waste, and to implement the comprehensive federal agenda on zero plastic waste.

1.1 Introduction to VRPs

Internationally VRPs are seen as playing an important role in the transition to a circular economy. VRPs are defined in the 2018 International Resource Panel (IRP) report (Nasr, et al., 2018) as:

> *"Activities, typically production-type activities, that enable the completion of, and/or potentially extend a product's service life beyond traditional expected service life. These processes include arranging **direct reuse, repair, refurbishment, comprehensive refurbishment and remanufacturing**".*

While there is still debate over universally acceptable definitions in this area, IRP's terms are both sufficiently clear and inclusive of principles to enable meaningful distinctions between practices.

These processes are already integrated in some economies though at relatively low levels. For example, in the European Union (EU), the remanufacturing industry currently generates an estimated €30 billion ($CAD 46.8 billion) annually and employs around 190,000 people across the following sectors: aerospace, automotive, electrical and electronic equipment, furniture, heavy-duty & off-road vehicle (HDOR) equipment, machinery, marine, medical devices and rail. Overall, this represents around 2% of total manufacturing sales revenue. In 2016, the European Commission announced €24 billion ($CAD 37 billion) in funding to support circular economy projects and businesses. (See (Parker & al., 2015))

The United States (US) has one of the largest remanufacturing industries in the world. According to the United States International Trade Commission (United States International Trade Commission, 2012a):

> *"Between 2009 and 2011, the value of US remanufactured production grew by 15% to at least $USD 43 billion ($CAD 48.6 billion), supporting 180 000 full-time US jobs. The remanufacturing-intensive sectors that account for the majority of remanufacturing activity in the US include aerospace, consumer products, electrical equipment, HDOR equipment, information technology products, locomotives, machinery, medical devices, motor vehicle parts, office furniture, restaurant equipment and retreaded tires. US*

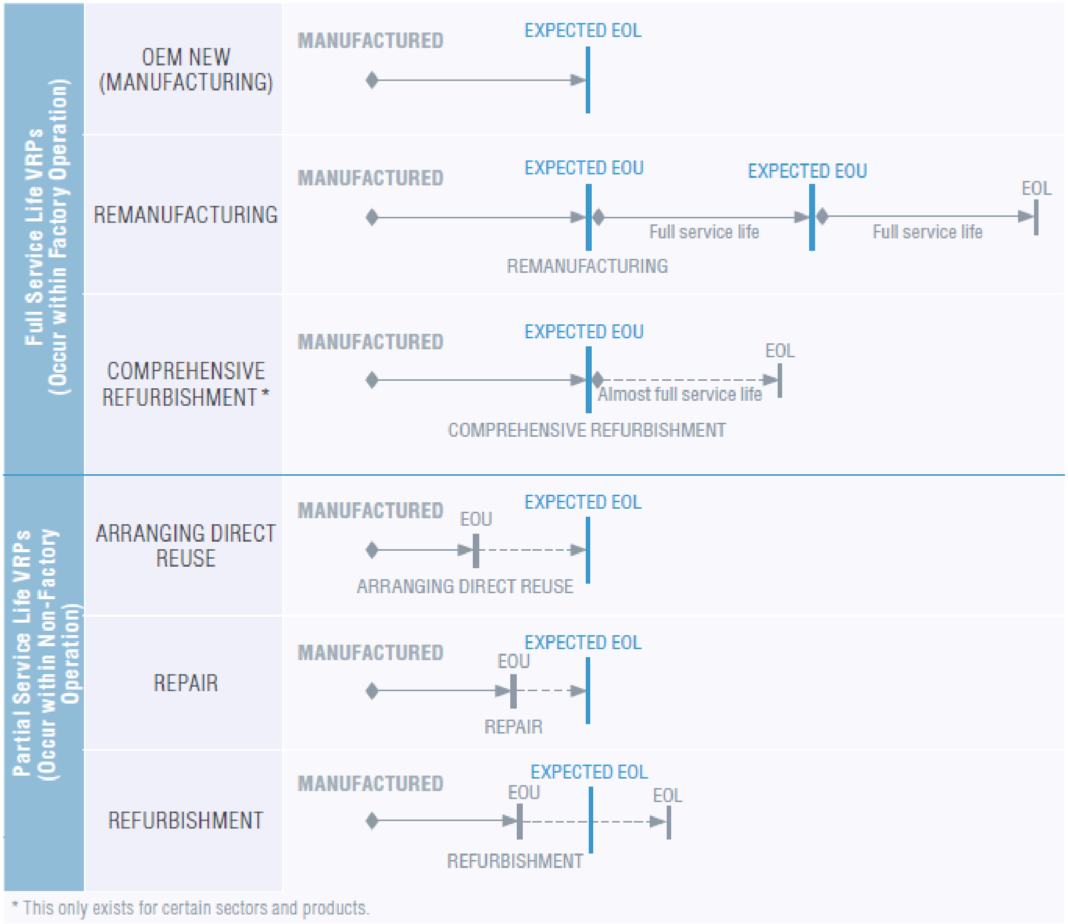
exports of remanufactured goods totaled $USD 11.7 billion in 2011 ($CAD 13.2 billion); almost 40% of these goods went to free trade agreement partners."

1.1.1 *Value-retention processes categorization*

VRPs can be assigned to one of two broad categories: full service life and partial service life. As shown in Figure 1, full service life VRPs are executed at the end of a full product service life, are comprehensive and take place within factory operations, extending the life of the product by a period at least equal to that of the original service life. In contrast, partial service life VRPs are executed usually due to a failure before end of expected life, are limited in scope and take place outside of factory operations and only partially extend the service life of the product (Nasr, et al., 2018).

VRP-related products offer a variety of environmental benefits over newly produced products including reduced new material input requirements, reduced embodied energy, reduced production emissions and lower production waste. In addition, VRPs are also associated with economic benefits such as job creation, reduced production costs, increased export opportunities and access to new market segments.

Figure 1: Summary of VRP End-of-Life (EoL) and End-of-Use (EoU) differentiation



Notes: Source: (Nasr, et al., 2018), Figure 11; OEM = Original Equipment Manufacturer

To what extent these benefits are realized depends upon the VRP approach, with full service life VRPs being associated with greater production costs, energy requirements and emissions when compared to partial service life VRPs, as summarized in Table 1. Partial service life VRPs are associated with lower product value-retention and employment opportunities (see 1.1.3).

Table 1: Relative economic and environmental benefits of full service life VRPs and partial service life VRPs

	Full Service Life VRPs (Remanufacturing & Comprehensive Refurbishment)	**Partial Service Life VRPs (Arranging Direct Re-use, Repair & Refurbishment)**
Environmental	• Higher energy requirement relative to partial service life VRPs • Higher emissions generation relative to partial service life VRPs	• Lower energy requirement relative to full service life VRPs • Lower emissions generation relative to full service life VRPs
Economic	• Higher employment opportunity relative to partial service life VRPs • Higher product value-retention relative to partial service life VRPs • Higher cost to produce relative to partial service life VRPs	• Lower employment opportunity relative to full service life VRPs • Lower product value-retention relative to full service life VRPs • Lower cost to product relative to full service life VRPs

Source: (Nasr, et al., 2018)

1.1.2 *Full service life VRPs*

Remanufacturing

There are varied definitions of what constitutes remanufacturing, although for the purposes of this project, the definition synthesized by the IRP in their 2018 report (Nasr, et al., 2018) will be used. This definition is as follows:

> *"A standardized industrial process that takes place within industrial or factory settings, in which cores are restored to original as-new condition and performance or better. The remanufacturing process is in line with specific technical specifications, including engineering, quality and testing standards, and typically yields fully warranted products. Firms that provide remanufacturing services to restore used goods to original working condition are considered producers of remanufactured goods."*

Remanufacturing is a full service life VRP that yields products that are 'as good as' or 'better than' new. To qualify as remanufacturing, products must be at a minimum, disassembled, cleaned, tested and documented. In most cases, remanufactured product units will comprise components and modules sourced from multiple product units. Irrespective of sourcing, these products must also be sold with the guarantee that they are in the aforementioned 'as good as' or 'better than' new condition (Nasr, et al., 2018).

Other definitions of remanufacturing exist, drawing upon a small pool of characteristics, emphasizing some over others. In pursuit of a standardized and universal definition, these variants show a tension between defining based on process steps employed (multi-step, disassembly, testing, validation etc.) or upon the properties of the product produced (as exemplified by the life expectation and warranty). In general, ISO and other standards (where such definitions would be used) are designed to regulate processes and methods in the belief that this determines outcome. However, because independent and original equipment manufacturer (OEM) remanufacturers do not operate from the same knowledge base, this may prove problematic. Therefore, a standard which guarantees a particular outcome, such as a lifetime expectation of 'x' years, offers a means of competition on an open basis and may indeed be more meaningful to a purchaser. This debate is ongoing.

Although remanufacturing is associated with investment of higher energy, labour and finance with increased emissions compared to partial VRP scenarios, three case studies detailed in the 2018 IRP VRP report (Nasr, et al., 2018) indicated that remanufacturing could reduce energy requirements relative to new production by between 57–87%, production waste by 90% and production costs by 44%.

Comprehensive refurbishment

Comprehensive refurbishment activities are conducted within industrial or factory settings and exceed the standards of refurbishment of all other refurbishment activities. The IRP VRP report defined comprehensive refurbishment as:

> *"Refurbishment that takes place within industrial or factory settings, with a high standard and level of refurbishment."*

The pipeline of the comprehensive refurbishment process will usually consist of collection, data wiping (for electronics) and upgrade, repair for functionality and then aesthetic touch-ups. Because of the rigorous nature of this process, the service life of the refurbished product will often be almost equal to that of the full new product service life. Comprehensive refurbishment can also result in a 44% production cost reduction relative to new production (Nasr, et al., 2018).

1.1.3 Partial service life VRPs

Refurbishment

As with repair activities, refurbishment can be undertaken on both EoL and pre-EoL products. Refurbishment can be characterized as exceeding the level of material replacement and renewal activity achieved during product repair, but not meeting the level of structure, industrialization or quality expected from comprehensive refurbishment activities.

Refurbishment can be further distinguished from repair activities by the fact that they modify the product unit as such that the usable product life can extend past the designed lifespan. For example, repair of a washing machine in year 8 may allow it to reach its design life of 12 years, while refurbishment in year 8 may allow its life to be extended beyond its design life, to say 15 years.

Within the IRP's 2018 report, refurbishment is defined as:

> *"Modification of an object that is waste or a product to increase or restore its performance and/or functionality or to meet applicable technical standards or regulatory requirements, with the result of making a fully functional product to be used for a purpose that is at least the one that was originally intended."*

Product refurbishment will usually take place within repair or maintenance facilities and will be accompanied with some form of warranty on major wearing components, although these will tend to be less comprehensive than for newly manufactured or remanufactured parts.

Repair

The definition of product repair as given by the IRP's 2018 report is:

> *"Fixing a specified fault in an object that is a waste or a product and/or replacing defective components, in order to make the waste or product a fully functional product to be used for its originally intended purpose."*

From this definition the repair of a product is not limited to end-of-life or end-of-use (EoU) items and can include both repairs to products so that they may meet their original expected lifespan, and maintenance activities that if not undertaken would limit the product's expected lifespan.

Unlike other VRP scenarios, repair activities take place elsewhere within the larger product system and can be considered as a separate flow. Further, most repair activities can be characterized as not requiring established infrastructure (collection, diversion or inspection), production facilities or distribution infrastructure.

Product repair requires that faulty or worn out components are removed and replaced in order to restore the product to a functional condition for the remainder of its expected lifespan. These activities are not usually accompanied by any form of warranty for the whole product unit, but generally are restricted to replaced components.

Repair activities are assumed to take place within all product sectors and for non-industrialized economies accounting for the great majority of VRPs that are undertaken. Repair activities are also widely recognized within national accounting systems, making their tracking a somewhat easier problem than for other VRPs.

Arranging direct re-use

Arranging direct re-use is separate from cascading re-use activities that occur between customers. This process was defined within the 2018 IRP report as:

> *"The collection, inspection and testing, cleaning and redistribution of a product back into the market under controlled conditions (e.g. a formal business undertaking)."*

Under this definition no disassembly, addition or removal of components can take place and activity is limited to the inspection and simple aesthetic reconditioning. As such, this VRP process is only possible for products that are in working condition. These products will often be offered with a very limited or no warranty and resold at a price much below the market value.

1.1.4 *Other terminologies in use*

We have presented here precise definitions of what constitutes each VRP scenario, but in practice the terminology used to refer to each of these activities often differs between regions and product sectors. For example, in conducting secondary research on companies undertaking VRPs in Canada, we determined that some small, independent VRP agents used the term 'remanufacturing' or 'overhaul' to describe what would be considered comprehensive refurbishment or refurbishment using the above definitions. To demonstrate this, an excerpt from HDOR producer Liebherr's report on its remanufacturing activities has been provided in Figure 2. From this figure it's apparent that Liebherr labels two of its activities as either 'exchange components' or 'general overhaul'; but by using the definitions provided above, these product offerings could be characterized as remanufacturing and comprehensive refurbishment respectively.

Figure 2: Extract from Liebherr remanufacturing program pamphlet.

	Exchange Components	General Overhaul	Repair Components
Components for customer	Exchange	Customer's property	Customer's property
Machine downtime	Max. 1 day (installation and removal – with proactive ordering)	5 days (plus transport time)	3 days after order is placed (plus transport time)*
Cost of repair	Fixed price	Fixed price	Offer
Disassembly and cleaning	Complete	Complete	Partial
Paint removal and derusting	Complete	As required	Partial
Assembly	Complete (based on current state of technology)	Complete (based on current state of technology or original condition)	Defective parts replaced with Reman grade or new parts
Inspection	As per OEM standard	As per OEM standard	As per OEM standard
Painting	Complete	Complete	Based on customer requirement
Warranty on complete component	As per new part	As per new part	50 % of new part

*applies to the Reman Competence Centre in Europe

Source: (Liebherr, 2019)

This imprecise use of terminology to describe VRP scenarios is not uncommon and can even occur within an individual product sector. For example, this is described by (Russell, 2018) who notes that the terms 'reconditioning', 'rebuilding' and 'remanufacturing' are all variously used to describe the same process of "returning electronic equipment to safe, reliable condition". Conflation and confusion over parallel terminology is also apparent amongst francophone practitioners of VRPs, and in other languages and so will require special handling in Canada's bilingual context.

1.2 Scope

The scope of work has covered the following:

- Identifying economically significant Canadian economic sectors which are amenable to remanufacturing and other VRP activity, and that form good targets for study;
- Undertaking desk-based and primary data collection to provide a description of the current (baseline) size and state of remanufacturing and other VRPs in Canada and estimating the socio-economic and environmental benefits associated with these activities;
- Providing a comparison with current VRP activities and policy support in other countries and regions including the EU, US and Mexico and identify trade barriers that could impact the flow of goods and services;
- Modelling the potential benefits and costs associated with increasing remanufacturing and VRP activities in six high-potential industry sectors;
- Identifying existing barriers, including financial, regulatory, technological, labour, availability of materials/cores, foreign competition, trade barriers, etc., that are inhibiting the growth of VRP activities in Canada;
- Identifying opportunities for the Government of Canada to positively influence market forces to encourage increased VRP activity using a range of approaches including policies, purchasing behaviours, taxation;
- Identifying current and future products that may be appropriate for remanufacturing and VRPs, the market demand for these products and options for the federal government to facilitate access to these resources and support the development of a market for these products; and
- Providing an overview and assessment of emerging technologies, processes and other innovations that can enable the remanufacturing of more products or of products in a way that improves the economics and/or value-retention of these activities.

1.3 Sectors studied

The ten sectors listed below were selected for study, of which the first six were analyzed in depth and are the focus of this report. ECCC specified sectors 1 through 3 for analysis as part of the original solicitation.

The additional sectors were selected based on their sales statistics and high amenability to VRP activity. We estimate that these ten sectors cover around 70% of the potential revenue available from feasible VRP services. The six sectors studied in-depth make up approximately 75% of the total revenue for the full ten sectors.

1. **Aerospace:** this sector includes commercial and military aircraft and their components (e.g. engines, avionics and airframe structures). Maintenance, repair and overhaul (MRO) activities are a key part of the Canadian aerospace sector and these activities encompass the value-retention processes explored in this report. MRO activities are considered to include remanufacturing and repair when defined using the VRP terminology described above. We do not include vehicles and components for space applications in this sector.
2. **Automotive:** this sector refers to passenger and light commercial vehicles (pickups, small delivery vehicles, utility vehicles such as ambulances). Remanufacturing activities focus on higher value and complexity elements such as engines and electromechanical components. The full range of VRP activities are typically found in the automotive sector.
3. **Electronics:** this sector refers to information and communication technologies (ICT) and consumer electronics, such as laptops, desktops and mobile phones. Also included is office imaging equipment, such as printers, photocopiers and printer cartridges. Amongst consumer electronics, there is a limited amount of repair; higher value electronics, such as ICT, has a higher, though still limited proportion of refurbishment activity.
4. **Home appliances:** this sector refers to home appliances such as washing machines, dishwashers and refrigerators. These represent a large activity with substantial opportunities for cascaded re-use, repair and refurbishment, perhaps motivated by different models of use (so called servitization).
5. **Heavy-duty/off-road equipment:** this sector is distinct from automotive and includes heavy-duty commercial vehicles, agricultural vehicles and off-road equipment (including construction and mining equipment). As per automotive, we observe a wide range of VRPs including world-leading remanufacturers such as CAT employing advanced service-based models of business.
6. **Furniture:** this is a sector of domestic importance where non-traditional remanufacturing practices and re-use models are of significance. This sector includes furniture for both commercial and domestic uses.

The following, smaller sectors, were not investigated to the same extent as the first six sectors, but we provide a one-page summary of the major quantifications of impacts below (see Figure 3).

7. **Marine:** this sector includes the remanufacture, refurbishment and repair of equipment and components for use in leisure, naval, commercial and offshore renewable energy applications.
8. **Medical devices:** this sector covers devices and equipment used in the process of providing medical care to patients. Devices and equipment best suited for value-retention processes are those that have been designed to have a long life are non-invasive, require significant research and development (R&D) investment and are capital intensive to build and purchase. Examples include magnetic resonance imaging (MRI), ultrasound and computed tomography (CT) scanners, X-ray and surgical imaging equipment.
9. **Industrial equipment:** this sector includes the remanufacturing, refurbishment and repair of a wide variety of equipment including machinery for manufacturing and process industries, machine tools, pumps and compressors, engines and turbines (excluding aircraft, automotive and HDOR engines).
10. **Rail:** this sector is restricted to analysis of VRPs in relation to rolling stock, i.e. traction units (providing motive power to pull passenger and freight trains), passenger carriages, self-propelled passenger vehicles, freight wagons and infrastructure maintenance vehicles. This sector does not include VRP activities related to static rail infrastructure.

Regarding the other 30% of potentially viable activity, this is broadly spread across the swathe of manufacturing incorporating a host of niche and not-so-niche products. Because of the vast range of individual products which fall under particular sector activities it is not possible to detail each and every one of these. However, Table 2 lists some of the sectors which fell into this category.

Table 2: Additional sectors not detailed in this study

Additional sectors	
Sporting Goods	Utilities
Construction (other than Heavy-Duty Equipment)	Manufacturing (other than Industrial Equipment)
Textiles and Apparel	Accommodation and Food Services
Space Industry	Health and Personal Care
Chemical Industry	Telecommunications
Extraction and Refining Industry (other than Heavy-Duty Equipment)	Energy Industry

Figure 3: One-page summary of the impacts calculated for the 4 initial sectors not taken forward for refined analysis

4 Sectors with 'initial' analysis *on a page*

Marine

~100 CO_{2e} kt avoided per year

~15 kt material savings per year

Estimated VRP revenue (2019)	Revenue ($CAD bn)
Remanufacturing	[0.06]*
Comprehensive refurbishment	
Refurbishment	4.5
Repair	
Reuse	N/A
TOTAL	4.5

*Included within Refurbishment/ Repair

Medical devices

? CO_{2e} kt avoided per year

? kt material savings per year

Environmental impacts unquantified due to lack of data

Estimated VRP revenue (2019)	Revenue ($CAD bn)
Remanufacturing	0.03
Comprehensive refurbishment	
Refurbishment	N/A
Repair	
Reuse	
TOTAL	0.03

Industrial equipment

~150 CO_{2e} kt avoided per year

~20 kt material savings per year

Estimated VRP revenue (2019)	Revenue ($CAD bn)
Remanufacturing	7.4
Comprehensive refurbishment	
Refurbishment	
Repair	
Reuse	N/A
TOTAL	7.4

Rail

~30 CO_{2e} kt avoided per year

~3 kt material savings per year

Estimated VRP revenue (2019)	Revenue ($CAD bn)
Remanufacturing	[0.07]*
Comprehensive refurbishment	
Refurbishment	1.0
Repair	
Reuse	N/A
TOTAL	1.0

*Included within Refurbishment/ Repair

2 Method and approach

2.1 Jurisdictional review

This study has focused on VRPs in Canada, but we have conducted a review of international practice. This allows some benchmarking of Canadian activity and practice against competitors, understanding potential barriers and supporting measures as well as assisting in modelling impacts, costs and benefits.

The review has examined the state of play – largely in remanufacturing – in the US, Mexico, EU, United Kingdom (UK), Japan, China and South Korea.

2.2 Data collection

Significant efforts were put towards the collection and assimilation of existing data and information from existing studies and research, largely from other jurisdictions. However, of prime importance, was to engage industry actors including businesses currently carrying out VRP activities in Canada as well as their related industry associations. Industry engagement took the form of a short and long-form voluntary survey, one-on-one interviews and webinars. This data was used directly and/or in modelling.

Overall, industry engagement was low, which means some caution must be applied to generalization of the findings. However, the responses received were very much in line with what has been discovered in other developed economies. Further, the webinars provided an opportunity for industry to review, refute and improve the findings. We received no major objections to the findings and have moderated our report where appropriate.

2.3 Update to business environment as a result of COVID-19

Relatively early in the project, the hazards of COVID-19, became very apparent to all countries. In March 2020, North American economies enacted 'lockdown' measures impacting the movement of and contact between citizens. This precautionary blanket approach meant that many businesses relevant to this study could not conduct their normal business. Mindful that priorities were rightly focused elsewhere, this project suspended its engagement activities until such time as the business situation eased and potential stakeholders had headroom to re-engage. This delay has not affected the conduct of the study to any great extent but has impacted on the outlook of many businesses.

Lockdown has had short-term impacts for many and long-term consequences for a fair proportion. Our projections cannot ignore the realities of the business environment. Therefore, our approach acknowledges two aspects:

- The views of 'what happens next' in VRPs will be highly coloured by any immediate business hit. For sure we cannot assume the baseline figures derived from pre-COVID research can be projected without moderation both from an absolute viewpoint or from consideration of what might happen in different sectors.

  It is already apparent that some actors see the situation as an opportunity for VRPs even with a reduction in business, particularly if capital investment is slow to return and assets must be exploited for maximum use potential. For example, both for-profit and not-for-profit consumer electronics VRP companies indicated that they are already seeing higher demand for their products due to the 'work/learn-from-home' requirements of COVID-19. The need for domestic and business economization may further drive life extension in both business-to-business (B2B) and business-to-consumer (B2C) domains.

- At a macro-economic level, it is uncertain whether the response in the immediate aftermath of this wave of the pandemic will be to drive for a return to a business-as-usual, pre-virus economic state (even if there is some effect of enforced 'new normal' social measures which have a lasting impact on ability to conduct business); or whether this major 'jolt' offers an opportunity to do things differently – to reflect on global environmental threats and how business and society might be re-engineered to offer greater resilience to man-made and natural effects.

  For example, we know that VRPs are largely locally or regionally based. This may be an advantage in a world where international movements are severely restricted, an opportunity perhaps to encourage and promote VRPs. A recent movement towards nationalism, onshoring, defence of local markets or securing of material supply chains might also benefit.

  More fundamentally, the role of government in promoting green technologies is in the spotlight. Huge sums of money have been injected by governments to directly finance individual employees and their employers, amounting to percentages of gross domestic product (GDP). In Canada, the federal government announced an immediate healthcare assistance package of over $CAD 1.1 billion (Government of Canada, 2020b) and a response plan of a comprehensive range of support to individuals, businesses and sectors (Government of Canada, 2020c).

  This willingness to push finance to short term issues is in stark contrast to the relatively modest investments (because they have a net return, not just a cost) into climate change avoidance and abatement suggested by Stern (Stern, 2009) of 1–2%, albeit over 20 years. Encouragingly, at the height of the pandemic in April 2020, statements emerged which offer hope of a shift in thinking: Prime Minister Trudeau reportedly charged key ministers with creating a 'green shift' economic booster plan for implementation post pandemic (Bellavance, 2020); shortly afterwards, German, EU, UK and UN leaders issued a statement on future intent at the 11th Petersberg Climate Dialogue, delivering rallying cries for nations to focus on climate mitigation as part of any efforts to counteract the economic downturn caused by the COVID-19 outbreak (edie, 2020). This signals some intent to 'bounce back better' though there will need to be strong ties of aid to delivery for high impact sectors like automotive and aerospace.

We acknowledge, however, that in such a fluid situation, great uncertainty in forecasting will remain.

2.4 Overview of modelling approach

Modelling has been used where primary or secondary data which differentiates different VRPs is not available.

2.4.1 *Socio-economic modelling approach*

We estimated economic benefits and costs using available economic data and input-output multipliers for VRP activities based on the North American Industry Classification System (NAICS), if available. Sometimes it was not possible to unpick the multipliers for each VRP. In this case, we used modelling using common proxies, for example, using performance of NAICS repair-type codes, to estimate benefits and costs.

Direct, indirect and **induced** impacts have been modelled. The **induced multiplier** measures the value of production driven by household expenditures associated with labour income (for example, wages) generated from the direct and indirect effects. Induced effects tend to exaggerate the impacts of final expenditures within a one-year production cycle.

2.4.2 *Predicting future performance*

As previously indicated, COVID-19 has introduced an unprecedented discontinuity into most business operations. The findings around activity uncovered at the beginning of the project will have been affected by sector, and even by product, to a greater or lesser extent. The forward-looking views of these businesses will reflect both the depth of the current impact and longer-term expectations of a return to normality of sorts. In our assessments of future performance, our approach has been:

- To undertake desk-based research to locate sector, company and consultant publications and statements which offer qualified forward projections across all timescales.
- To estimate a medium-term response scenario per sector to 2030 (described within each sub-section) which analyzes the trajectory to some point of stability with whatever activity level that may be. (This has drawn extensively on proxy information – such as expected disposable income – as part of the inputs to modelling for certain product classes.)
- To compile and explore a list of factors that we believe will influence the longer-term outlook for the sector based on secondary data but moderated by the background trends which we believe will be a persistent feature of business. For example, we can anticipate that climate change and other resource impacts will return to prominence; that certain technologies will evolve and enter use; and that changes underway in business practice and product-service delivery will not be reversed.

The 2030 medium-term sector scenarios fall into four categories:

- **As-Is**, where pursuing a 'business-as-usual' approach the market penetration of VRP activities remains at the same level in 2030 as it does in 2019. This can be considered a business-as-usual scenario.
- **Natural Growth**, where the evolution of VRP activities is assumed to follow a natural growth trajectory, driven predominantly by existing market forces. This scenario is strongly aligned to actions under the "Sustain" focus (see Table 3), where any policy intervention would seek to maintain existing activity.
- **Moderate Action**, where the evolution of VRP activities is supported by more targeted business and policy action. In addition to the actions in the "Sustain" focus, this scenario is also strongly aligned to policy actions under the "Grow" and "Defend" focuses. Business and policy action seek proactive growth and protection of the VRP industry.
- **Strong Action**, where the evolution of VRP activities is promoted in a coordinated effort from business and policy action. In addition to actions in the "Sustain", "Grow" and "Defend" focuses, this scenario is strongly aligned to actions under the "Transform" and "Leverage" focuses. Business and policy action seek to maximize the impact and promote the widespread deployment of VRP activities.

The aerospace sector has been treated differently: its scenario analysis does not follow the same format as the other five sectors. VRP activity in the aerospace sector is a mature and well-developed industry with more limited potential for external intervention to influence its development. By far the most significant influence for future VRP activity in the aerospace sector is the global industry response to the current COVID-19 pandemic. As such, we decided to align our aerospace VRP scenarios, with scenarios for the global aerospace industry response to COVID-19. These scenarios consider a **rebound**, **delayed rebound** and **recession-based** trajectory. The 'As-Is' scenario refers to a pre-COVID-19 business-as-usual scenario. (See Section 4.3 for more detail.)

Table 3: Description of basic strategic approaches

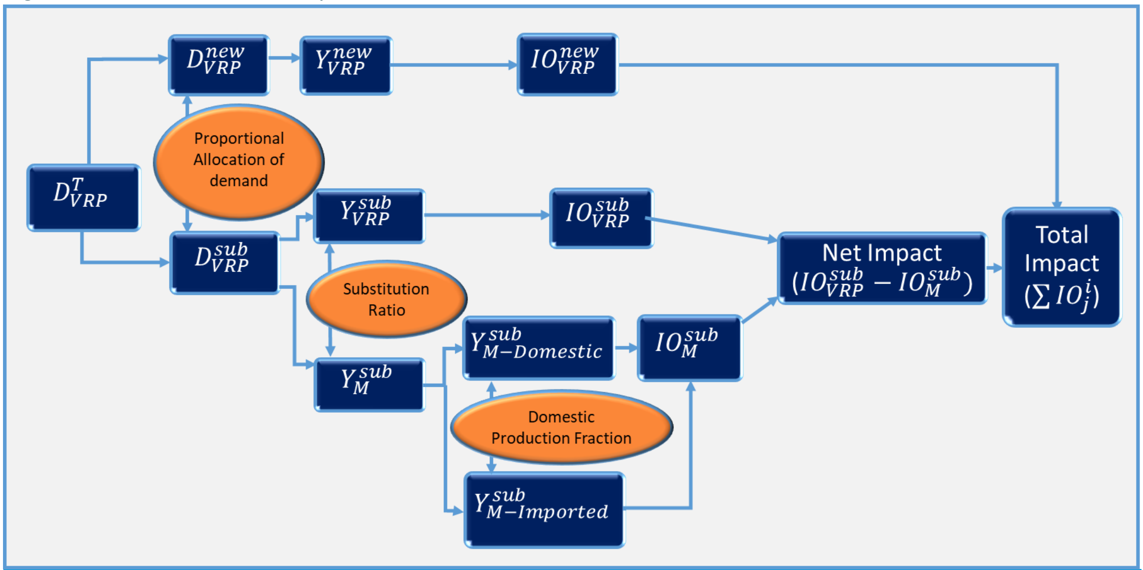
Strategic Thrust		Scope
	Grow	The sector, or a product/VRP service within it, is not at saturation, and there is room for growth. E.g. electronics, home appliances, automotive, office furniture.
	Sustain	The sector is unlikely to grow significantly, but is beneficial, with a positive effect on the skills pool of Canada. Its decline would be a loss of capability. E.g. aerospace, automotive.
	Transform	The sector requires a radical change in its attitude, business models or supply chain in order to realize beneficial environmental impacts. E.g. home appliances, electronics and other consumer goods.
	Defend	The sector may be threatened, particularly from foreign competition which is not subject to the same constraints. High-level or international action may be needed to create level playing fields. E.g. tires, home appliances.
	Leverage	The sector has capabilities which are leading edge and could either be applied in less mature sectors or could be used to kick start related high-value sectors such as renewables. E.g. aerospace, automotive. Also applied in the reverse direction to indicate required boost from R&D support or infrastructure development e.g. centralized collection, design for re-use.

2.4.3 *Scenario modelling*

Under each scenario, we assessed the socio-economic impacts of increased remanufacturing and VRP activities using the model shown below. The model relies on scenario-driven demand projections based on sectoral forecasting. Once we had defined the demand projection, we used Input-Output multipliers from Statistics Canada to project the socio-economic impact of the demand shock including output, GDP contribution, labour income, production taxes and jobs from direct, indirect and induced economic activity. In this case, the **demand shock** is defined as the difference between economic activity in 2019 and 2030 for each sector due to a change in VRP activities.

The model estimates the simple difference between the economic impact of VRP activities in 2019 and 2030 due to a projected increase (or decrease) in VRP activities in Canada for each sector. Therefore, the size of the impact of market disruptions, such as policy or technological changes, on the sector are the difference between the business-as-usual growth forecast (i.e. '**As-Is**' scenario) and the other scenarios. These assume some increase in the percentage of VRP products that act as a substitute for new manufactured goods.

Figure 4: Socio-economic impact model



D = demand	**Sub = substitution demand**
Y = production	**T = total demand**
IO = Input-Output Multipliers	**j = Production Type**
i = demand type	**VRP = Value-retention process production**
New = new demand	**M = manufacturing production**

We have summarized the key assumptions and considerations in the model here:

- We expect that economic gains due to increased VRP activities will be borne by Canada. However, we have allocated the corresponding reductions in manufacturing activity to Canadian producers, relative to the proportion of these goods manufactured in Canada and based on the value of the goods.
- Once goods are identified as imported, they are no longer considered as inducing downstream effects to supply chains (i.e. purchasing and importing goods) in these sectors. We assume these activities are redirected towards VRP activities (i.e. purchasing VRP services and VRP produced goods).
- Substitution effects presume the total number of goods sold will remain the same and will be substituted on a per good basis.
- We have defined substitution ratios across a sector and these are not reflective of individual goods or processes, which will have some variance.
- No multipliers specific to value-retention processes are available, so we have used proxies. These proxies are clearly stated in the relevant sections.

Further details of the technicality of this model can be found in Annex A.

2.4.4 *Evaluating environmental impacts*

In addition to the economic benefits, there are environmental benefits. These include a reduction in waste and emissions generated and a reduction in raw feedstock (chemicals, energy, water and other raw materials) needed to produce products. Estimates of environmental benefits relied primarily on reviewing life cycle analyses (LCA) and other case studies, bottom-up partitioning of multi-product sectors and analogy to similar products in other sectors.

This study has gathered available information or synthesized estimates of environmental impacts in a number of key categories. Here is an explanation of these metrics.

Global Warming Potential (GWP) – the capacity of an emission to affect climate, quantitatively expressed for the purposes of this report as tonnes of carbon dioxide equivalent (CO_{2e}) emitted.

Equivalences accounts for the fact that the GWP of different emissions varies from that of CO_2 but has been scaled to be expressed as if it were CO_2.

Material Savings – If goods are disposed at end of life a certain fraction of their material will go to waste. Employing a VRP will result in some or all of that material not going to waste, a fraction we describe as Material Savings. This is material which does not need to be replaced by virgin material with all its associated impacts.

Waste Prevented – All processes are wasteful to some extent. The process of manufacturing a new item generates waste but, on the whole, remanufacturing (or other VRP) generates lower amounts of waste, largely because of the lower new material content. The difference between the wastefulness of the new versus VRP process we describe as Waste Prevented.

Plastics Re-used – ECCC has a particular interest in the recovery of plastics. A component of many goods is plastics and so may be amenable to re-use. 'Materials Savings' includes plastics re-use, but 'Plastics Re-used' makes this contribution explicit.

We have also attempted to place the impacts in terms that might be recognizable to the average Canadian citizen. For this we have selected the following comparators:

For **Global Warming Potential Avoided** we benchmark against the CO_2 emitted by the average Canadian automobile in a year. According to (Natural Resources Canada, 2014), this is approximately 4.6 t/yr. GWP is therefore expressed as the equivalent number of cars which would be removed from use to match the saving.

For **Material Savings** (and waste prevented) we benchmark against the current recycling performance of all materials from waste in Canada, translated to how much that is per Canadian. Material Savings are therefore expressed as the equivalent number of people's **all-material** recycling achieved. According to (Government of Canada, 2018), in 2016, waste diversion amounted to almost exactly 10 Mt across domestic and non-domestic waste, equating to 0.265 t/yr per person (population 37.6 million).

For **Plastics Re-used** we benchmark in a similar fashion to waste but consider only the recycled plastics component. Plastics re-used is therefore expressed as the equivalent number of people's **plastic** recycling achieved. According to (Deloitte and Cheminfo, 2019), of 3.2 Mt of plastic waste in Canada in 2016, just 9% was recycled into new products. This equates to 0.0077 t/yr per person (population 37.6 million).

It should be noted that these numbers are from mixed years as they are those most readily available but are sufficient to illustrate the points being made.

2.4.5 *Data availability and comprehensiveness*

By far the most commonly reported impacts advertised regarding the benefits of VRPs are materials and Global Warming Potential (GWP) reduction expressed as CO_{2e}. This reflects the headline priorities of businesses and of their target audiences and corresponds in a simple way to United Nations (UN) reporting goals. There is little incentive for businesses to either assess or reveal any other impacts although, typically, these would be expected to fall in line with materials savings.

LCA studies are not straightforward to create or compare. They depend on drawing a boundary (a box showing what's in and what's out of the analysis) and proper choice of the 'functional unit'. For remanufacturing, the functional unit (the product or service to compare) is treated relatively straightforwardly and can be taken as the delivery of an item with a full normal life expectancy (more on this later with respect to other VRPs). The system boundary ought to be straightforward embracing the collection and transportation of used product, its reprocessing, addition of new materials and onward distribution for use.

For energy-using products, the treatment of energy in use is one of the most problematic considerations: VRPs ought to be returned to at least as-new performance, often with some improvement in functionality. This makes a solid comparative basis for ‘stable’ products, that is those where technology is relatively mature, but can muddy the waters for fast-evolving technologies (with a concentration here on energy-using ones) where lifetime embodied impacts may be offset or dominated by improvements in energy use.

Such comparisons are fraught with issues of fair comparison. These should be on the basis of ‘average then’ versus ‘average now’, but as with all statistics, the basis can be manipulated. For example, a retailer wishing to sell new equipment would prefer to compare best-in-class now with ‘average then’ (or worst in class) which would accentuate any difference in performance. This is most important for consumer goods such as home appliances and electronics, so we have attempted to locate like-for-like comparisons and to exclude the operating phase to isolate the embodied impact effects.

2.4.6 *Comparing the impacts of different VRPs*

Our analysis has used the categories outlined by Nasr et al. in the IRP report on VRPs (Nasr, et al., 2018). In particular, the report described how each VRP would affect the expected life or life extension of an item.

Although full service life VRPs (remanufacturing and comprehensive refurbishment) consume greater energy and material requirements than partial service VRPs (refurbishment, repair, and direct re-use), they result in a full, or nearly full, extension of the products service life. That means more generally that the energy and material intensity of VRPs must be judged relative to the improvement in the product lifespan (Russell, 2018), a topic important for calculating net benefits.

Expected useful (and residual) life impacts fundamentally the scale of benefits which might be delivered by each VRP and deserves much greater consideration than was possible previously, especially as it highlights what we do and do not know about how products are used, un-used, re-used, rejuvenated and disposed of in the real world.

In summary, we have attempted to account for differences in residual life which might be gained using different VRPs. This has been turned into a ‘residual life factor’ (0 = no life left, 1 = a whole life left as per remanufacturing) which acts as a multiplier on the headline environmental impact of the particular VRP. The method is approximate but has a rational basis, more explanation of which may be found in Annex A.

2.4.7 *Modelling environmental benefits*

Basic impact modelling takes a relatively simple approach:

- Economic activity is translated into numbers of units processed, by use of survey data and extrapolation where available, or by translation using an average value of sale of goods in question. We take an average mass of a unit processed to derive a total mass of core retrieved. We assign a material saving percentage (%) and from this a derived average CO_{2e} benefit per kg then scale this to the entire mass of products in the sector.
- CO_{2e} is (ideally) gathered from product-specific LCA data, but this is rare. Next best is to use data from a product of similar construction or complexity (e.g. machinery from automotive components). Failing that, a generic LCA ‘machined steel’ figure is used.

Caution must be used in this approach, particularly in sectors which embrace a diverse range of products such as home appliances. Generalizations based simply on value, mass and composition are very error-prone.

For VRPs other than remanufacturing, information is poor, heavily influenced by user preferences and behaviours and estimations of lifetime. Our assessment uses the IRP report which provides good comparison of repair, refurbishment, remanufacturing and new for digital printers, HDOR engines and parts and the same for automotive. However, some important data is not published and cannot be estimated with certainty. Because of this, the analysis is still somewhat crude, with many products treated the same with simplifying assumptions made on numbers of product in sectors. However, the analysis is sufficient to show the magnitude of the effects.

2.5 Formulation of policy and action options

In the last fifteen years or so, there has been a good deal of material produced internationally – if not in Canada – regarding the barriers to remanufacturing and re-use and the actions that might be taken by various stakeholders to address them. However, very few of these suggestions have been put into practice. In part this is because many of the proposals are too generic. More recent work in this field indicates that policies and actions cannot be implemented at a sector level but must be driven down to a finer segmentation, in particular by domain (B2B or B2C), to target OEMs versus independent agents, and possibly down to a product class level.

This study has considered actions which are appropriate for particular sectors, and some of them can be applied across multiple sectors with the caution that this work focuses on only six sectors in detail. Sector-specific actions are responsive to the concerns of interviewees and respondents and are presented in the relevant sector section.

However, this practical drive to formulate actions which can gain a critical mass of support in a subset of stakeholders and businesses must be balanced against the requirement that any supporting actions by government must be seen to be fair and equitable. Accordingly, a later section of the report considers government actions which more address the business environment and supporting systems in which VRPs operate, especially at the federal level. Provincial and territorial jurisdictions, of course, have a large degree of autonomy in enacting their own economic and Circular Economy-friendly policies, but it is a strong recommendation of this work that they be highly coordinated or harmonized to avoid perverse outcomes and to simplify messaging.

2.6 Financial reporting

Unless otherwise stated, where financial statistics (revenues, etc.) are converted in a foreign currency at a particular date, they have been transcribed to Canadian dollars ($CAD) using the exchange rate prevailing at the time, but inflated to 2019 ($CAD (2019)) using rates quoted by Statistics Canada and Bank of Canada.

3 Research response overview

3.1 Research engagement

The following is a list of the industry associations that we contacted and who contributed directly or indirectly in the research. Note that the content of this study is the work of the authors and is informed by these contributions but may not reflect the views of the participants in full.

- Aerospace Industries Association of Canada (AIAC)
- Association of British Columbia Marine Industries
- Association of Home Appliance Manufacturers (AHAM)
- Automotive Industries Association of Canada (AIA of Canada)
- Automotive Parts Manufacturers Association
- Automotive Recyclers of Canada (ARC)
- Canadian Association of Railway Suppliers
- Canadian Home Furnishings Alliance
- Canadian Manufacturers and Exporters
- Canadian Marine Industries and Shipbuilding Association
- Canadian Transportation Equipment Association
- Canadian Vehicle Manufacturers Association (CVMA)
- Electro-Federation Canada
- Electronic Products Recycling Association
- Electronics Product Stewardship Canada (EPSC)
- Global Automakers of Canada (GAC)
- MedTech Canada
- MERA (Association for Sustainable Manufacturing)
- Motorcycle and Moped Industry Council/Canadian Off Highway Vehicle Distribution Council
- National Marine Manufacturers Association
- Quebec Furniture Manufacturers Association
- Railway Association of Canada
- Remanufacturing Industries Council (RIC)
- Retail Council of Canada
- Truck and Engine Manufacturers Association

These organizations represent a substantial membership and their collective view holds a great deal of weight within this process. We have been reliant on their interest and collaboration in getting uptake of the voluntary survey.

Only one association declined to participate citing commercial confidentiality concerns. Efforts were made to highlight the scope of this study as a technical analysis to help inform policy decision-making to no avail.

In later phases of the project, to reduce barriers to participants and target data gaps, we developed a shortened ‘Quick-Fire’ survey. The Quick-Fire survey was submitted to several of the industry associations with a request to distribute to their members prior to the suspension of industry engagement due to COVID-19.

In addition, we have also reached out to over 370 individual companies via phone and e-mail to solicit their participation in the study. The uptake of the survey or interview by participants was quite low with only 48 company responses. To some extent, this can be attributed to the COVID-19 lockdown which diverted business attention to high priorities, although this occurred late in the process. To a greater extent, the Canadian audience appeared somewhat less engaged than has been the case for surveys in other regions, and this may be attributable to a general lower state of awareness and engagement with VRP-related issues. This does perhaps indicate that good sector engagement will be necessary and a challenging feature of taking forward the action plan described later in this report.

Despite this, the one-to-one interviews we have held have been rich, accounting for the high-level sector views in some cases, but their acknowledged weakness is the lack of sector coverage and perspectives from the low level.

Representatives of the provincial and territorial governments were also contacted to gather insights into the state of VRP activities in their region. Such evidence could include supporting policies, strategies or legislation or public or private initiatives in place that may encourage VRPs. We received 6 responses. For any provinces and territories who did not respond, the team scanned government websites for any potentially relevant legislation or policies and submitted our synopsis to the pertinent representatives for comment.

In general, responses indicate that the extent to which VRP activities are present in the provinces and territories is not known and not routinely monitored. They suggest that policies and legislation largely target waste diversion through recycling only. Some provinces and territories provide discussion of the benefits of waste reduction through re-use and waste minimization, but we could not identify any plans, policies or economic supports to support VRPs. A summary of findings from each province and territory is included in Annex G.

3.2 Response summary

This section provides information on the 48 businesses that responded to the voluntary survey or interview requests. We received responses from businesses with locations in all provinces, although none appeared to have locations within the Territories.

- Over 80% of the survey respondents are headquartered in Canada with most of the remainder based in the US.
- Around 60% of respondents were in the small company (5-99 employees) bracket.
- There are indications that these smaller companies have above-average revenue per employee.
- Nearly half the respondents were in the automotive and HDOR sectors reflecting the general weight of activity amongst sectors found in this and other surveys.
- There was representation across all VRP types, but predominantly refurbishment and repair, again reflecting the weight of these activities in the economy.
- Over half the respondents classified their VRP operations in the independent category. Contract agents are in a minority. This may influence the choice of where supporting policies could best stimulate activity.
- Respondents were surprisingly forthcoming regarding gross margin achieved on VRP sales. The bulk of responses were in the range of 10 to 50%, a figure very much in line with the US and UK experience, with a median of 30% for remanufactured products.
- Considering the prospects for VRPs in the short to medium term, opinions seemed positive with over two-thirds of respondents anticipating strong (>3%/yr) or moderate (>1%/yr) growth. Note this reflects pre-COVID-19 sentiment.
- Two-thirds of respondents believed that it was ‘probably’ or ‘definitely’ the case that raw material resource pricing is positively motivating ‘circular business’.

4 Aerospace

4.1 Industry insight

Most aerospace maintenance and repair organization (MRO) economic activity occurs in Western Canada (41%) followed by Ontario (25%), Quebec (23%) and Atlantic Canada (11%). Approximately forty companies were identified during the course of this study that are active in VRP activities in the aerospace industry in Canada. This group comprised a mixture of OEM, OEM-contracted and independent VRP agents servicing commercial, defence, small airplanes and helicopters. Products listed as being repaired or overhauled included landing gear, aerostructures, electrical harnesses, tubing, ducting, avionic computers, navigation systems, engines and fuelling components.

VRP activity in this sector is dominated by remanufacturing or comprehensive refurbishment and repair (see Table 4).

Table 4: A map of VRP practice and drivers in aerospace

Remanufacturing	Comprehensive Refurbishment	Refurbishment	Direct Re-use	Repair	Cascading Consumer to Consumer (C2C)
Safety driven		Does not meet quality needs	Does not meet quality needs	For non-qualified[c] parts	Not applicable

Note: a. Boxes with no comment indicate activity is generally applicable across all markets or requires no caveat,
b. Cascading between consumers – the handing on of goods to users with similar or lower expectations of performance.
c. 'Non-qualified' means 'not requiring aviation authorizations or certifications on processes employed'
d. Pink = VRP activity not applicable or insignificant.

The aerospace VRP sector in Canada is comparable to that in other developed nations - strongly tied to supporting airline operations for domestic and international travel and consequently, needs to achieve a high standard of safety, reliability and conformance. Competition for aerospace VRP services is global which suggests that industry players in Canada need to be near the front of engineering and technology in this sector to be and remain competitive.

4.1.1 *Motives to undertake VRP activities and barriers to growth*

Respondents indicated that their motives for undertaking VRP activities were primarily customer demand, to increase profitability and market share and to meet federal legislation, which is highly prescriptive, and which meet international industry standards.

As demand for VRPs is directly related to the demand for air travel, the ongoing effects of COVID-19 is likely to be one of the main barriers to the growth of these activities. The lack of an overall regulatory regime for exporting VRP'd goods – with Canada, and other countries, needing to negotiate bilateral arrangements in order to export to other countries – was cited as a barrier. Lack of skilled labour was also cited as a barrier – one that is predicted to get worse due to an aging workforce demographic (AIAC, n.d.). Other barriers to future growth cited by participants included foreign legislation, lack of customer recognition, inadequate product knowledge, high labour costs and protectionism in the US against foreign VRP military aerospace products.

4.1.2 *Predictions for future growth*

The Aerospace Industry Association of Canada (AIAC) has outlined a strategic growth plan for the Canadian aerospace industry in their document *Charting A New Course: Canada as a Global Aerospace Champion* (AIAC, n.d.) that sets industry growth targets for 2025 of an additional: 55,000 jobs, $CAD 4.5 billion in exports and $CAD 7 billion in GDP contributions. It is not known how much of this growth would be for MRO or how these targets have been impacted by COVID-19. However, one of the priorities set out in the document is for the Government of Canada to invest in maintaining Transport Canada's internationally recognized status for aircraft certification and regulation and continuing to secure bilateral agreements with other countries – something that has been previously identified as a barrier to growth for MRO services. Further, they discuss increasing consideration of how defence procurement decisions can be used to benefit Canadian firms.

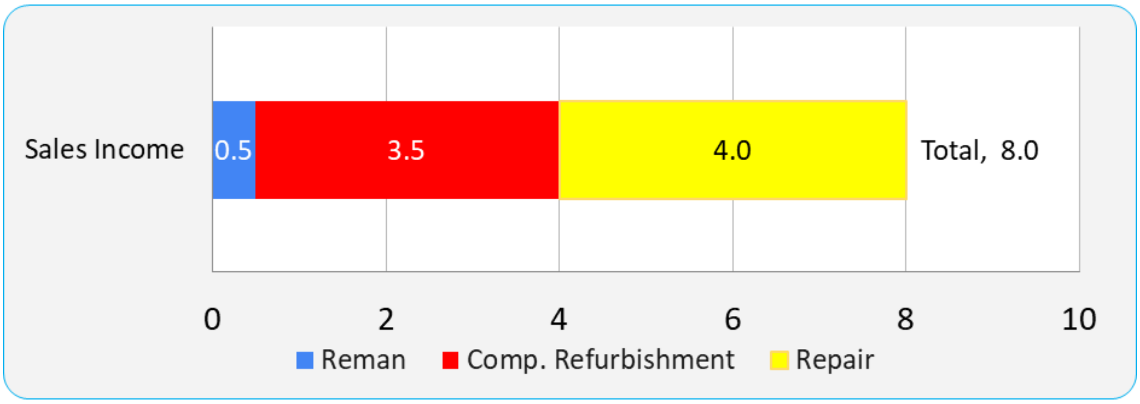
4.2 Impact analysis

4.2.1 *Estimate of socio-economic impacts*

The aerospace industry, as a whole, contributes over $CAD 20 billion to the Canadian economy while employing (directly and indirectly) 160,000 people (ISEDC and AIAC 2019). Maintenance, repair and overhaul (MRO), accounts for 31% of GDP in this sector (ISEDC and AIAC 2019). Over 25% of MRO revenue was related to defence spending (ISEDC and AIAC 2019).

The overall impact of VRPs in the aerospace sector was estimated using aerospace MRO as a proxy. This results in an overestimate of economic impact of aerospace VRPs as it also includes services such as general maintenance, ferrying, inspection and testing (ISEDC and AIAC 2019). In 2019, aerospace MRO contributed $CAD 4.0 billion to GDP in Canada, generated $CAD 8.0 billion in revenues (see Figure 5) and created approximately 33,000 direct and indirect jobs.

Figure 5: Revenue generated by VRP activity in the aerospace sector, 2019 $CAD bn



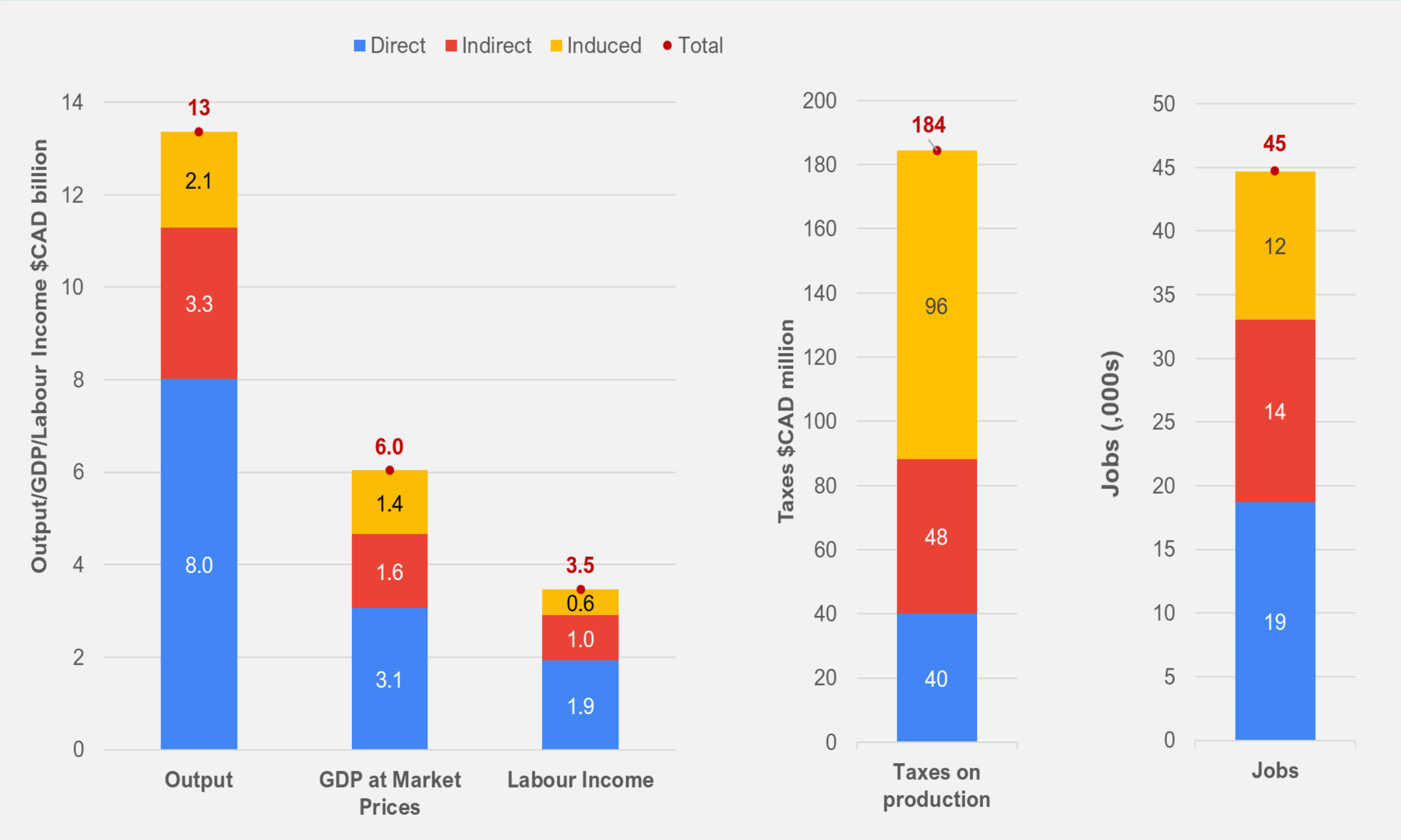
Notes: *Totals may not add due to rounding.*
Data on MRO revenue can be considered to cover the full range of VRP activities, except for re-use. Some additional non-VRP activities are expected to be included in MRO revenue. N.B. Crude remanufacturing estimate based on direct comparison with UK intensity.

Additional indirect and induced economic effects were approximated, using the 2016 National Input-Output Multipliers (Statistics Canada, 2020) and/or information provided in the Government of Canada's 2019 State of Canada's Aerospace Industry Report (summarized in Annex F).

Using the National Input-Output Multipliers, we calculated induced economic effects. We estimate that labour income for the 26,000 indirect and induced jobs would be approximately $CAD 1.5 billion. The labour income estimate assumes the same per job labour income as the national multipliers. Total taxes on production were estimated to be $CAD 0.184 billion including $0.048 billion on indirect production and $CAD 0.096 billion on induced economic activity.

The full range of economic effects are shown in Figure 6.

Figure 6: Economic and employment impacts of aerospace VRP activity, 2019



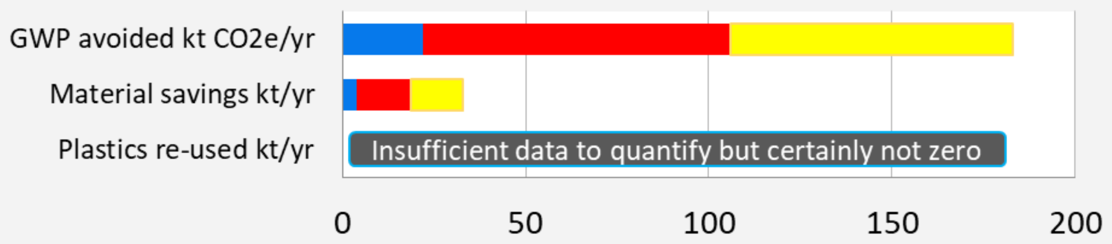
Note: Totals may not add due to rounding.

4.2.2 *Estimate of environmental impacts*

Respondents indicated that, on average, they completed overhaul and repair activities on 1,000 units per year. In keeping with other studies on remanufacturing, respondents indicated that all, or nearly all, of the materials saved through their remanufacturing process were metals (aluminum, steel, etc.). No information was forthcoming regarding plastic material savings via other VRPs, largely because of the relative low value. However, this does not mean that plastics are not being re-used or recovered. Internal plastics parts on components are known to be retained and some exterior plastics are cosmetically refurbished. The exception to this is high-end engineering plastics and composites where the inherent value justifies more extensive technical input.[1]

Our estimate of environmental impacts of VRPs in the aerospace sector attempts to take into account the benefits of each VRP type – i.e. life extension intervention versus full-life regeneration. To adjust for this, we have applied a residual life factor which considers that comprehensive refurbishment also incorporates a significant element of scheduled maintenance, such as is the case of aerospace engines ‘remanufactured’ before any failure has occurred.

Figure 7: Breakdown of estimated environmental impacts for Aerospace by VRP, 2019



	Plastics re-used kt/yr	Material savings kt/yr	GWP avoided kt CO2e/yr
Reman	Insufficient data	3.8	22
Comp. Refurbishment	Insufficient data	15	84
Repair	Insufficient data	14	77
Total	Insufficient data	33	183

Note: Totals may not add due to rounding.

As aerospace is one of the major contributors to VRP activity in Canada, it is not surprising that it shows substantial benefits in environmental impacts. However, these are moderated in the following ways:

- GWP benefits are reduced compared to other products because aerospace products need more processing (often at several locations).
- Because of the higher processing needs, remanufactured products in this sector incur relatively more costs. This means material savings are lower compared to value.

[1] For some classes of product, the material composition is well quantified. As a first approximation, the plastics element might be simply calculated from the recovery rate, with some allowance for losses or irreparable parts. This might apply to home appliances, for example. In the case of complex and highly varied products and assemblies, such as in automotive or aerospace, this approximation cannot be used.

4.3 VRP expansion scenarios

Prior to COVID-19, respondents indicated that they expected moderate to strong growth for their VRP activities in the next 5–10 years. However, the aerospace sector has been dramatically impacted by the COVID-19 pandemic due to travel restrictions and a reduction in demand, which has resulted in job losses in this sector in Canada (Ouadia, 2020).

An article by Roland Berger (Hader, 2020) suggests that the magnitude and duration of the negative impact on the aerospace industry due to COVID-19 are dependent on four factors:

1. The length of travel restrictions – the longer restrictions to domestic and international air travel are in place, leading to reduced demand, the greater financial strain on the industry and the more likely it is that aerospace companies will collapse. Additionally, the longer travel restrictions are in place, the more likely it is that long-term behavioural change will occur, including reduced demand for air travel.
2. The time to recover to pre-COVID-19 levels – further waves of the virus, and potentially further tightening of travel restrictions would impact upon the time the industry takes to recover back to pre-pandemic levels.
3. The "new normal" – behaviour changes embedded during the pandemic, as well as aspirations to direct societal recovery to "better" behaviours and practices may impact future demand for air travel.
4. The future growth path – post-recovery, the aerospace industry may or may not be on the same growth trajectory as it was prior to the pandemic. Roland Berger has defined three scenarios for the future growth of the global aerospace industry (Hader, 2020), as shown in Table 5 below:

Table 5: Aerospace industry scenarios from Roland Berger analysis

Scenario	Duration of air travel restrictions	Reaching the "new normal" by beginning of…	Level of the "new normal"	Deferred aircraft replacement	CAGR after reaching the "new normal"
Pre-crisis baseline	-	-	100%	-	4.6%
Scenario 1: Rebound	2 months	Winter 2020	100%	12 months	4.6%
Scenario 2: Delayed cure	4 months	Summer 2021	90%	18 months	4.1%
Scenario 3: Recession	6 months	Summer 2022	80%	24 months	3.6%

Source: Adapted from (Hader, 2020)

The Roland Berger report specifically references the expected impact of the pandemic-induced downturn on aerospace MRO activity:

> *"Demand for MRO services is primarily driven by the size and flight activity of the global fleet, albeit with some complex transitory factors. As soon as aircraft are grounded, demand for all flight hour/flight cycle linked maintenance disappears (although calendar time-based maintenance remains). Thus, MRO is hit first in any downturn, and MRO providers and spare parts suppliers suffer immediately. As aircraft return to flight, MRO activity picks up, but MRO shops first consume existing inventory before purchasing new parts from suppliers. In addition, aircraft that have been grounded may be disassembled and their parts used as spares, further reducing demand for spare parts from equipment suppliers."* (Hader, 2020)

An additional factor that might impact MRO activity is the current low oil price: when oil price is low, operating older, less fuel efficient planes is less costly, and so replacement cycles may be delayed. This could result in a slight uptick for MRO activity if these older planes require more servicing.

The Roland Berger analysis anticipates the pandemic will induce a cash squeeze for the aerospace industry. This will be a particular challenge to MRO operators who may have large amounts of cash tied up in inventory. Downsizing of operations and consolidation of the industry is anticipated, although whether this will be OEM- or supplier-led is unknown.

Medium-term scenario

The medium-term scenario is dominated by the scale of the COVID-19 impact and the time taken to return to pre-pandemic levels. We have used the three Roland Berger scenarios as the framework for defining our VRP scenarios. The Roland Berger analysis refers to fleet size in its projections of future scenarios and we have used this in our modelling approach. Our assumptions are as follows:

- MRO activity is assumed to be proportional to fleet size, i.e. the larger the fleet size, the larger the required MRO activity to support it.
- The 2019 baseline for MRO activity is $CAD 8.02 billion.
- The number of movements (defined as "A take-off, a landing or a simulated approach by an aircraft as defined in the NAV CANADA Air Traffic Control Manual of Operations (ATC MANOPS, see (Statistics Canada, 2020ad))") and their classification are assumed to be a suitable proxy for MRO activity. Take-off and landing are the procedures that induce the greatest demands on the aircraft and are an important driver of the maintenance cycle.

The number of movements for the 2019 baseline is taken from Statistics Canada data (Statistics Canada, 2020aa; Statistics Canada, 2020ab; Statistics Canada, 2020ac) and distinguished between:

- Domestic movements.
- Transborder movements ("to or from a point in the United States including Alaska, Hawaii and Puerto Rico").
- Other international movements ("to or from points in countries other than Canada and the United States").
- The number of movements for the 2019 baseline includes data from airports with towers (Jan 2019 – Dec 2019 data used) and from airports without towers (Sept 2018 – Sept 2019 data used as this is the latest available).

Levels for the "new normal" number of movements compared to the 2019 baseline were estimated as shown in Table 6. The qualitative factors behind these projections are described in Table 7.

The compound annual growth rate (CAGR) for the baseline is taken as the CAGR of the Canadian aerospace and defence market between 2014 and 2018 (MarketResearch.com, 2019).

The CAGR values for the three scenarios are scaled as per the Roland Berger values for global aerospace industry.

Table 6: Aerospace scenarios based on number of movements

	Duration of air travel restrictions	Reaching the "new normal" by beginning of…	Level of new normal (no. movements)				CAGR after reaching "new normal"
			Domestic	*Transborder*	*Other international*	*Local*	
Pre-crisis baseline	-	-	100%	100%	100%	100%	1.7%
Scenario 1: Rebound	2 months	Winter 2020	100%	100%	100%	100%	1.7%
Scenario 2: Delayed cure	4 months	Summer 2021	100%	90%	85%	98%	1.5%
Scenario 3: Recession	6 months	Summer 2022	80%	75%	50%	82%	1.3%

Table 7: Factors impacting on number of movement projections

Movement type	Factors
Domestic itinerant	• Business travel – may reduce if shift to on-line meetings/conferences, etc. • Leisure travel – may reduce with earnings/increases in unemployment; may increase as people prefer to take vacations within Canada.
Transborder itinerant	• Business travel – may reduce if shift to on-line meetings/conferences, etc.; may reduce with any requirements for self-isolation; may reduce with increased burden of going through airports. • Leisure travel – may reduce with earnings/increases in unemployment; may reduce as people prefer to take vacations within Canada; may reduce if flight prices increase due to social distancing requirements.
Other international itinerant	• Business travel – may reduce if shift to on-line meetings/conferences etc.; may reduce with any requirements for self-isolation; may reduce with increased burden of going through airports. • Leisure travel – may reduce with earnings/increases in unemployment; may reduce as people prefer to take vacations within Canada; may reduce with any requirements for self-isolation; may reduce if flight prices increase due to social distancing requirements – likely to be a greater reduction than transboundary flights.
Local	• Local movements assumed to scale with itinerant, e.g. training flights, equipment tests considered to scale with itinerant movements.

Modelling limitations

In addition to the limitations to this scenario analysis arising from the significant uncertainty surrounding the evolution of the COVID-19 pandemic and the changing business landscape, our model is limited by the assumption that MRO revenue is dependent only on the number of movements. Additionally, we assume that domestic, transboundary and other international movements have the same weighting (i.e. one domestic movement induces the same MRO revenue as one international movement). While this is unlikely to be the case due to the different sizes and value of aircraft used on these different flight types, the lack of data to inform weighting assumptions led us to pursue an equal weighting approach.

Long-term outlook

In the long term, MRO activity will likely continue to scale with fleet activity. Unlike other sectors, VRP activities are already an integral part of the aerospace industry and we do not perceive there are many additional interventions that could be deployed to promote further VRP activity. The largest factors to influence long term VRP activity will likely be changes to future air travel demand, driven by both the post-pandemic and climate agendas.

Barriers to VRP activities cited during industry engagement and initial options for addressing these are shown in the table below.

Table 8: Barriers to greater uptake of VRP activities and suggested mitigation actions

Barrier	Possible actions
Foreign legislation	There is potentially little that Canadian actors can do to influence foreign legislation that hampers MRO activity. Wherever possible, Canadian actors (e.g. businesses, trade bodies and policy makers) should promote the benefits of legislation that supports MRO activity in platforms that might influence foreign legislation development in this area.
Customer recognition	It was surprising to see customer recognition listed as a barrier to the industry due to the high degree of certification and standardization in the aerospace sector, including in MRO activity. Broader societal awareness of VRP strategies could assist with overcoming issues of mistrust and the social engrained mantra that "new equals best, used equals inferior".
Product knowledge	The aerospace components undergoing VRP activity are likely to be technically complex. Independent MRO operators may struggle to access the original technical information for components, necessitating reverse engineering of parts. Reinforcement and extension of design for maintenance and repair principles could help MRO operators, but the challenge lies in motivating these principles if they incur additional costs.
Skilled personnel availability	This cross-sectoral issue could be mitigated through targeted education program development and promotion. Outreach between industry and academia and apprenticeship schemes could help increase awareness and appetite for jobs in the aerospace VRP industry.
Labour costs	This cross-sectoral issue would likely require policy intervention related to taxation on labour to fully mitigate. Technical options may include the development and implementation of automation in VRP processes; however, these may not be practical in all processes and would be costly to design and implement.

4.3.1 *Estimate of potential socio-economic impacts*

Three demand shocks were identified for aerospace, summarized in Table 9. Substitution effects are not anticipated for aerospace because the activity is already widespread, possibly saturated.

Table 9: Aerospace VRP Activity Revenue Scenarios

Scenario	2019 Output (VRPs) $CAD	2030 Output (VRPs) $CAD	Average Annual Growth Rate
As-Is	8.02 billion	9.65 billion	1.70%
Rebound		9.33 billion	1.39%
Delayed rebound		8.98 billion	1.04%
Recession		7.29 billion	-0.87%

Annual gains due to increased aerospace VRP activity are expected to vary across years consistent with the parameters of the specific scenario.

'As-Is' scenario

- In this scenario, linear growth is presumed at a rate of 1.7% annually.
- The figures presented in Figure 8 summarize the *difference* between VRP generated revenue, contribution to GDP, labour income, taxes on production and jobs in 2030 relative to 2019 under this scenario (and similar for the other scenarios).
- This includes an increase in direct and total output of $CAD 1.6 billion and 3.3 billion, relative to 2019 (current) levels, respectively, which suggests a total output multiplier of almost 2.

We consider this scenario to be unlikely as the demand for aerospace VRP activities is reliant on the demand for air travel, which has drastically reduced due to the COVID-19 pandemic and which will likely continue for the foreseeable future.

Rebound scenario

- In this scenario, the aerospace sector is expected to contract in 2020 before reaching 2019 levels in 2021.
- After 2021, the average growth rate is expected to be 1.7%, consistent with business-as-usual, giving an annual linear growth rate of 1.39%.
- The differences illustrated in this scenario include an increase in direct and total output of $CAD 1.3 billion relative to 2019 and $CAD 2.6 billion relative to 2019, respectively.

Delayed rebound scenario

- In this scenario, the aerospace sector is expected to contract in 2020 before reaching 98% of 2019 levels in 2021.
- The 98% level assumes domestic travel reaches 2019 levels; transborder travel to the United States reaches 90% of 2019 levels; and other international travel reaches 85% of 2019 levels.
- After 2021, the average growth rate is expected to be 1.5%, 0.2% below the 'As-Is' scenario, for an annual average growth rate of 1.04%.
- The differences illustrated in this scenario include an increase in direct and total output of $CAD 1 billion and $CAD 1.9 billion relative to 2019, respectively.

Recession scenario

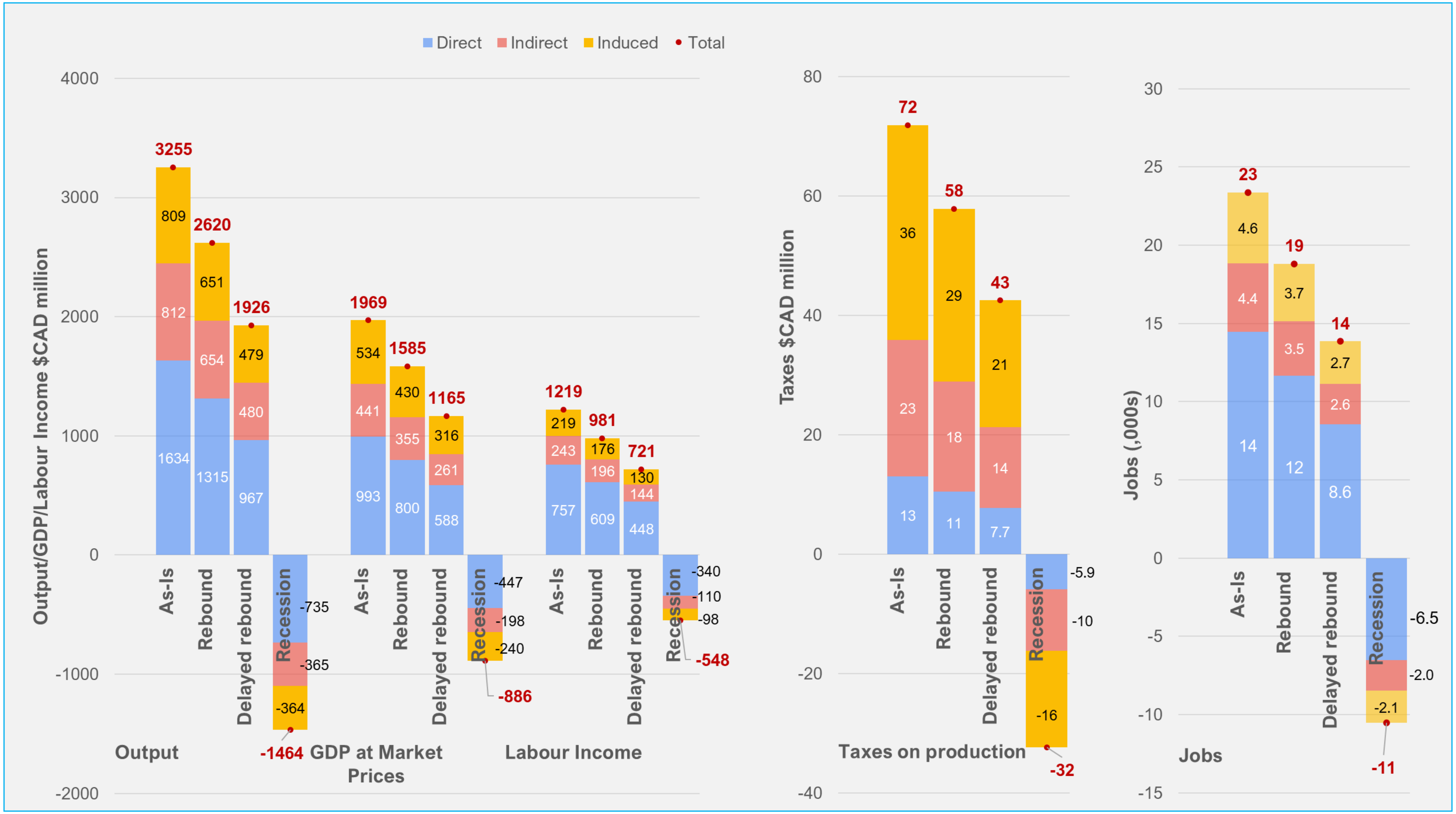
- In this scenario, losses are most pronounced in the first year with a rebound in 2021 and normalized growth by 2022. However, the average annual growth rate is -0.87% as the aerospace sector is not expected to reach pre-COVID 19 levels by 2030.
- In the Recession scenario, the aerospace sector is expected to reach 82% of 2019 levels in 2022.
- The 82% level assumes domestic travel reaches 85% of 2019 levels; transborder travel to the United States reaches 75% of 2019 levels; and other international travel reaches 50% of 2019 levels.
- After 2022, the average growth rate is expected to be 1.3%, 0.4% below the 'As-Is' scenario.
- Therefore, while over the period considered, there are expected to be net losses relative to the present, the sector is expected to grow from 2021 onward within the bounds of the scenario.
- The differences illustrated in this scenario include a decrease in direct and total output of $CAD 0.7 billion and $CAD 1.5 billion compared to 2019, respectively.

Summary

The gross change in activity levels relative to 2019 (i.e. for VRPs, not accounting for substitution), financial and employment, of the scenarios are shown in Figure 8. Note that for aerospace, we have not projected any substitution effects because we think that the aerospace MRO market is highly developed with little room for growth and, therefore, substitution.

Although the outlook for the aerospace sector in late 2019 looks poor, it is still both a high value employer, revenue generator and a repository of personal and process skills related to remanufacturing and other technically rich VRP activities. The sector is worthy of sustenance and nurture to ensure this knowledge base is not lost, and could even be applied to other sectors, existing and emergent.

Figure 8: Economic impacts in the aerospace sector, 2030 – forecasts for the change in the VRP industry relative to 2019, gross levels, not accounting for substitution effects

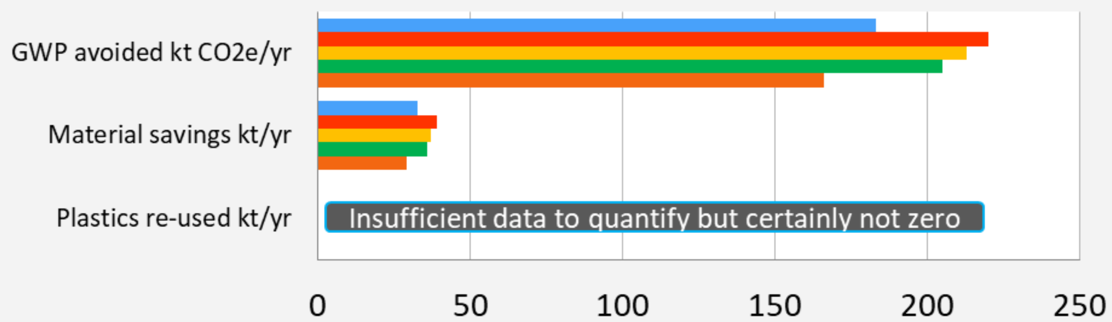


Note: Totals may not add due to rounding.

4.3.2 *Estimate of potential environmental impacts*

The potential environmental impacts of the four VRP scenarios described are summarized in the figure below. The impacts have been calculated assuming that they scale with VRP sector revenue and that there is no change in the mix of activities and products treated with scale.

Figure 9: Environmental Impact projections for aerospace to 2030



	Plastics re-used kt/yr	Material savings kt/yr	GWP avoided kt CO2e/yr
Current 2019	Insufficient data	33	183
As-Is	Insufficient data	39	220
Rebound	Insufficient data	37	213
Delayed rebound	Insufficient data	36	205
Recession	Insufficient data	29	166

Of all the analyses, aerospace provides the lowest confidence due to the extreme impact of the COVID-19 pandemic with the recovery trajectories offering very different outcomes.

To provide context around the environmental impacts of aerospace VRPs:

- at 2019 (current) levels, GWP avoided through aerospace VRP activities is equivalent to taking 40,000 cars off the road per annum and an additional 8,000 cars off the road in 2030 due to the increase in VRP activity modelled in the ‘As-Is’ scenario.
- at 2019 (current) levels, the materials saved is equivalent to the material saved through recycling in Canada for approximately 120,000 people compared to 150,000 people in 2030 due to the increase in VRP activity modelled in the ‘As-Is’ scenario.

A fuller assessment of the significance of the aggregated results is provided in Section 10.2.

5 Automotive

5.1 Industry insight

Our research suggests that the Canadian automotive remanufacturing industry is dominated by small to medium-sized enterprises (Automotive News, 2017). The Asia-Pacific Economic Cooperation (APEC, 2013) identified 77 remanufacturers operating in the Canadian automotive sector in 2013 (APEC, 2013) however, only 51 remanufacturers/rebuilders were identified through desktop research for this current study. While we caution that this may not be the entirety of remanufacturers/rebuilders in Canada, we have heard, through interviews with industry participants that the number of firms focused exclusively on remanufacturing activities in this sector is in decline in Canada. Nearly half of the identified remanufacturers/rebuilders are located in Ontario, with the remainder distributed between Alberta, British Columbia, Manitoba, Newfoundland and Labrador, Nova Scotia, Quebec and Saskatchewan.

Repair activity in this sector is dispersed across Canada and is dominated by small (fewer than 100 employees) and micro (fewer than 5 employees) sized businesses (Statistics Canada, 2018), with greater density of mechanics and repair shops in more populated regions (Statistics Canada, 2018).

Approximately 400 end-of-life vehicle dismantlers exist in Canada (Automotive Recyclers of Canada, n.d.).

VRP products reported amongst respondents include powertrain components, alternators, starters, carburetors, electronics, transmissions, turbo chargers, transfer case and brakes as well as tires.

Automotive displays the typical spectrum of OEM, contracted and independent operators. However, the maturity of the sector allows us to describe more fully the roles covering in and out of warranty activities and activities independent from or connected to the OEM. These actors and relationships are summarized in Annex C.

Table 10 outlines the observed VRPs in operation.

Table 10: A map of VRP practice in automotive

Remanufacturing	Comprehensive Refurbishment	Refurbishment	Direct Re-use	Repair	Cascading (C2C)
Targets in-warranty	Targets in-warranty	Targets aftermarket	Targets aftermarket	Targets aftermarket	Insignificant

Note: a. Cascading between consumers – the handing on of goods to users of similar or lower expectations of performance – is not overtly described in the IRP report. However, it is included here as it represents an important option for some products, especially given the geographical challenges identified previously, and one within the bounds of influence of ECCC.
b. Pink = not present or insignificant.

Our findings elsewhere are that, in contrast to the almost-clean-room, high-tech status of the vehicle manufacturers, remanufacturers can be much more rough-and-ready operations. They do employ great craft and leading techniques in diagnostics and repair, but their processes seldom match those of the manufacturers. In particular, they usually do not run 'Lean' – for example, holding inventories for months or years is a particular and perhaps unavoidable feature – but there are many parts of operations amenable to standard Lean techniques and which could be applied to improve the fitness of – in particular – independent agents.

Most respondents indicated that they sell their remanufactured/refurbished products primarily in Canada, with some sales to the US and South America. Respondents indicated that their main competition is from the import of cheaper new or VRP products from China, Mexico, India or Taiwan.

There is also stiff competition domestically between aftermarket shops and/or dealerships (Automotive Industries Association of Canada, 2015).

Canadian vehicle dismantlers have indicated that most of the cores sold in Canada are for direct re-use only, with the cores set for remanufacturing being exported primarily to OEMs and aftermarket remanufacturers in the US, Mexico and South America. Their main competitors for sales are core suppliers from countries such as China that can undercut them substantially on price.

5.1.1 *Motives to undertake VRPs and barriers to growth*

Other than profitability (with average gross profits of between 7.5% and 50%), no clear motive was identified from industry respondents. Historically, and by analogy elsewhere, the primary driver for VRP activity is economic - to uphold margins in the aftermarket to offset those of new sales in this highly competitive primary car sales market. A large part of overall profitability comes from the aftermarket including from reducing warranty liabilities.

Given the labour-intensive nature of remanufacturing, the cost of labour was cited as a significant barrier to VRP activities in Canada, especially when competing with cheaper imports. Other barriers to growth included difficulty achieving economies of scale, the high cost of transporting cores, variable quality and quantity of feedstock, lack of customer recognition, inadequate sales channels, lack of access to skilled labour and inadequate product knowledge (for non-OEM affiliated companies). Barriers to exporting VRP products included a lack of money and time, the cost to transport products, a patchwork of provincial/territorial hazardous waste regulations making it difficult to transport batteries inter-provincially and a ban on VRP imports by some countries, specifically in South America.

Respondents from the aftermarket industry indicated that product design is a barrier to VRP activities. For example, the proliferation of telematics, such as embedded sensors in bumpers, in new vehicles is a barrier to repair and re-use because the software and equipment is proprietary and cannot be reset by third parties. In addition, the increased use of plastic components for light-weighting purposes makes these components increasingly difficult to repair or re-use due to safety concerns. Further barriers to VRP activities in the aftermarket sector include automakers increasingly requiring in-warranty vehicles to be repaired with OEM parts in their repair procedures.

Note that in the EU, the so-called Block Exemption Directive (European Commission, 2010) prohibits automakers and their franchises from mandating use of OEM parts. This learning is potentially transferable.

Automotive Service Providers also struggle to find skilled labour (Automotive Industries Association of Canada, 2015) and a further labour gap is projected in the next five years as demand for skilled and unskilled labour in this industry outpaces the supply of qualified people (Automotive Industries Association of Canada, 2018a). A lack of training on vehicle flashing/reprogramming has also been cited as a barrier to growth for aftermarket shops.

Barriers to growth cited by vehicle dismantlers include competing with unregistered ‘backyard’ vehicle recyclers for EoL vehicles, a lack of space to store parts, low demand for viable parts that are not traditionally remanufactured or re-used and a lack of knowledge regarding which part can be re-used on which vehicles.

5.1.2 *Predictions for future growth*

Nearly all respondents indicated that they expect moderate (1–3%) or strong (>3%) annual growth of demand for VRP activities. However, these responses reflect pre-COVID-19 conditions.

A respondent from the aftermarket industry indicated that demand for used parts may increase as insurance companies are starting to push for repairs to be completed with a mix of new aftermarket and salvaged parts to keep premiums down.

A 2018 labour market study for the automotive aftermarket supply chain conducted by AIA Canada found that (pre-COVID-19) demand for aftermarket services is expected to increase by 2.3 percent per annum as the average age of vehicles increase (Automotive Industries Association of Canada, 2018a). Projected growth in demand for skilled and experienced labour is expected to increase since technological advances in vehicles, such as hybrid vehicles, fuel cell light vehicles, electronics and sensors, cellular and digital technologies demand more specialized labour.

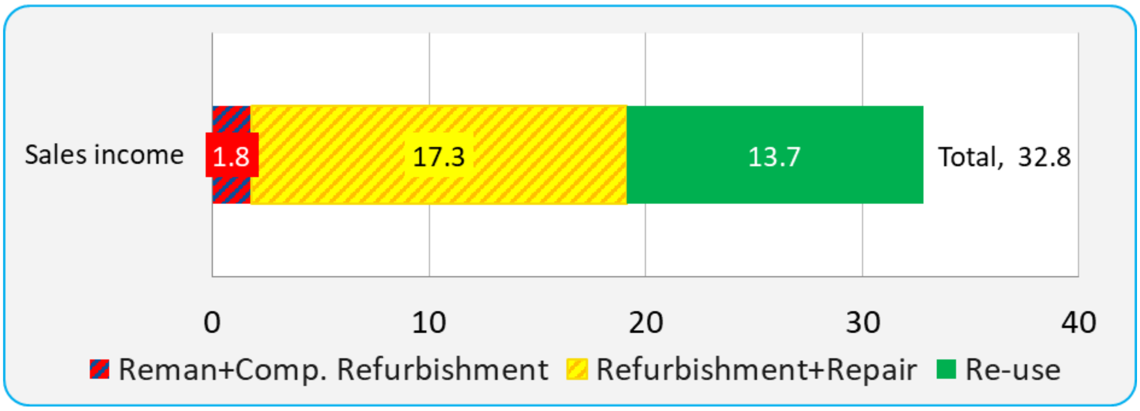
The study suggests that retraining programs will be needed for existing technicians to stay current with emerging technologies. The Government of Canada can help bridge the employment gap by working with industry associations, technical colleges and high schools to develop programs that: empower women by supporting campaigns and programs that showcase the industries changing Science, Technology, Engineering and Mathematics skills needs; assist aboriginal and foreign-trained workers to develop technical skills needed in the automotive industry; fund research that aligns industry needs with school curriculum.

5.2 Impact analysis

5.2.1 *Estimate of socio-economic impacts*

Direct economic impacts for automotive VRP activities in this sector are estimated to be $CAD 32 billion (see Figure 10). We have used Statistics Canada data but adjusted for elements which we do think fit into this category, such as tire retreading. Re-use was estimated at $CAD 13.7 billion based on used automotive sales revenue from Statistics Canada.

Figure 10: Revenue generated by VRP activity in the automotive sector, 2019 $CAD bn



Notes: a. Totals may not add due to rounding.
b. Remanufacturing estimated by scaling to EU estimates of remanufacturing activity.
c. 17.3 bn figure derived from 19.2 bn (StatCan) by assuming the latter includes remanufacturing and refurbishment activities. Includes tire retreading.

Based on the total estimated direct economic impacts, VRP activities in the automotive sector contribute approximately 341 thousand direct jobs and $CAD 0.61 billion of taxes on production. Labour income from these jobs is estimated to be $CAD 15 billion.

The total economic impacts of VRP activities can be estimated using Statistics Canada's National Input-Output Multipliers for relevant sectors. While VRP activities are not disaggregated to include their own multipliers, we can use multipliers for similar sectors to approximate the economic impacts of these activities. We therefore took multipliers from repair and maintenance categories as listed in Annex F.

The key takeaways from this analysis are:

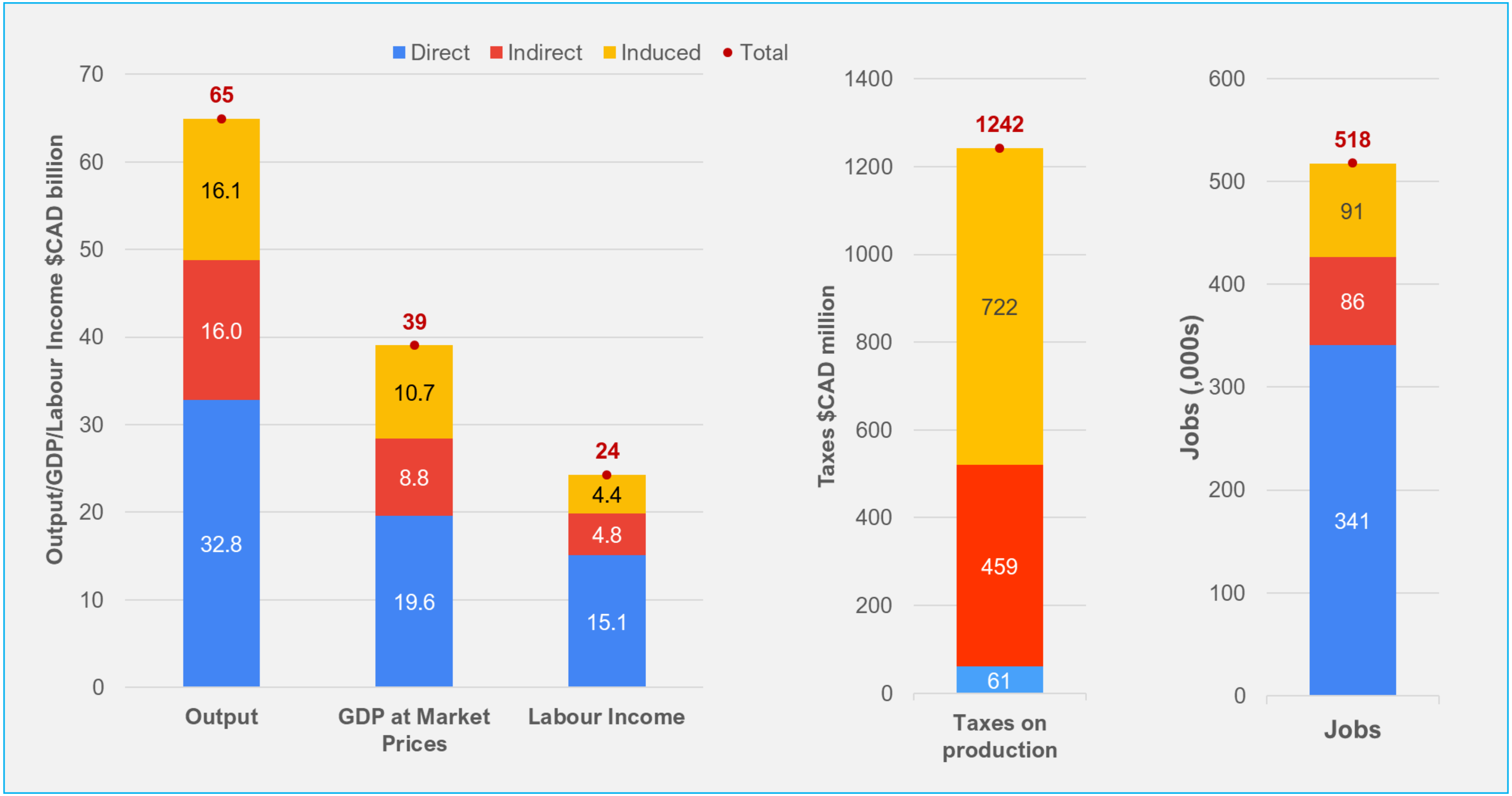
- Based on the direct economic impact of $CAD 32.8 billion, we estimate total output to be approximately $CAD 65 billion.
- This equates with a total GDP contribution of $CAD 39 billion.
- These VRP activities are estimated to indirectly generate 86 thousand jobs and induce 91 thousand jobs.
- Total taxes on production are estimated to be $CAD 1.24 billion including direct, indirect and induced taxes.

This analysis is summarized in Figure 11 below.

Our estimates of remanufacturing plus comprehensive refurbishment suggest it is a high-activity sector, but this is because the estimate is geared to underlying manufacturing activity, which is similarly – and somewhat surprisingly, given the alleged junior player relationship to its neighbours – high. Remanufacturing therefore appears to be a sector to at least defend and sustain. Re-use is high because of the vibrant market in pre-owned vehicles, which may change hands multiple times in their lives, generating an incremental return to the dealerships each time. It cannot be claimed, however, that this activity preserves a whole vehicle life, and certainly not a vehicle life each sale!

This does throw into stark relief that VRPs are an obvious solution from all perspectives when goods are sufficiently valuable, and the economics of enduring goods clearly favour continued use. The challenge is to extend the enabling practices – long life, parts availability, regular service, safety checks, pre-sale checks and warranties, leasing contracts – into other retail sectors. Being an energy using product, a car is – conceptually – on par with a washing machine – and throws down a thought-provoking challenge to sectors whose model is to pile high, sell cheap and sell many times.

Figure 11: Economic and employment impacts of automotive VRP activity, 2019



Note: Totals may not add due to rounding. Figures include tire retreading.

5.2.2 *Estimate of environmental impacts*

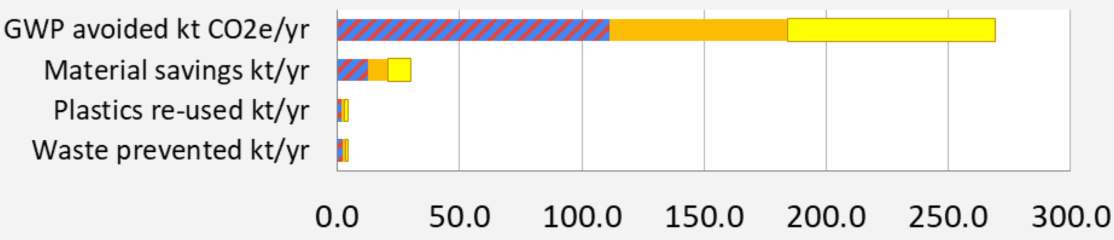
Our assessment of the impacts in this sector draws strongly on the life cycle analyses conducted by Nasr et al. published in the IRP report (Nasr, et al., 2018). This has been fused with a bottom-up analysis of material recovery carried out by Oakdene Hollins for the World Steel Association (unpublished) – specifically steel and iron – applied across the breadth of automotive components. Steel is a good indicator of embodied carbon but does not tell the entire story. Therefore, we have used Nasr's analysis to project for other components, used his kg/kg GWP factors and his estimates of process GWP savings per kg of device. In addition, Nasr also estimates waste avoidance data which we have used directly.

Nasr (Nasr, et al., 2018) estimated that manufacture of an automotive engine generated around 0.15 kg of waste for every 1 kg of input material, whereas a remanufactured engine generated an order of magnitude less (typically 0.015 kg/kg, referred to new build inputs). Repair generated even less. For a HDOR engine, there was a similar story, but, interestingly, remanufacturing and repair had similarly low rates.

Our residual life factors reflect the practices of the sector. Refurbishment is taken to mean – on the whole – both a lower class of life extension for components, but also a cosmetic action on vehicles. Hence its benefit has been downgraded. Repair we believe to be dominated by accident repair, which again for most cases do not jeopardize the life of the vehicle and is merely cosmetic. Re-use pertains to the 2nd hand market for cars.

The environmental impact of re-use has not been included in the total impacts for VRP activity in the sector as this activity is primarily economically motivated – you resell your vehicle because it still has a significant residual value. It would be misleading to include these environmental impacts as 'savings' or 'avoided' impacts as they do not displace other activities.

Figure 12: Breakdown of estimated environmental impacts for automotive by VRP, 2019

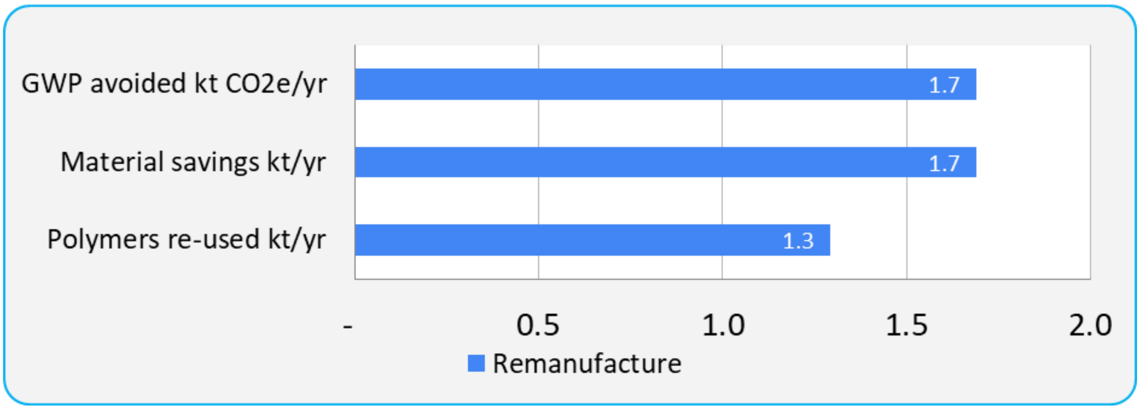


	Waste prevented kt/yr	Plastics re-used kt/yr	Material savings kt/yr	GWP avoided kt CO2e/yr
Reman+Comp. Refurb	1.9	1.8	12.3	111.1
Refurbishment	1.2	1.2	8.1	73.3
Repair	1.4	1.4	9.4	85
Total	4.5	4.4	30	269

Notes: Totals may not add due to rounding.
Figures exclude tires.
In this sector, refurbishment may be heavily biased to aesthetic processes rather than restoration of functional equipment. Repair judged to be mostly superficial, related to replacement of wearing parts, repair of accident damage, etc. and hence mostly not impacting on the viability of the vehicle. Re-use not included in this graph, but estimated at around 600 kt/yr CO_{2e} attributed solely to sales of pre-owned vehicles, converted to number of sales by margin of $CAD 4k per sale, to mass at 1.5 t/vehicle, 65% steel content, 3.6 kg/kg GWP conversion, 0.5 fractional life and 8 resales. This is a notional figure which serves to illustrate how financially obvious VRPs can also be environmentally obvious.

The impact of automotive tire retreading (which displays all process characteristics of remanufacturing) should be compared to that in HDOR which is ten times higher despite servicing half the number of vehicles and trailers. Light vehicle tires are small and less valuable than those from HDOR and are often not constructed for retreading. This is particularly the case for imported tires which, re-treaders say, are undermining the sector, clearly an area of potential intervention.

Figure 13: Breakdown of estimated environmental impacts for automotive tires by VRP, 2019



Note: Polymers are bespoke engineered resin/rubber compounds used in tires – considered to be plastics.

Further commentary on the significance of these numbers appears as the end of this sector section.

5.3 VRP expansion scenarios

Medium-term scenario

The medium-term (10 years) outlook for VRP activity in the automotive sector is driven by projections of post-pandemic recovery. The COVID-19 pandemic has had a profound impact on the automotive sector, both in terms of the supply of automotive business activities and in the demand for automotive products and services.

A report on the impacts of the pandemic on the automotive aftermarket and an assessment of how the industry may evolve has been compiled by McKinsey (McKinsey & Co., 2020). The automotive aftermarket is considered to be more resilient than new and used vehicle sales – it is a function of the size of the car inventory, with repair and maintenance of vehicles a necessity, unlike new vehicle sales, which are more dramatically impacted in a recession. As an example, the McKinsey report reference the performance of the US aftermarket after the financial crisis of 2008. This analysis shows that in contrast to new vehicle sales, which fell by 42%, aftermarket sales saw only a 1% decrease (McKinsey & Co., 2020).

Factors impacting on the aftermarket outlook during the peak of the pandemic, where non-essential travel has been banned and stay at home orders issued, and explored in the McKinsey analysis(McKinsey & Co., 2020) include:

- A significant reduction in Vehicle Miles Travelled (VMT), which is a key driver for the aftermarket. With reduced VMT, there is a reduction in demand for aftermarket parts and services.
- A reduction in the number of vehicle collisions – aftermarket activity related to collisions is subsequently lower.
- A reduction in the volume of retail demand – initiatives such as allowing extensions on mandatory vehicle checks and consumers delaying non-essential repairs has led to reduced demand.
- A significant increase in digital channel and e-commerce volumes as consumers look to alternative sales channels. This has a particular importance for VRP activity as a consumer may

not understand and/or trust descriptions of remanufactured or refurbished parts and so may choose a new replacement part over one that has undergone a VRP.

- A reduction in the use of public transport – on the upside, this could lead to greater use and subsequently maintenance and repair of personal vehicles. However, public transport-based remanufacturing contracts could suffer under reduced usage, although the impacts of this would be captured in the HDOR sector.
- A potential consolidation of the industry catalyzed by actors suffering financial difficulties. As for the aerospace sector, VRP-actors with large part inventories may not be able to survive the current squeeze on cash.

Post-pandemic, several of these factors are anticipated to persist, including the avoidance of public transport and a potential reduction in VMT due to behavioural shifts towards walking and cycling. Other factors may come into play, including:

- Low oil prices supporting a shift towards use of private vehicles – this could bolster aftermarket demand.
- Reduction in new car sales with an increase in used car sales and repair.
- A surge in service demand once lockdown measures are lifted and mandatory checks resumed – this would provide a temporary boost to the aftermarket.
- The form of any government stimulus – incentives for car scrappage schemes could negatively impact upon the aftermarket, particularly independent operators who rely on out-of-warranty activities. If a scrappage scheme is targeted towards low-emission vehicles, this could perhaps accelerate demand for electric vehicle component remanufacturing development.
- Locally sourced parts, including VRP parts, may have better availability than imports of new components.

The McKinsey analysis projects the size of the automotive aftermarket in 2025 in the US, China and Europe for three scenarios: the pre-COVID-19 estimate, the virus contained (“A3”) and virus recurs (“A1”) scenario. The results of this analysis are shown in Table 11.

Table 11: Aftermarket scenarios for 2025 by McKinsey

Scenario	Light-vehicle aftermarket size, $ billion		
	United States	China	Europe (France, Germany, Italy and United Kingdom only)
2019	209	158	91
2025 (pre-COVID-19 estimate)	230–235	210–215	100–105
2025 (scenario “A3”: virus contained)	225–230	205–210	100–105
2025 (scenario “A1”: virus recurs)	220–230	200–205	85–95

Source: Adapted from (McKinsey & Co., 2020)

We have used the McKinsey scenarios as the framework for defining our VRP scenarios. The McKinsey analysis refers to the whole aftermarket (i.e. parts and services) in its projections of future scenarios and we have used this in our modelling approach using the following methodology:

- We have used the more optimistic “A3”, virus contained scenario for our analysis.
- We have assumed the development of the Canadian aftermarket is most likely to follow the US forecast (rather than the Chinese or European projections).
- The mid-point of the US A3 scenario value was used to establish the 2019 to 2025 growth rate to be applied to the Canadian aftermarket.
- The calculated growth rate was used to estimate the size of remanufacturing/comprehensive refurbishment and refurbishment/repair VRP activities.

- In the absence of other data, we assume that by 2025, used car sales (a re-use VRP activity) have recovered to 2019 levels.
- The CAGR between 2019 and 2025 is assumed to continue until 2030.

The McKinsey analysis focuses on the evolution of the aftermarket and does not include analysis of VRP activities, such as remanufacturing and refurbishment. We have defined a series of substitution scenarios to explore the impact of substituting revenue spent on newly manufactured parts with remanufacturing activities. The increases in remanufacturing revenue by 2030 explored in the scenarios are 1%, 5% and 10%.

Long-term outlook

Beyond 2030, the main drivers of the automotive industry will likely be related to global mega trends. A 2017 report by Deloitte identified future drivers which may influence the automotive value chain (Deloitte, 2017) (see Table 12). We use these drivers as the basis for exploring how VRP activities may expand in the future.

The Deloitte report identified and clustered future drivers by five market forces as shown in the table below. We note that there is some cross over between some drivers (e.g. alternative powertrains could be classified under both the 'Technology' and 'Environment' drivers), but we have maintained the original Deloitte classifications, except for two drivers, as noted in the table footnote.

Table 12: Deloitte classification of future drivers in automotive

Society		
Safety awareness	Competition for talent	Importance of material wealth
Ride sharing	Trust in OEMs	Pay-per-use models
Degree of customization	Future standard of driving	Urbanization
Technology		
Artificial Intelligence	Telecommunication grid	Stringency of cyber security standards
Capability of cars	Man-machine dialogue	Autonomous driving
Energy storage	Lightweight technology	3D printing
Connectedness of cars	Source of automotive innovation	Vehicle structure
Predominant powertrain technology	Power charging	Updatable car
Availability of batteries	Protection of personal information	Life cycle
Artificial and organic components	Energy storage location	Adaptive cars
Economics		
Infrastructure spending	Data monetization	Market control by new players
Sales channels	Buying vs. leasing	Place of production
Corporate valuations	Financing options	Shareholder interest
Growth in Asian markets	Cost of capital	Oil price
Consumer power	Role of suppliers	E-mobility business models
Power of suppliers	Autonomous production networks	White-label cars
Form of ownership	End-to-end mobility services	Remanufacturing processes
Cost pressure on suppliers	Financing options	
Environment		
Polluter pays principle	Recycling technology	Environmental concern
Pollutant-free production	Alternative powertrains	
Politics		
Strength of IP laws	Freedom of Trade	
State of public transport infrastructure	Data storage	

Source: Adapted from Figure 4 in (Deloitte, 2017) – "oil price" driver was reclassified as an economic rather than environment driver; "alternative powertrains" driver was reclassified as an environment rather than economic driver.

Almost all the drivers listed could impact on the evolution of VRP activities, in positive or negative ways. Key examples of these impacts are grouped and listed in Table 13 below.

Table 13: Drivers and VRP impacts in automotive

Drivers and VRP impacts
Evolution of vehicle technology: Rapid and/or substantive changes in technology and functionality in vehicle components and systems can make VRP implementation more challenging. Consumers may be less willing to prolong the life of vehicles that do not have the latest technology, resulting in premature obsolescence and a decline in the market for all VRP activities, unless they can be upgraded. New technologies require remanufacturing, refurbishment and repair practitioners to invest in the development of the skills, tooling and supply chains necessary to process these new products and/or upgrade older products. The transition away from conventional powertrain technologies, e.g. electric vehicles, represents a significant change to the traditional product ranges and supply chains for existing automotive remanufacturers. Increasing 'softwarization' of components and systems that accompanies many technological advancements is also a challenge for independent VRP practitioners, who would not have access to OEM software, necessitating significant investment in reverse engineering of systems. However, not all technological changes are negative - increased complexity of automotive components and systems implies an increased value. A higher value product may make value-retention more attractive. Also, trends towards updatability and customization may result in more modular vehicle design approaches that would support VRP approaches. Additionally, the greater connectedness of cars could facilitate better condition monitoring of key automotive components. This could allow scheduled and preventative maintenance VRP activities to further improve the value-retention of these activities.
Driver examples: Alternative powertrains ● Autonomous driving ● Artificial intelligence ● Connectedness of cars ● Updatable car ● Man-machine dialogue ● Stringency of cyber security standards ● Capability of cars
Changing consumer attitudes towards vehicle ownership and use: Societal changes in attitudes towards, and the feasibility of, vehicle ownership may impact upon VRP activities. Where consumers are increasingly less likely to own a vehicle, either through financing arrangements or through the servitization of mobility services, the vehicle owner may be more motivated to pursue value-retention processes and better positioned to implement preventative maintenance. These processes would support maximizing the life of the asset and reduce the capital costs for the fleet owner. While individual consumers are less likely to have a clear understanding or trust of some VRP activities (most notably remanufacturing), consolidation of maintenance and replacement part procurement decisions to fewer, and potentially more rational decision-makers (intermediary fleet owners, or OEMs) could catalyze the uptake of VRP activities. Ride sharing schemes have also been early adopters of alternative powertrain vehicles. The higher value of these vehicles could further incentivize VRP activities.
Driver examples: Importance of material wealth ● Ride sharing ● Pay-per-use models ● Urbanization ● Autonomous driving ● Buying vs. leasing ● E-mobility business models ● Form of ownership ● End-to-end mobility services

Structural changes to the automotive value chain: Changes to the value chain for automotive production and sales may impact upon VRP uptake. Consolidation of the supply chain is occurring in both manufacturing and remanufacturing.

Driver examples: Market control by new players ● Sales channels ● Place of production ● Role of suppliers ● Power of suppliers ● Autonomous production networks ● Cost pressure on suppliers ● Buying vs. leasing ● E-mobility business models ● White-label cars

Production processes: Changes to manufacturing processes may support the uptake of VRP activities by making processes more efficient and cost-effective, or by increasing the technical range of VRP operations.

Development of VRP processes for new automotive components, particularly for alternative powertrains and increased connectivity vehicles would allow practitioners to compete against replacement sales.

3D printing technologies could be harnessed to support VRP activities. Replacement of obsolete or unavailable components during VRP activities can be a significant barrier. Parts no longer in production, or only available in high batch sizes must currently be reverse engineered. 3D printing technologies can reduce the costs associated with the prototype development process, as well as in the iterative development of jigs and fixtures needed for part manufacture. 3D printing technologies may also encourage an Original Equipment Supplier (OES), who were the original component manufacturer, to offer legacy components in smaller batch sizes.

Driver examples: 3D printing ● Remanufacturing processes

5.3.1 *Estimate of potential socio-economic impacts*

Three demand shocks were identified for automotive, summarized in Table 14.

Table 14: Automotive VRP Activity Revenue Scenarios, 2019 vs 2030

Scenario	2019 Output (VRPs) $CAD	2030 Output (VRPs) $CAD	Average Annual Growth Rate (Sector)	Substitution Rate	New Revenue Attributed to Substitution
As-Is	32.8 billion	35.8 bn	0.8%	0%	0%
Natural Growth		36.2 bn	0.8%	1%	11%
Moderate Action		37.6 bn	0.8%	5%	37%
Strong Action		39.4 bn	0.8%	10%	54%

Because no market forecasts were available for the automotive sector in Canada, we used US and Europe expected growth rates. US growth rates, being at the lower end, provided a conservative view more likely to be reflective of the Canadian context. Estimated growth was then annualized to produce an intermediate 2030 projection free from substitution effects. The results of these projections are shown in Figure 14.

Unlike aerospace, the automotive VRP sector is not necessarily a mature market. Influences such as new technology, changing consumer preferences and policy action result in the substitution of new manufactured goods by VRP products. These are shown in Figure 15. To judge these effects, we applied a substitution rate of 0.7 (typical of other sectors) to the intermediate 2030 projection outlined above.

Further, about 50% of automotive vehicles (by value) are manufactured in Canada. Accordingly, only 50% of the manufacturing output reduction is expected to be borne by Canada.[2]

In all scenarios, annual gains will vary from year to year. Within the first year (2020), we expect a decline and economic losses due to COVID-19, with sectoral growth expected in subsequent years. It is reasonable to suggest that increased substitution could result in higher annual growth rates for VRP activities in the automotive sector since the base growth rate provided does not include substitution effects.

'As-Is' scenario

- In the 'As-Is' scenario, there is an 0.8% average annual growth, and no substitution effects, between 2019 and 2030.
- This results in a $CAD 3.0 billion increase in annual direct revenues relative to 2019.
- The total output increase, including direct, indirect and induced output, is estimated to be $CAD 5.9 billion.
- The increased output results in an additional GDP contribution of $CAD 3.6 billion.
- Annual production taxes increase by $CAD 0.14 billion, driven largely by induced economic activity.
- The additional direct output results in an additional 31 thousand jobs with additional direct labour income of $CAD 1.41 billion.
- In total, the additional output results in 47 thousand additional jobs and $CAD 2.2 billion in additional labour income over 2019 levels.

Natural Growth scenario

- Under the Natural Growth scenario, direct output increases by $CAD 3.1 billion relative to 2019 and $CAD 0.07 billion relative to the 'As-Is' scenario ($CAD 3 billion) due to substitution effects.
- Total output increases by $CAD 6.0 billion relative to 2019.
- Due to the increased output, GDP increases by a total of $CAD 3.7 billion, of which $CAD 1.9 billion can be attributed to direct activity.
- Taxes on production increase by $CAD 0.148 billion relative to 2019 driven by induced economic activity.
- The direct output due to increased VRP activities results in an additional 33 thousand jobs with additional labour income of $CAD 1.5 billion.
- In total, the increase in output is estimated to result in 50 thousand additional jobs with a total additional labour income of $CAD 2.3 billion.

We estimate that substitution effects result in an increased total output of $CAD 0.10 billion. Increased output demonstrates that, for Canada in this scenario, the negative effects on output on a per good basis and lost domestic manufacturing activity are outweighed by the benefits of domestic VRP activities. This is due to 50% of the new goods production losses being borne by international producers.

Benefits are most pronounced for direct and induced economic activity, as the new direct VRP activity and the additional labour income from VRP activities spurs induced economic activity. Benefits are less apparent for indirect economic activity as there is less reliance on suppliers for VRP activities, as illustrated by the indirect multipliers. This means the economic gains for these

[2] This was calculated using the Supply and Use Tables from Statistics Canada for 2016. Products considered include MPG336111 (Passenger cars), MPG33620 (Motor vehicle bodies and special purpose motor vehicles), MPG336310 (Motor vehicle gasoline engines and engine parts), MPG336320 (Motor vehicle electrical and electronic equipment and instruments), MPG336330 (Motor vehicle steering and suspension components), MPG336340 (Motor vehicle brakes and brake systems), MPG336350 (Motor vehicle transmission and power train parts), MPG336360 (Motor vehicle interior trim, seats and seat parts), MPG336370 (Motor vehicle metal stamping), MPG336390 (Other miscellaneous motor vehicle parts), MPG326107 (Motor vehicle plastic parts), MPG326201 (Tires), MPG332700 (Threaded metal fasteners and other turned metal products including automotive), MPG336112 (Light-duty trucks, vans and sport utility vehicles (SUVs)), MPG336120 (Medium and heavy-duty trucks and chassis), and MPG336201 (Buses)

firms and industries are less apparent as Canada transitions to VRP activities. However, economies of scale and other micro-economic factors may present new opportunities for these firms, or others, if supply chains were to change.

Overall, the substitution of new manufactured goods for goods produced through VRPs is expected to result in **2.4 thousand additional jobs** over the 'As-Is' scenario with an additional total labour income of **$CAD 0.09 billion**.

Moderate Action scenario

- Under the Moderate Action scenario, direct revenues increase $CAD 3.4 billion relative to 2019 and $CAD 0.4 billion compared to the 'As-Is' Scenario.
- Total output increases by $CAD 6.4 billion relative to 2019, which is almost double the direct output increase.
- Contributions to GDP increase by a total of $CAD 4.3 billion, including $CAD 2.2 billion attributed to direct activity, relative to 2019.
- Taxes on production are $CAD 0.175 billion higher than 2019 levels driven by induced economic activity.
- The direct output due to increased VRP activities results in 41 thousand additional jobs with additional labour income of $CAD 1.7 billion.
- In total, the increase in output is estimated to result in an additional 59 thousand jobs with additional total labour income of $CAD 2.7 billion.

Substitution effects result in an increased total output of $0.48 billion, which demonstrates that, under this scenario, the negative effects on output on a per good basis and lost domestic manufacturing activity are outweighed by the benefits of increased domestic VRP activities.

Overall, the substitution of new manufactured goods for goods produced through VRPs is expected to result in **12 thousand** additional jobs over the 'As-Is' scenario with additional total labour income of **$CAD 0.44 billion**.

Strong Action scenario

- Under the Strong Action scenario, direct revenues increase by $CAD 3.7 billion compared to 2019, an increase of $CAD 0.7 billion over the 'As-Is' Scenario.
- The increased substitution of new manufactured goods for goods produced through VRP activities results in increased positive outcomes (relative to the previous scenarios) as the benefit of capturing more activity domestically outweighs the revenue reduction due to the expected change in production method from manufacturing to a VRP activity.
- Total output increases by $CAD 6.9 billion.
- Contributions to GDP increase by $4.9 billion, of which, $CAD 2.7 billion can be attributed to direct activity.
- Taxes on production increase by $CAD 0.209 billion driven by induced economic activity.
- The direct output due to increased VRP activities results in 51 thousand additional jobs with additional labour income of $CAD 2.1 billion.
- In total, the increase in output is estimated to result in 71 thousand additional jobs with additional total labour income of $CAD 3.1 billion.

Substitution effects result in an increased total output of $CAD 0.95 billion over 2019 levels. As with all automotive scenarios, the benefits of domestic VRP activities, outweigh the negative effects of lost new product manufacturing.

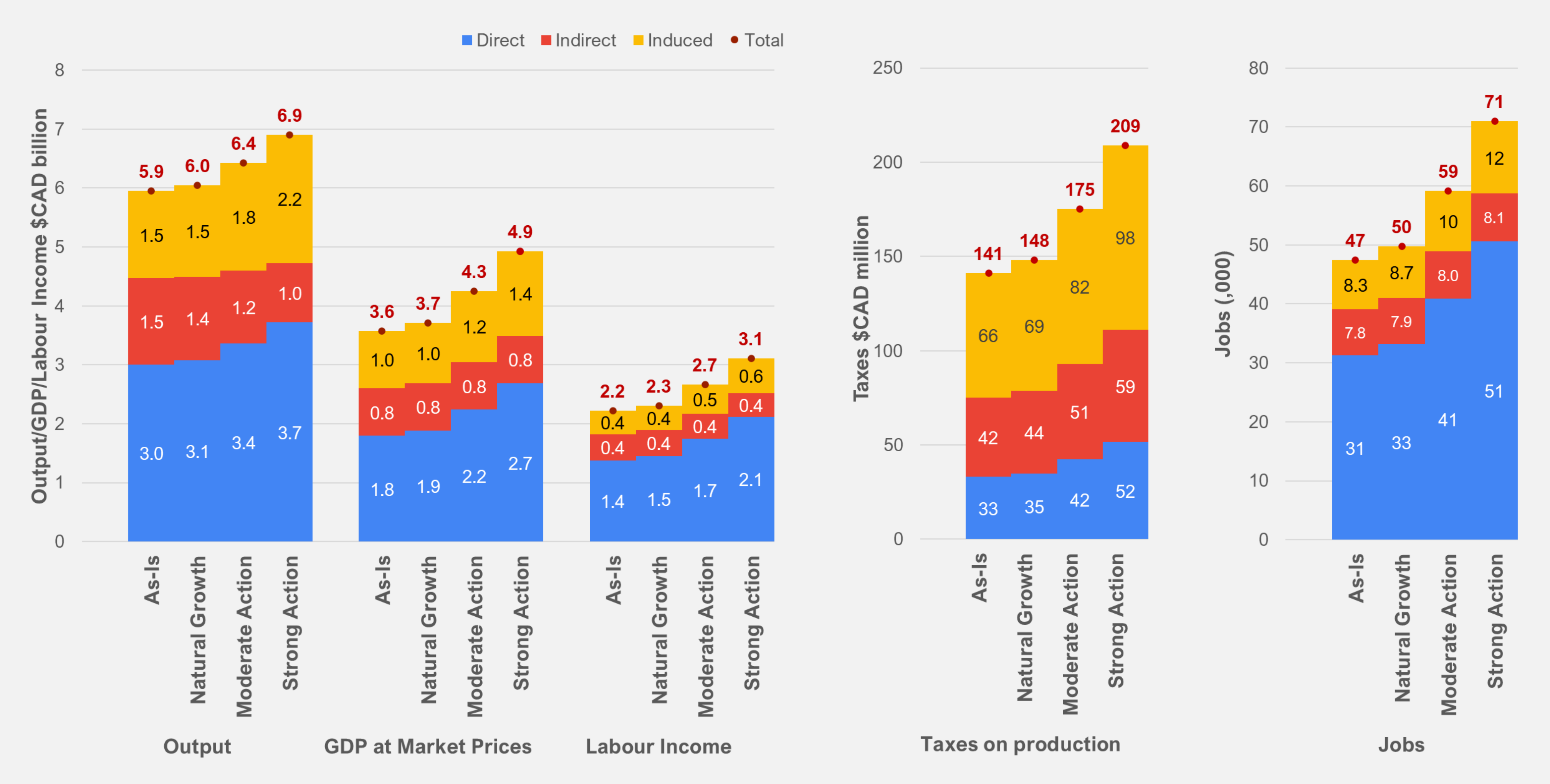
Overall, the substitution of new manufactured goods for goods produced through VRPs is expected to result in **24 thousand additional jobs** over the 'As-Is' scenario with additional total labour income of **$CAD 0.89 billion**.

Summary

The gross levels (relative to 2019), financial and employment, of the scenarios are shown in Figure 14. Note that these do not include any substitution effects, but the overall net effect of these compared to the As-Is scenario is shown in the subsequent graphic, Figure 15.

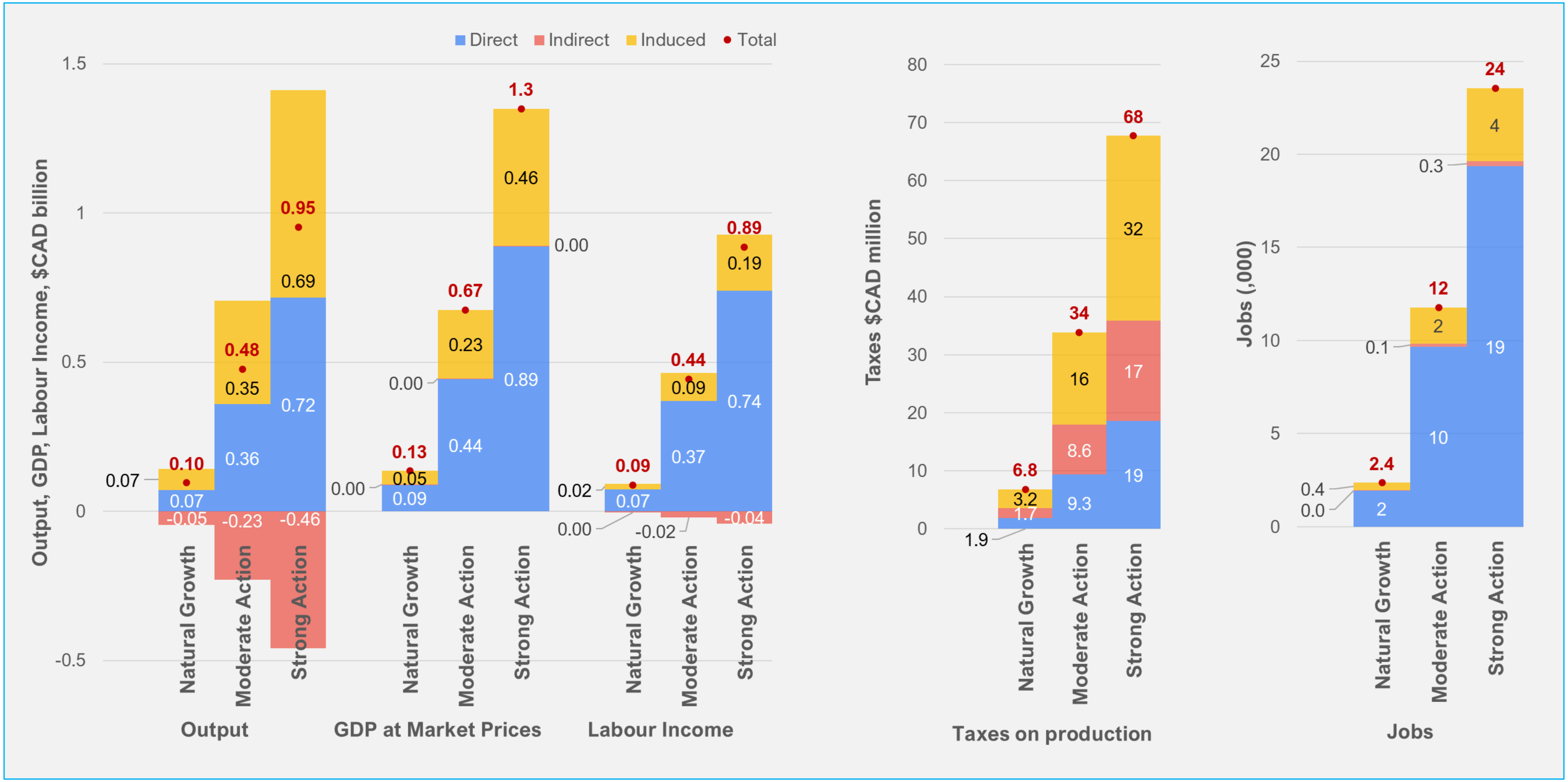
Overall, an expansion of VRP activities in the automotive sector has some trade-offs. However, losses in the manufacturing sector are not expected to be borne entirely by Canada as many goods are imported for Canadian consumption. As a result, in all scenarios, economic benefits are expected for Canada across all total multiplier metrics. The economic benefits are driven by direct and induced activity. Direct activity increases are due to an increased production of goods occurring in Canada relative to manufacturing since increased VRP demand is assumed to be filled by domestic production. Induced benefits are driven by the increased labour income associated with VRPs. When losses are observed, it is from indirect economic activity. However, expansion of VRP activities may generate new supply chains presenting market opportunities for new and existing firms.

Figure 14: Economic impacts in the automotive sector, 2030 – forecasts for the change in the VRP industry relative to 2019, gross levels, not accounting for substitution effects



Note: Totals may not add due to rounding.

Figure 15: Economic impacts in the automotive sector, 2030 – net impact of VRPs on Canadian economy over 'As-Is' scenario

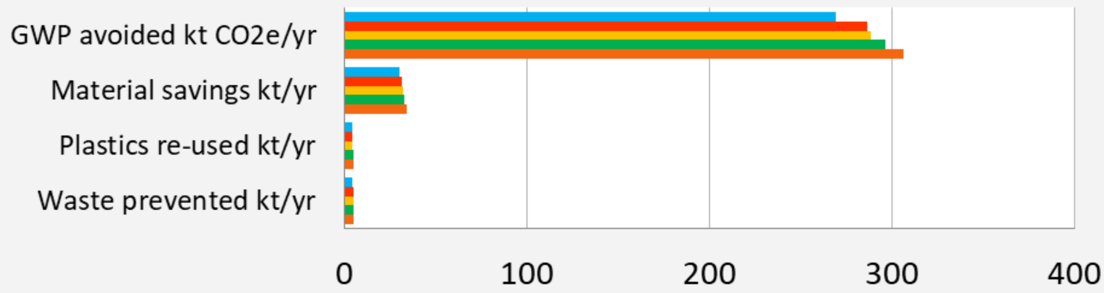


Note: Totals may not add due to rounding.

5.3.2 *Estimate of potential environmental impacts*

The potential environmental impacts of the four VRP scenarios described are summarized in Figure 16 below. The impacts have been calculated assuming that they scale with projected VRP sector outputs described above.

Figure 16: Environmental Impact projections for automotive to 2030



	Waste prevented kt/yr	Plastics re-used kt/yr	Material savings kt/yr	GWP avoided kt CO2e/yr
Current 2019	4.5	4.4	30	269
As-Is	4.8	4.7	32	286
Natural	4.9	4.7	32	289
Moderate	5.0	4.8	33	296
Strong	5.2	5.0	34	306

Notes: These figures exclude tire retreading benefits.

The separate benefits of tire retreading have not been calculated in detail.

Section 5.2 provided commentary on the current level of impacts, which provide the basis of the scenario analyses.

To place the GWP savings in context, this is equivalent to taking 60,000 cars off the road at current levels and by about 67,000 cars following the Strong Action scenario.

To place the materials savings in context (including tires), it is equivalent to all the recycling from waste achieved by about 120,000 people at current levels and by about 135,000 people following the Strong Action scenario. Waste prevented can be judged similarly.

To place the plastics re-use in context (including tires), it is equivalent to all the plastics recycling achieved by about 740,000 people at current levels and by about 840,000 people following the Strong Action scenario. Including tire retreading, this figure rises to around 1 million people.

A fuller assessment of the significance of the aggregated results is provided in Section 10.2.

6 Heavy-duty/off-road equipment

6.1 Industry insight

Respondents indicated that there are fewer than 15 medium to large sized companies focusing on HDOR remanufacturing in Canada, with a concentrated presence in Alberta, followed by Ontario and British Columbia, and up to 5,000 small operators, focused mainly on HDOR repair, located across Canada.

Approximately 400 end-of-life vehicle dismantlers exist in Canada (Automotive Recyclers of Canada, n.d.) with fewer than 5 large dismantlers in Canada.

There is a broad coverage of VRP activity in this sector except for refurbishment, which is displaced by managed maintenance under comprehensive refurbishment (see Table 15).

Table 15: A map of VRP practice in HDOR

Remanufacturing	Comprehensive Refurbishment	Refurbishment	Direct Re-use	Repair	Cascading (C2C)
Targets in-warranty/service contract	Targets in-warranty/service contract	Quality not high enough for this sector	Targets aftermarket	Targets aftermarket	Insignificant

Note: a. Pink = Not present or insignificant.

A majority of the VRP sales market is in Canada with only one respondent indicating that they export to the US. Their main competition is imports from independent VRP agents, primarily from the US, but more frequently from China and India. However, it was reported that these imports were generally of a lower quality than the Canadian products.

As with the automotive sector, Canadian vehicle dismantlers have indicated that most of the HDOR cores sold in Canada are for direct re-use only, with the cores set for remanufacturing being exported primarily to OEMs and aftermarket remanufacturers in the US for remanufacturing in Mexico, but also South America. Their main competition are core suppliers from countries such as China that can substantially undercut them on price.

6.1.1 *Motives to undertake VRP activities and barriers to growth*

Motives for undertaking VRP activities varied but all respondents cited business benefits as an important motive, with reported average gross profits of between 2.5% to over 50%. In addition, most respondents cited environmental benefits as an important motive.

Nearly all respondents indicated a lack of available skilled labour as a barrier to growth. Lack of competency in additive manufacturing, lack of adequate product knowledge (for independent VRP agents), high labour costs, lack of access to feedstock and variable quality of feedstock were also cited as barriers.

The main barrier to product export is the cost and level of effort required to export. In addition, some Central/South American countries such as Argentina, Brazil, Chile and Columbia ban the import of cores into their country, which is a barrier for vehicle dismantlers/core suppliers, however they permit refurbished and remanufactured parts, with the exception of Brazil which considers remanufactured products to be used parts.

6.1.2 *Predictions for future growth*

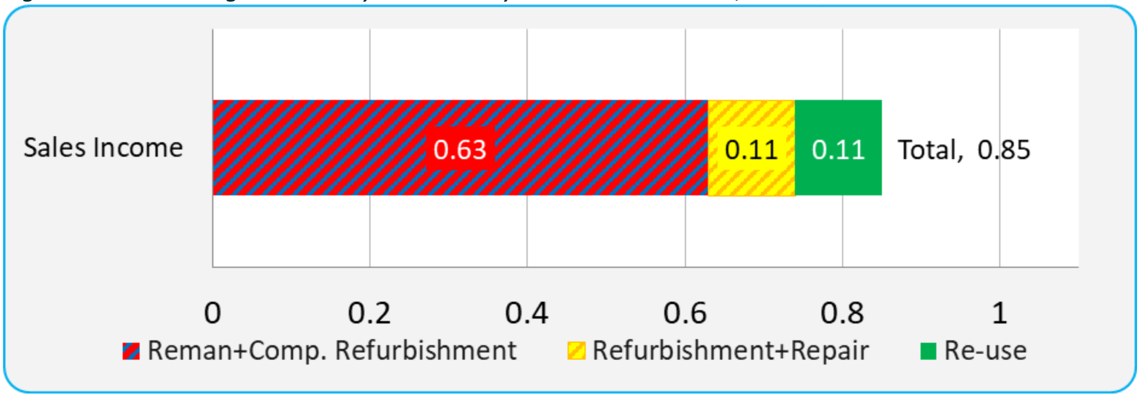
Nearly all respondents indicated that they expect moderate to strong annual growth of VRP activities, but this does reflect pre-COVID-19 conditions.

6.2 Impact analysis

6.2.1 *Estimate of socio-economic impacts*

We used primary data to estimate the contributions of the HDOR VRP industry to Canada's economy. Combined, their VRP activities generate an estimated $CAD 850 million dollars in direct revenue and 2,800 full-time equivalent employees (FTEs) (see Figure 17 and Figure 18). (N.B. Only half of the revenue and employment impacts dismantlers were attributed to HDOR – the remainder was attributed to the automotive sector). Respondents indicated that a majority of their VRP activity occurs in Alberta, accounting for over $CAD 600 million of the revenue and nearly 3,000 FTEs.

Figure 17: Revenue generated by VRP activity in the HDOR sector, 2020 $CAD bn



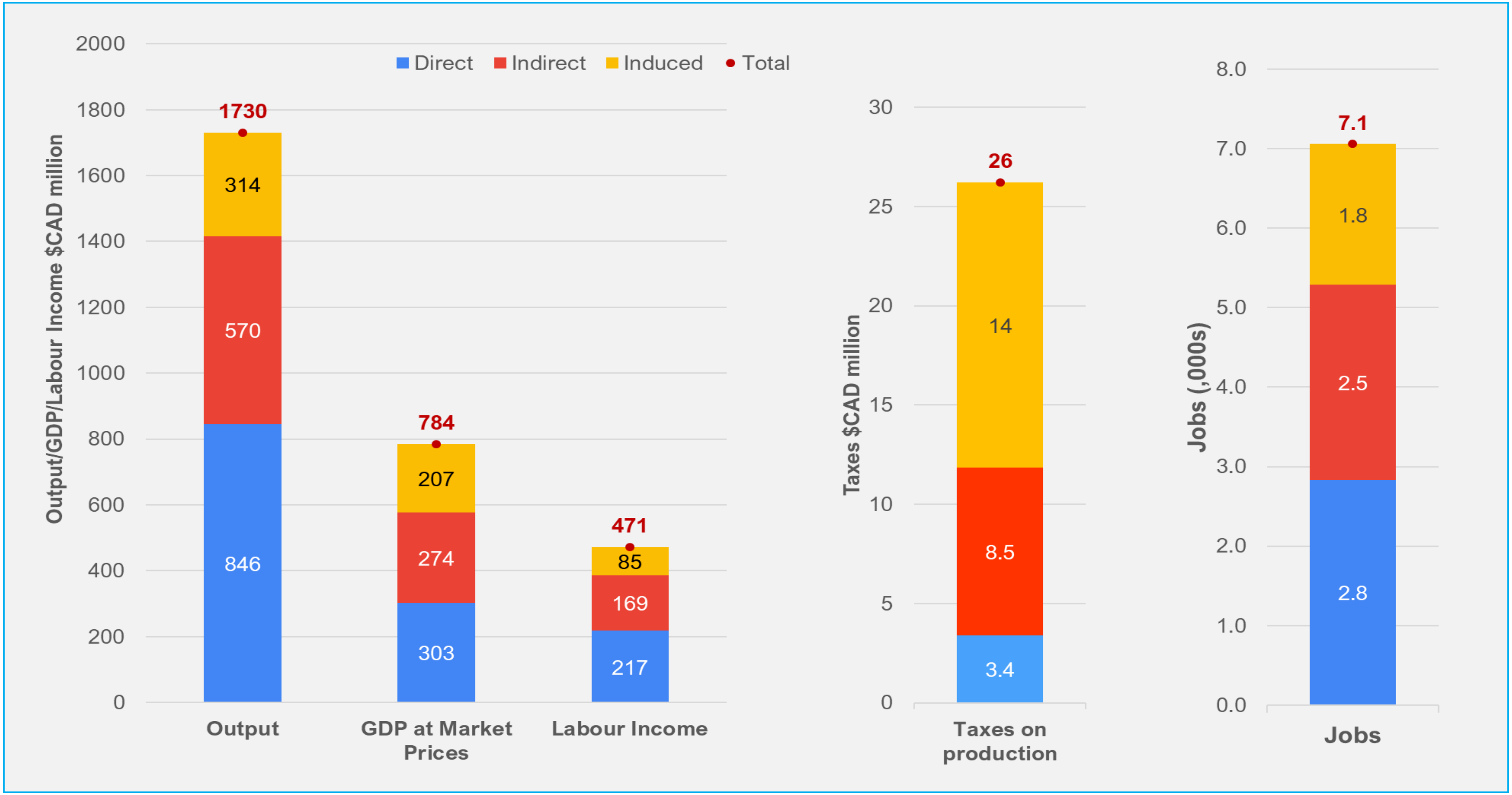
Note: Totals may not add due to rounding
Remanufacturing estimate from primary sources. Repair and re-use estimated by scaling to EU activity.

As shown in Figure 18, direct labour income from these activities were estimated to be $CAD 217 million. Production is expected to result in $CAD 3.4 million of direct tax revenues. These firms generate an estimated $CAD 846 million in direct revenue.

In addition to the direct economic benefits of remanufacturing in the HDOR sector, there are also indirect and induced economic benefits. Multipliers from Statistics Canada can provide an estimate of the total economic benefit of these remanufacturing activities. A summary of multipliers for the agriculture, construction and mining machinery manufacturing sector are included in Annex F. This sector was used as a proxy for HDOR VRP activities.

Based on the primary data collected, we estimated the indirect and induced benefits for HDOR. As noted above, total direct revenues earned by firms providing primary data were $CAD 846 million. It is likely this represents only a small portion of HDOR VRP activity. These firms generate $CAD 1,730 million dollars total economic output and $CAD 784 million in GDP contributions. Labour income is expected to be approximately $CAD 471 million, including $CAD 169 million of indirect labour earnings. These firms are likely to contribute 2,460 indirect jobs and induce 1,770 jobs due to their VRP economic activity.

Figure 18: Economic and employment impacts of HDOR VRP activity, 2019



Note: Totals may not add due to rounding

6.2.2 *Estimate of environmental impacts*

The IRP report used HDOR as a case study and undertook life cycle benefit analysis for multiple VRPs for three HDOR components: an engine (standard and lightweight), alternator and starter motor. The projected impacts were detailed and remarkable, as shown in Figure 19.

Figure 19: Results of life cycle analysis on a vehicle alternator

Vehicle alternator					Represented product weight (kg):		4.9 kg
	New material inputs by process and material (kg/unit)					Embodied material energy (MJ/kg)	Embodied material emissions (kgCO$_2$-eq./unit)
	Steel	Cast iron	Copper	Aluminum	TOTAL	TOTAL	TOTAL
OEM New	1.8	1.2	1.3	1.1	5.4	286.1	18.4
Reman	0.3	0.2	0.3	0.2	1.0	12.7	3.6
Refurb	-	-	-	-	-	-	-
Repair	0.0	0.0	0.1	0.0	0.1	4.8	0.3
Arranging direct reuse	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: (Nasr, et al., 2018), *Table 8*

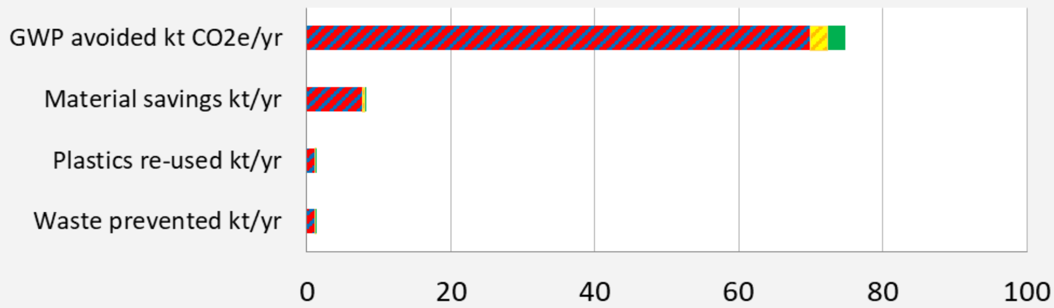
For remanufacturing an alternator, material and emissions reductions exceeded 80% and sometimes more than this for other products.

The revelation here is the potential avoidance of emissions from repair, particularly if this can be translated into consumer goods. In general, consumer goods failures prompt new purchases rather than repair. This indicates the disparity between the residual perception of value by the owner (once repair costs are factored in) and the value in potential avoidance of new product environmental burdens.

The differential is an action area which could be attacked by better consumer information and possibly tax reliefs related to carbon avoidance. This requires further research.

Respondents to this study indicated that approximately 65% of a remanufactured core's metal components and up to 10% of its plastics are recovered. The remaining plastics and metals are recycled. Statistical data is unavailable for much HDOR activity, including the much-publicized activity of tire retreading (which is typically cast as remanufacturing because of its high-quality control). Accordingly, we have made estimates of the activity using analogy with similar jurisdictions. These figures are presented in Figure 20.

Figure 20: Breakdown of estimated environmental impacts for HDOR by VRP, 2019

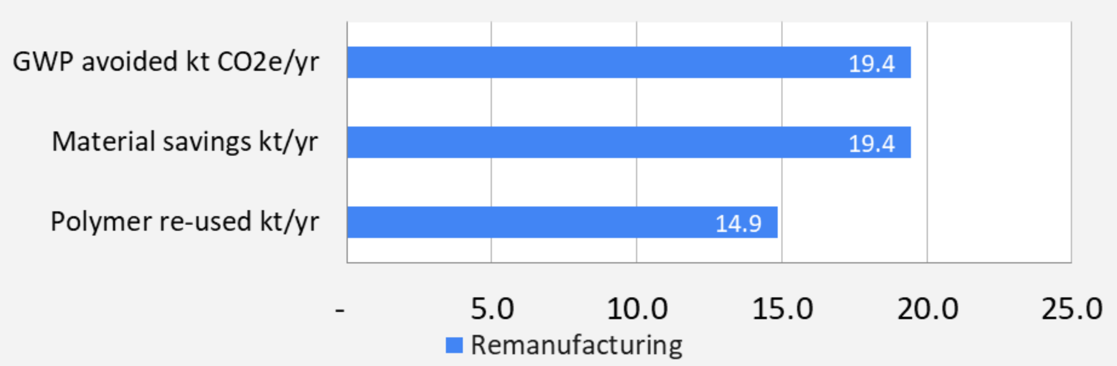


	Waste prevented kt/yr	Plastics re-used kt/yr	Material savings kt/yr	GWP avoided kt CO2e/yr
Reman+Comp. Refurbishment	1.2	1.1	7.8	70
Refurbishment+Repair	0.04	0.04	0.3	2.4
Re-use	0.04	0.04	0.3	2.4
Total	1.3	1.2	8	75

Notes: Totals may not add due to rounding.
Total sector activity level from survey data. Repair/Re-use assumed 50:50 split. Low re-use residual life factor reflects the fact that equipment is largely fleet managed and hence single owned, only passed on towards end of life. Low repair residual life factor reflects the fact that most repairs are not life-critical in this high-value sector. GWP impact ratios taken as per automotive, which may understate their value. Excludes benefits of tire retreading and materials (see below).

As reported in the Automotive section, the impacts of tire retreading are not included within Figure 20 but have been displayed separately in the Figure 21. They have been estimated by pro-rating the number of HDOR vehicles in Canada to other jurisdictions.

Figure 21: Breakdown of estimated environmental impacts for HDOR tires by VRP, 2019



Notes: This is a minimum estimate; the true numbers could be double these depending on the interpretation of information in a Bandag report (Daystar et al., 2018).

6.3 VRP expansion scenarios

Medium-term scenario

We couldn't find any relevant references to the expected impact of COVID-19 on the HDOR sector. Sectoral heatmaps by Deloitte (Deloitte, 2020) give an assessment for HDOR-related activities in Canada as shown in Table 16.

Table 16: Deloitte assessment of HDOR-related activities and COVID-19 outlook

Sector	Response Level (1 to 4)	Details
Engineering & Construction	2 - Significant disruption, likely financial impact loss	• Firms with lower fixed costs will be more resilient • Government spending on infrastructure projects to stimulate the economy should help firm's recovery • Construction projects in the oil and gas sector are unlikely to see much rebound
Mining & Metals	2 - Significant disruption, likely financial impact loss	• Commodity demand is currently low, and prices are expected to remain low, driven by Chinese activity • Mining companies with cash may be able to pursue mergers & acquisitions (M&A) opportunities • Energy prices are low driven by low oil prices
Construction & Base Metals	1 - High impact on businesses trading & cash flows	• Same as for Mining & Metals

Using the responses from our industry engagement conducted prior to the outbreak of the pandemic, we can define a pre-COVID-19 baseline scenario of 2% CAGR for HDOR. Since we do not have an external basis for the likely post-COVID-19 scenario, we have defined three scenarios to explore different trajectories. Features of these scenarios are summarized in Table 17.

Table 17: HDOR scenario definitions

Scenario	Year returned to 2019 levels	CAGR (%)
Scenario 1 – Natural Growth **In this scenario, COVID-19 impacts cause a slow recovery and low subsequent growth.**	2023	1
Scenario 2 – Moderate Growth **In this scenario, the return to pre-COVID-19 levels is delayed, but once returned, growth is strong.**	2022	3
Scenario 3 – Strong Action **In this scenario, government investment in infrastructure projects leads to fast and strong growth in the sector.**	2021	5

For each of these scenarios, we explore the impact of substituting revenue on new goods with revenue on remanufactured goods. The increase in remanufacturing revenue by 2030 explored in the scenarios are 1%, 5% and 10%.

Long-term outlook

In general, the HDOR sector has a well-established VRP industry driven by the high capital cost of equipment and vehicles (there is a high value that can potentially be retained) as well as the importance of availability in some applications (where unexpected downtime can be extremely costly). There is likely some scope for greater VRP uptake, particularly where pursued by OEMs. Potential challenges to greater VRP uptake include increasingly stringent emissions regulations necessitating replacement, and the uptake of alternative powertrains, but to a lower degree than in the automotive sector.

Barriers to VRP activities cited during industry engagement and initial options for addressing these are shown in the table below.

Table 18: Barriers to greater uptake of VRP activities and suggested mitigation actions

Barrier	Possible actions
Core access and quality	Component exchange programs including core deposits, and in the longer-term, transition towards service-based business models could help secure access to core. Greater use of sensors and real time monitoring of usage and performance could help implement more sophisticated preventative maintenance strategies. Components reaching their end of life could be extracted before suffering irreparable damage and could feed a supply of core for remanufacturing and refurbishment.
Product knowledge	Independent VRP operators may struggle to access the original technical information for components, necessitating reverse engineering of parts. Reinforcement and extension of design for maintenance and repair principles could help VRP operators, but the challenge lies in motivating these principles if they incur additional costs.
Skilled personnel availability	This cross-sectoral issue could be mitigated through targeted education program development and promotion. Outreach between industry, academia and apprenticeship schemes could help increase awareness and appetite for jobs in the HDOR VRP industry.
Labour costs	This cross-sectoral issue would likely require policy intervention related to taxation on labour to fully mitigate. Technical options may include the development and implementation of automation in VRP processes; however, these may not be practical in all processes and would be costly to design and implement.
Insufficient additive manufacturing competency	Additive manufacturing capabilities may be valuable to VRP actors through reducing the costs of the reverse engineering process, overcoming barriers of economies of scale when ordering replacement parts (e.g. minimum order quantities) and replacement of legacy parts no longer in production. Strategic investment in developing this capability, both in skills and capital equipment is necessary to build this competency. Support for businesses targeting the deployment of advanced manufacturing technologies, like additive manufacturing, could assist, for example through low interest rate loans or grants. Businesses could also look to collaborate with academic researchers to develop their additive manufacturing knowledge.

6.3.1 *Estimate of potential socio-economic impacts*

Socio-economic estimates for the HDOR sector considered a delayed rebound curve. A delayed rebound assumes contraction in 2020 followed by a return to 2019 levels by 2022, similar to the delayed rebound scenario considered for aerospace. Overall, we assume the average annual growth rate is 2.17% between 2019 and 2030. Key metrics for HDOR VRP revenue in each scenario are summarized in Table 19. Revenue estimates for HDOR are based on primary data as Statistics Canada data disaggregation results in overlaps between industrial equipment and HDOR. Therefore, we assume these projections understate the expected economic impacts.

Table 19: HDOR VRP Activity Revenue Scenarios

Scenario	2019 Output (VRPs) $CAD	2030 Output (VRPs) $CAD	Average Annual Growth Rate	Substitution Rate	New Revenue Attributed to Substitution
As-Is	846 million	1,071 million	2.17%	0%	0%
Natural Growth		1,082 million	2.17%	1%	5%
Moderate Action		1,124 million	2.17%	5%	19%
Strong Action		1,178 million	2.17%	10%	32%

All 2019 economic and employment data was retrieved from (Statistics Canada, 2020c). For the expansion of HDOR VRP activities, multipliers for Repair and Maintenance (except Automotive) were used. These multipliers are detailed in Annex G. For lost manufacturing revenues due to substitution, the multipliers for Agriculture, Construction and Mining Machinery Manufacturing were used.

As no market forecasts were available for Canada, we assumed the post-rebound growth rate was 3%, as pre-COVID 19 industry engagement had previously indicated moderate (1-3%) to strong (>3%) prospects for the industry. This growth was then applied to define an intermediate 2030 projection with no substitution effects.

Similar to the automotive VRP sector, HDOR VRP activity is not necessarily a saturated market. Influences such as new technology, changing consumer preferences and policy action may result in the substitution of new manufactured goods by VRP products. Therefore, in addition to growth effects, substitution effects can also be expected. To judge these effects, we applied a substitution rate of 0.7 (typical of other sectors) to the intermediate 2030 projection defined above.

Further, only 42% of HDOR manufacturing occurs in Canada[3]. Accordingly, only 42% of the manufacturing output reduction is expected to be borne by Canada.

Annual gains can be expected to vary year to year. Within the first year (2020), we expect a decline due to COVID-19 with output returning to 2019 levels in 2022 and growth annually in subsequent years. This will result in economic losses in this sector in 2020, but sectoral growth in subsequent years could include potentially increased rates during the rebound in 2021 and 2022.

'As-Is' scenario

- In the 'As-Is' scenario, there is a 2.17% average annual growth between 2019 and 2030 resulting in an additional $CAD 225 million in direct revenues and $CAD 449 million in total output in 2030 relative to 2019.
- Contributions to GDP increase by $CAD 272 million including $CAD 137 million due to direct activity.
- Production taxes increase by $CAD 9.9 million relative to 2019, driven largely by induced economic activity.
- The additional direct output results in an additional 2 thousand jobs generating additional total labour income of $CAD 104 million.
- In total, the additional output results in 3,200 additional jobs and $CAD 168 million in additional labour income.

Natural Growth scenario

- Under the Natural Growth scenario, direct output increases for HDOR due to sectoral growth and increased substitution of new manufactured products for VRP produced products at a rate of 1%.
- Direct output increases by $CAD 228 million while total output increases by $CAD 455 million relative to 2019.
- Direct output and total output are $CAD 3 million and $CAD 6 million higher than the 'As-Is' scenario, respectively.
- Total contributions to GDP increase by $CAD 276 million, including $CAD 140 million attributed to direct activities relative to 2019 numbers.
- There is a $CAD 10.1 million increase in production taxes driven largely by induced economic activity.
- Increased VRP activity results in 2,000 additional direct jobs with a labour income of $CAD 107 million.
- In total, an additional 3,300 jobs are created with a labour income of $CAD 171 million over 2019 numbers.

[3] This was calculated using the Supply and Use Tables from Statistics Canada for 2016. Products considered were those under MPG333102 (Logging, mining and construction machinery and equipment).

The trade-offs are related to output losses on a per good basis relative to the assumed increase in domestic production associated with VRP activities. In this case, we estimate the substitution effects result in an increased total output of $CAD 6 million over the 'As-Is' scenario. Additionally, all economic indicators are positive suggesting there are socio-economic benefits for expanding VRP activities. These benefits include **116 additional jobs** and **$CAD 3.1 million** in labour income over the 'As-Is' scenario.

Moderate Action scenario

- Under the Moderate Action scenario output increases for HDOR due to sectoral growth and increased substitution of new manufactured products for VRP produced products at a rate of 5%.
- Relative to 2019, direct output increases by $CAD 240 million while total output increases by $CAD 478 million.
- Contributions to GDP increase by $CAD 296 million, including $CAD 152 million attributed to direct activities.
- An increase of $CAD 10.9 million in production taxes is driven largely by induced economic activity.
- Increased VRP activity results in 2,300 additional direct jobs generating an additional labour income of $CAD 116 million relative to 2019.
- In total, this scenario generates an additional 3,600 jobs leading to an additional labour income of $CAD 184 million above 2019 levels.

The trade-offs are related to output losses on a per good basis relative to increased re-shoring of production associated with VRP activities. Under the Moderate Action scenario, the substitution effects result in increased total output of $CAD 29 million relative to the 'As-Is' scenario. Additionally, all economic indicators are positive suggesting there are socio-economic benefits for expanding VRP activities. These benefits include **348 additional jobs** and **$CAD 15 million** in additional labour income relative to the 'As-Is' scenario.

Strong Action scenario

- Under the Strong Action scenario for HDOR, direct output increases by $CAD 255 million, relative to 2019 while total output increases by $CAD 506 million relative to 2019 levels.
- Total contributions to GDP increase by $CAD 320 million, including $CAD 166 million attributed to direct activities.
- There is a $CAD 11.8 million increase in production taxes driven largely by induced economic activity.
- Increased VRP activity results in 2,500 additional direct jobs with a labour income of $CAD 127 million relative to 2019.
- In total, an additional 3,900 jobs are created generating an additional labour income of $CAD 199 million.

The trade-offs are related to output losses on a per good basis relative to increased re-shoring of production associated with VRP activities. In this case, the substitution effects result in increased total output of $CAD 57 million over the 'As-Is' scenario. Additionally, all economic indicators are positive suggesting there are socio-economic benefits for expanding VRP activities. These benefits include **698 additional jobs** generating **$CAD 31 million** in additional labour income relative to the 'As-Is' scenario.

Summary

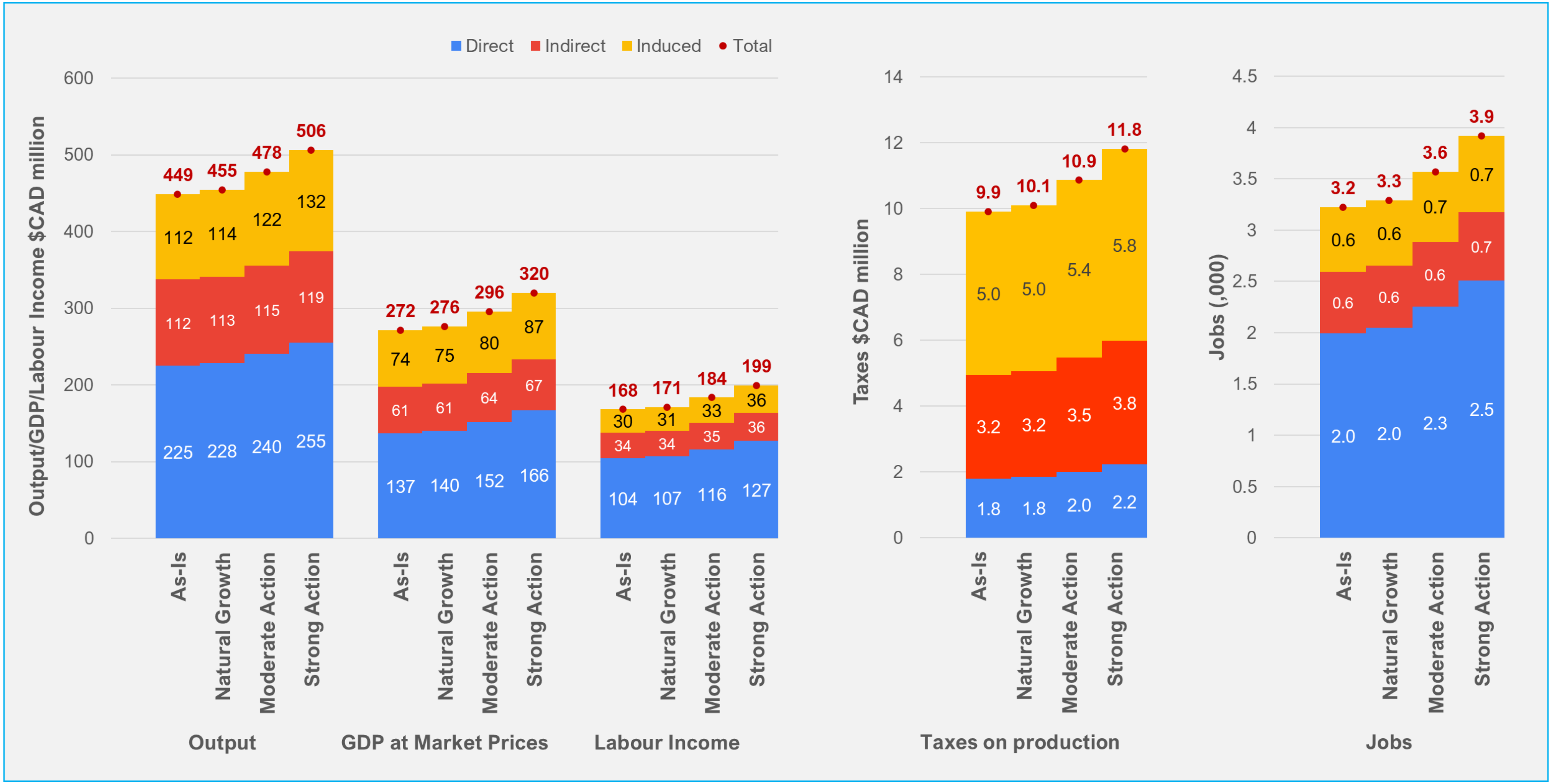
The gross levels, financial and employment, of the scenarios, relative to 2019, are shown in Figure 22. Note that these do not include any substitution effects, but the overall net effect of these compared to the 'As-Is' scenario is shown in the subsequent graphic, Figure 23.

For the HDOR sector, we expect economic benefits across all multiplier types and all key metrics for all scenarios modelled. Unlike the automotive sector, this also includes gains across indirect economic activities. The estimated gains due to increased VRP activity can be attributed to a net benefit when considering a multitude of factors including:

- Gains expected due to increased production of VRP produced goods.
- Losses to new goods manufacturers in Canada.
- Output losses driven by reduced output on a per good basis relative to the substitution ratio (0.7 for HDOR).
- Gains due to increased re-shoring of production as 58% of new manufacturing losses are borne by international manufacturers (consistent with the current import rate for HDOR).

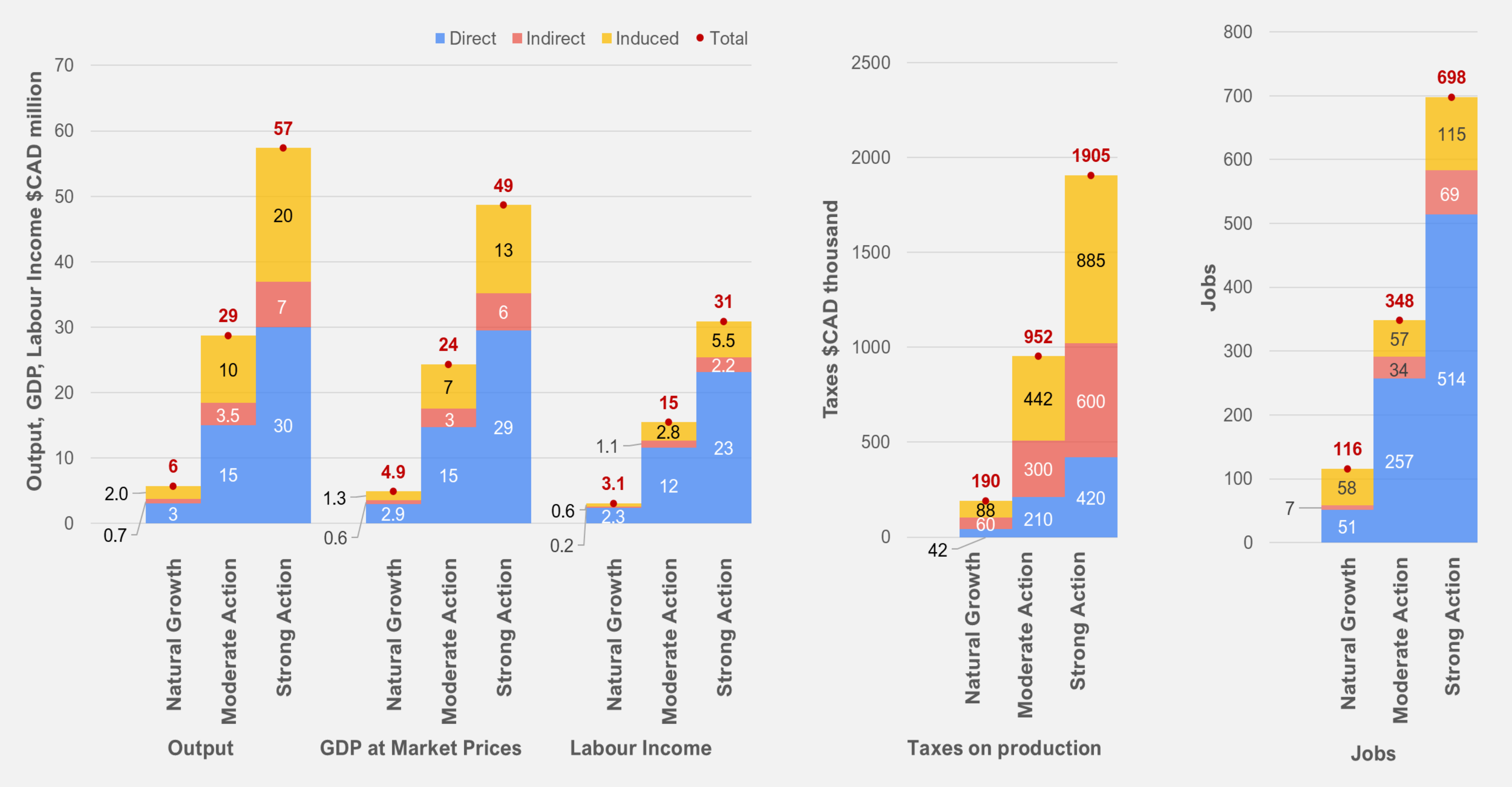
Overall, this means that actions to spur VRP activities should be expected to increase national production in Canada of HDOR (which, is assumed to include new manufactured goods and VRP produced goods). These gains in production exceed losses to Canadian manufacturing and the reduced output on a per good basis. Therefore, it can be reasonably expected that socio-economic gains would result from expanding VRP activities in the HDOR sector.

Figure 22: Economic impacts in the HDOR sector, 2030 – forecasts for the change in the VRP industry relative to 2019, gross levels, not accounting for substitution effects



Note: Totals may not add due to rounding.

Figure 23: Economic impacts in the HDOR sector, 2030 – net impact of VRPs on Canadian economy over 'As-Is' scenario

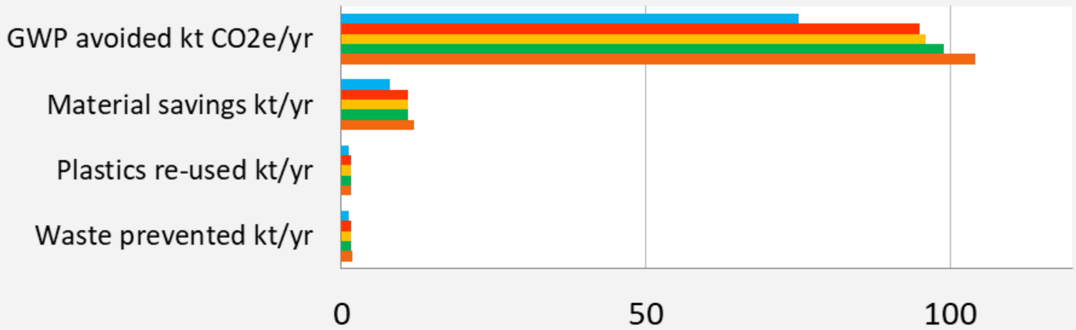


Note: Totals may not add due to rounding.

6.3.2 *Estimate of potential environmental impacts*

The potential environmental impacts of the four VRP scenarios described are summarized in Figure 24 below. The impacts have been calculated assuming that they scale with VRP sector revenue.

Figure 24: Environmental Impact projections for HDOR to 2030



	Waste prevented kt/yr	Plastics re-used kt/yr	Material savings kt/yr	GWP avoided kt CO2e/yr
Current 2019	1.3	1.2	8	75
As-Is	1.6	1.5	11	95
Natural	1.6	1.6	11	96
Moderate	1.7	1.6	11	99
Strong	1.8	1.7	12	104

Estimates for tire retreading in 2030 have not been calculated and are not included in the figure above.

To place the GWP savings in context, this is equivalent to taking 16,000 cars off the road at current levels and about 23,000 cars following the Strong Action scenario.

To place the materials savings in context, it is equivalent to all the recycling from waste achieved by about 30,000 people at current levels and by about 45,000 people following the Strong Action scenario. Waste prevented can be judged similarly.

To place the plastics re-use in context, it is equivalent to all the plastics recycling achieved by about 170,000 people at current levels and by about 230,000 people following the Strong Action scenario. This excludes tires. If these are included, this figure rises to something over 2 million people.

A fuller assessment of the significance of the aggregated results is provided in Section 10.2.

7 Consumer, industrial and other electronics

7.1 Industry insight

Primary data suggests that the Canadian electronics VRP sector consists of approximately 5 large refurbishers ($10–50 million per annum in VRP revenue) and approximately a thousand small and medium enterprises (SME) (<$CAD 1 million to 10 million per annum in VRP revenue). The bulk of the VRP activity reported is conducted in Ontario with the remainder in Quebec, Alberta and British Columbia.

Table 20: A map of VRP practice in electronics

Remanufacturing	Comprehensive Refurbishment	Refurbishment	Repair	Direct Re-use	Cascading (C2C)
Not applicable	Minor activity				Not quantified

Note: *a. Boxes with no comment indicate activity is generally applicable across all markets or requires no caveat.*
b. Cascading between consumers – the handing on of goods to users of similar or lower expectations of performance – is not overtly described in the IRP report. However, it is included here as it represents an important option for some products, especially given the geographical challenges identified previously, and one within the bounds of influence of ECCC.
c. Pink = not present or insignificant.

The federal government, through the Computers for Schools Plus (CFS+) program, is one of the largest refurbishers of digital equipment in Canada. The CFS+ is a federal government funded initiative that collects, refurbishes or repairs surplus digital devices and equipment from government and the private sector for redistribution to not for profit and public organizations, including schools, public libraries and Indigenous communities, as well as newcomers and low-income families and individuals, throughout Canada. The program distributes approximately 60,000 units per annum, and they indicate that the current level of equipment donations cannot meet the demand for refurbished, low-cost digital devices in Canada.

Respondents indicated that the sales markets for their VRP products include Canada, US, Mexico, Central and South America, Asia, the EU and the rest of Europe, Africa and the Middle East. Sales channels include storefront sales as well as on-line resale through OEM outlets, Alibaba, Kijiji, Craigslist, eBay and the like. Most micro businesses and not for profit VRP agents reported only selling or donating their products domestically

Competition for sales is global with refurbished electronics available on-line through OEMs, electronics retailers, Alibaba, eBay, Amazon etc. In addition, they are competing with new, cheap electronics that are entering the market from countries such as China.

7.1.1 *Motives for undertaking VRP activities and barriers to growth*

Business and economic motives, such as increasing profitability, were cited by most respondents with gross profits reported by the for-profit organizations on their VRP products ranged from 10 to greater than 50%. Customer demand, increasing market share, gaining strategic advantage, securing spare parts, legislation and environmental benefits were also listed as very important. Refurbishers in Ontario identified that obtaining subsidies (such as the Re-use Incentive provided under the previous Ontario Electronic Stewardship organization) was also of high importance.

Product design, construction and product knowledge were cited as big issues in this product class. For example, non-reversible joints are often made by gluing the exterior of products reducing accessibility. Coupled with this, inadequate product knowledge and proprietary, non-standard replacement parts were identified as barriers to VRP activities by independent and not for profit

VRP agents. This is exacerbated by the rapid turnover of technologies which limit the availability of replacement parts as well as the demand for perceived out-dated goods.

The short product cycle is likely to make it challenging to acquire sufficient core volumes, remain current with product knowledge and generate sufficient demand for refurbished products. Additionally, as producers know the average lifespan of their goods are short, the quality of these products may not lend themselves to VRP activities and may be designed to be disposed of.

Features of the mobile phone market – such as bundled phone and service on monthly payment schemes - mask the cost of new devices, making one-off purchases of refurbished devices appear expensive even when this may not be the case.

In certain areas of electronics, particularly in consumables such as toner cartridges, design elements have been included by OEMs which detect end-of-use and third-party maintenance, rendering them inactive when replaced into a host machine. For example, so-called 'killer chips' have been the subject of court cases in the US and EU, with the general outcome that their practice is disallowed. The area remains a battleground, however, with software upgrades and similar tactics deployed to render parts incompatible.

A feature of this sector is the propensity of equipment owners to hold on to equipment or to return the equipment without the hard drive, both of which erode the (eventual) value. This is due to data concerns, a problem which might be addressed by accreditation. However, many viable electronics finds itself as waste, motivated perversely by extended producer responsibility (EPR) schemes which reward collection and destruction rather than higher environmentally beneficial options, another clear policy target.

Foreign import restrictions weigh heavy, unsurprising given the high-profile cases of e-waste dumping. Lack of clarity over what is and is not e-waste, and the validity of processes which can genuinely prepare it for re-use should be targets of accreditation and international efforts to lay down actionable criteria.

7.1.2 *Predictions for future growth*

A majority of respondents indicated that they expect moderate (1–3%) to strong (>3%) annual growth of VRP activities in Canada and that demand for their VRP products has increased due to the need to learn/work from home as a result of the COVID-19 pandemic.

Additional potential enablers of future growth cited by respondents in this sector include:

- Educating consumers on the value of professionally refurbished equipment.
- Enacting legislation that mandates EPR programs to consider refurbishment/re-use over recycling.
- Continuing/expanding subsidies for refurbishers (such as those provided in Ontario).
- A recent CRTC ruling requiring telecom providers in Canada to separate the costs of new cell phones on customer bills, may provide enough sticker shock to encourage consumers to look for lower cost alternatives.
- The increased demand for electronics and IT equipment as a result of work and learn from home orders as a result of COVID-19 (at the time of writing this report, an increase in demand has already been experienced by for- and not-for-profit respondents).

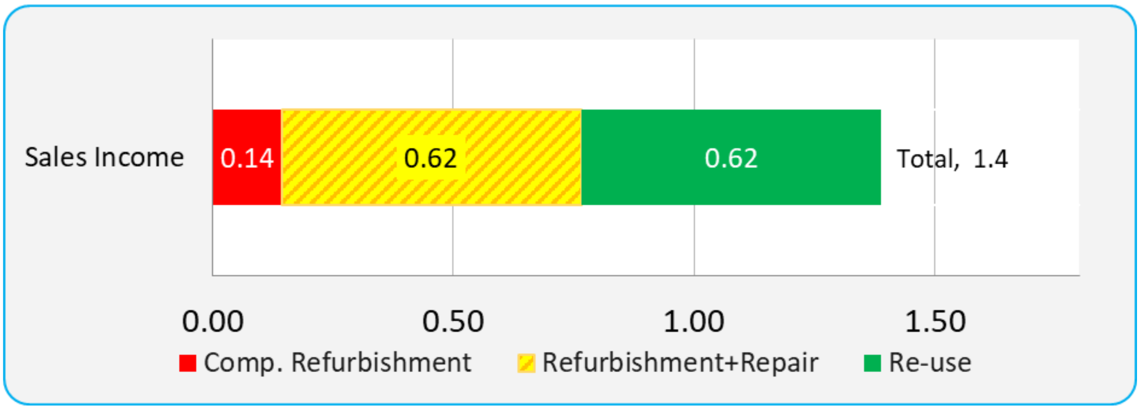
7.2 Impact analysis

7.2.1 *Estimate of socio-economic impacts*

Based on the disaggregation of data by Statistics Canada, we grouped electronics together covering both industrial and consumer electronic products, using electronic and precision equipment repair and maintenance as a proxy. According to Statistics Canada, this classification includes both consumer and industrial electronics repair and maintenance activities, including medical devices (Statistics Canada, 2018). No further disaggregation of data is available. Within the electronic and precision equipment repair and maintenance industry, there are 4,661 businesses. Of which, 99.3% have fewer than 99 employees and 68% have fewer than five employees (Statistics Canada, 2018).

Based on the 4,661 firms and an average revenue of $CAD 298,600, total annual revenues are estimated to be $CAD 1.39 billion (Statistics Canada, 2018) (see Figure 25).

Figure 25: Revenue generated by VRP activity in the electronics sector, 2019 $CAD bn



Notes: *Totals may not add due to rounding*
Estimate of comprehensive refurbishment (validated by sector feedback) by scaling to EU estimates of remanufacturing activity, but at 50% intensity i.e. the ratio of remanufacturing to manufacturing. Re-use estimated as a fraction of reported Refurbishment+repair+re-use figure.

Based on the total revenue, we estimated other direct economic impacts using a range of multipliers as Statistics Canada does not consolidate detailed multipliers into one applicable category. The range of multipliers for electronics is included in Annex F, including the industry for which multipliers were used. Within the range, minimum multipliers are between 40% and 87% (excluding direct output) of maximum multipliers. Relative to other sectors where impacts were estimated using ranges, the variance in electronics is highest. This is likely due to the number of activities considered and the differing nature of these activities. For example, production of consumer goods is likely to vary drastically from the production of industrial goods for both VRP activities and traditional manufacturing activities. This variance is particularly large for job estimates where on average the minimum value in the range is 59% of the maximum value.

The key takeaways from this analysis are:

Key direct impacts (see Figure 26):

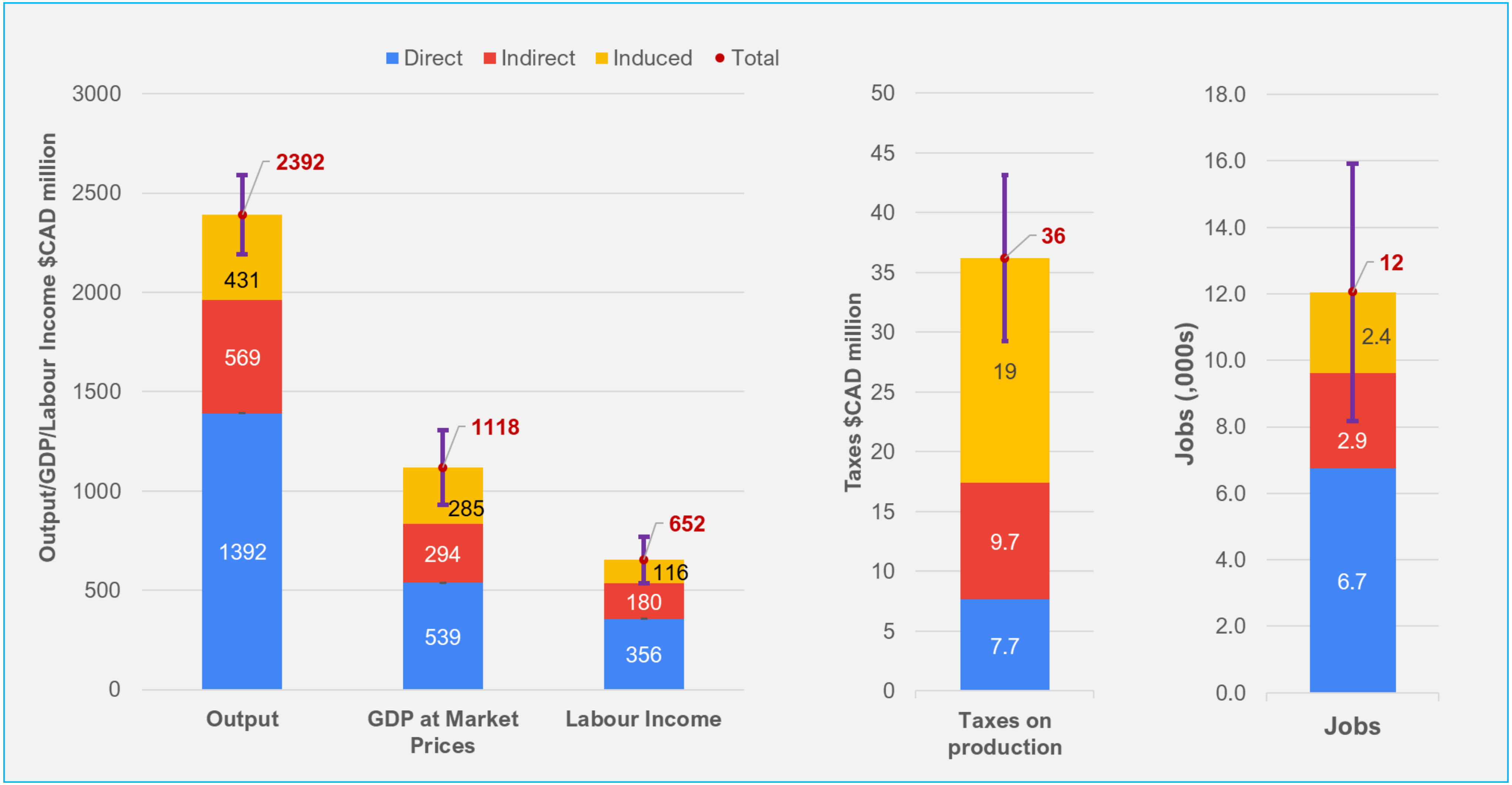
- We estimate direct GDP contributions due to electronics VRP activities to be between $CAD 0.45 billion and $CAD 0.63 billion.
- These activities generate $CAD 0.29 billion to $CAD 0.42 billion in direct labour income across 3,800 to 9,600 direct jobs.
- Direct taxes attributed to this production are approximately $CAD 7.7 million.

In addition to the direct economic benefits of VRP activities in the consumer electronics sector, there are also indirect and induced economic benefits. Multipliers from Statistics Canada can provide an estimate of the total economic benefit of these remanufacturing activities. A summary of multipliers for the consumer electronics manufacturing sector is included in Annex F.

- Key indirect and induced impacts are:
    - Indirect labour income is between $CAD 0.14 billion and $CAD 0.22 billion across 2,200 to 3,600 jobs.
    - Induced jobs are between 2,100 and 2,700 generating between $CAD 0.10 billion and $CAD 0.13 billion in labour income.
    - Total taxes on this production range from $CAD 0.03 billion to $CAD 0.04 billion.
    - Typically, most production taxes are generated through induced economic activity.

These effects probably overestimate the net impacts of VRP activities within the sector. Net impacts will be reduced if goods produced through VRP activities substitute for new products. This is likely, implying that changes to VRP activities will have corresponding consequences in the new product industry. However, we assume labour will benefit due to increased VRP activity as these activities are more skilled and labour-intensive.

Figure 26: Economic and employment impacts of electronics VRP activity, 2019



Note: Totals may not add due to rounding

7.2.2 *Estimate of environmental impacts*

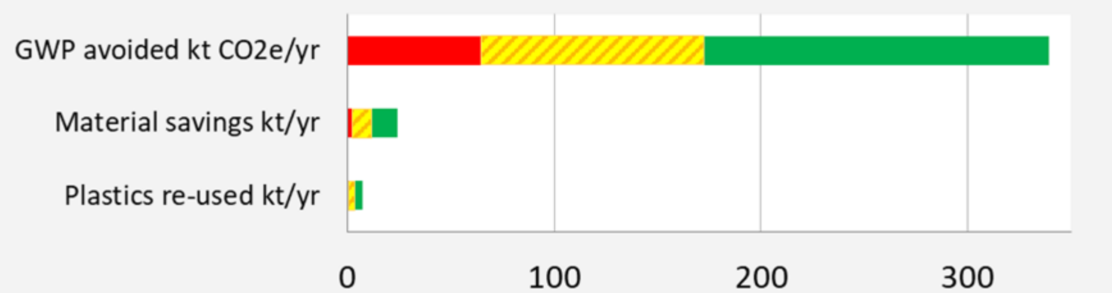
Research on closed-loop supply chains for information technology network equipment has shown that remanufacturing reduces CO_2 emissions by 50–70% over the entire life cycle of the product, depending on the type of energy used (Gutowski, Boustani, & Graves, 2011).

Remanufactured products can lower the barrier to entry for technology that may lead to an expansion of markets in developing countries. This may create an increase in overall energy use due to an expansion in electronics use as well as end of life disposal issues if appropriate legislation and disposal/handling facilities are not in place.

The environmental impacts of electronics VRP activities have been estimated using life cycle data from Fairphone (Proske, Clemm, & Richter, 2016), which compare the impacts of a new, refurbished and repaired mobile phone. Our analysis has focused on the production impacts, with use phase, end-of-life and transport impacts omitted. Although the Fairphone analysis does not include direct re-use, we scaled impacts in proportion to those observed for home appliances, in section 8.2.2. As mobile phones have a high environmental impact per mass, we do not consider the Fairphone analysis to be representative of the electronics sector as a whole. We have instead used this analysis to establish the relative impacts of VRP activities against new and scaled these to the impacts of a laptop computer (Hoang, Tseng, Viswanathan, & Evans, 2009) which we consider to be a more representative proxy device for the sector.

As we do not know the fraction of devices treated by different VRP scenarios, the environmental impacts are estimated assuming an equal split (by mass) across refurbishment, repair and re-use.

Figure 27: Breakdown of estimated environmental impacts for Electronics by VRP, 2019



	Plastics re-used kt/yr	Material savings kt/yr	GWP avoided kt CO2e/yr
Comp. Refurbishment	0.6	2	65
Refurbishment+Repair	2.9	10	108
Re-use	3.7	12	167
Total	7.2	24	339

Note: Totals may not add due to rounding

As mentioned elsewhere, we do not consider that VRP activities associated with electronics sit comfortably with the definition of remanufacturing emanating from the 'hard' engineering sectors. There is, however, a fair spread of activity across other VRPs with which the citizens of Canada are likely familiar. In our analysis, because they cannot be differentiated statistically, we have arbitrarily split them equally across categories, simply to obtain a moderated view of impacts.

Further commentary on the significance of these numbers appears at the end of this sector section.

7.3 VRP expansion scenarios

Medium-term scenario

No literature specifically on the expected impact of COVID-19 on the electronics sector has been found to date. A recent news report (Rematec News, 2020) suggests that the pandemic has led to an uptake of demand for electronics having undergone VRPs, however, anticipated post-pandemic impacts have yet to be analyzed. For our analysis, we used changes in real per capita disposable income to act as a proxy for changes in VRP expenditure. A projection of real per capita disposable income in Canada has been compiled by Moody's Analytics (Moody's Analytics, 2020), as shown in Table 21 below. While this data is for consumer spending, without additional data on business expenditure, we consider consumer spending to be a suitable proxy.

Table 21: Change in real per capita disposable income from Moody's Analytics

	2019	2020	2021	2022	2023	2024	2025	CAGR (2019 to 2025)
Real per capita disposable income % change	2.65	0.48	0.89	2.59	2.54	1.97	1.83	**1.71**

While a reduction in per capita disposable income may lead to a decrease in expenditure on non-essential items, including electronics, there may be an uptake in demand due to increased demand for equipment to facilitate tele-working. Lower disposable income may also lead to an uptake of VRP activities, where the prices of electronics are lower than new. We explore three scenarios of displaced expenditure on new goods to remanufactured goods. The increase in remanufacturing revenue by 2030 explored in the scenarios are 1%, 5% and 10%.

Long-term outlook

The long-term uptake of VRP activity in the electronics sector is challenging to define. Drivers for greater uptake include increasing resistance to existing waste electrical and electronic equipment (WEEE) disposal strategies that are environmentally damaging and do not retain or recover significant value. Issues of material security and scarcity may become increasingly important, sharpening the focus on the technical and/or critical materials embodied in devices. In contrast, fast rates of technological evolution may make many VRP approaches difficult, as products become obsolete.

Barriers to VRP activities cited during industry engagement and initial options for addressing these are shown in the table below.

Table 22: Barriers to greater uptake of VRP activities and suggested mitigation actions

Barrier	Possible actions
Product knowledge	Independent VRP operators may struggle to access the original technical information for components, necessitating reverse engineering of parts. Reinforcement and extension of design for maintenance and repair principles could help VRP operators, for example through Right to Repair regulations, but the challenge lies in motivating these principles if they incur additional costs.
Skilled personnel availability	This cross-sectoral issue could be mitigated through targeted education program development and promotion. Outreach between industry, academia and apprenticeship schemes could help increase awareness and appetite for jobs in the electronics VRP industry.
Labour costs	This cross-sectoral issue would likely require policy intervention related to taxation on labour to fully mitigate. Technical options may include the development and implementation of automation in VRP processes. Automation is perhaps most pertinent to the electronics sector due to the large volumes, relatively low unit value and highly automated manufacturing processes.
Feedstock quality and volumes	A combination of factors can limit feedstock quality and volume, including short product cycles, consumer hoarding and high dispersion of devices. Options to promote the return of EoL devices could include financial incentives and harmonized EPR schemes. Right to Repair regulations could also support the long-term supply of spare parts, which would increase the proportion of cores suitable for VRPs.
Import restrictions	Most electronic devices are not allowed to be classified and imported/exported as remanufactured under Canada-US-Mexico Agreement (CUSMA) regulations (see section 12.3.1). Discussion around the treatment of electronics that are intended for VRP activity or have already undergone VRP activity could be included in future trade negotiations. Standards for and certification of VRP activity could support the argument for allowing trade of these products. Note that international agreements and local restrictions on the control of hazardous substances in products could form part of these barriers. While there is some scope for negotiation on, for example, WEEE 'dumping' on the basis of process accreditations for remanufacturing, substance-based bans may prove more intractable to avoid. Such bans generally aim to prevent personal exposure and – especially – landfill leaching. By definition, remanufacturing diverts from landfill and, with substances intimately embedded in products, there could be a strong case for exemption. However, various authorities appear to take the view that all substances (with a few performance-related exceptions) should be cleared from the product inventory at end of first life, which hampers some remanufacturing. In some cases, in line with the remanufacturing definition, certain hazardous substances might be designed out by component upgrade during remanufacturing, rendering them once again fit to place back on domestic and international markets with the right trade agreements in place.
Product design/construction	Software and hardware barriers to VRPs could be mitigated through regulations to either promote VRPs (e.g. Right to Repair) or to prohibit harmful design practices (e.g. irreversible joints). A potential challenge to the pursuit of electronic design aligned with VRPs is whether it is better to design in durability and upgradability (and extend the product's life) or design in repair/refurbishment/remanufacturing. Environmental analysis of these trade-offs may be needed to explore this question.

7.3.1 *Estimate of potential socio-economic impacts*

We modelled three demand shocks for electronics, summarized in Table 23.

Table 23: Electronics VRP Activity Revenue Scenarios

Scenario	2019 Output (VRPs) $CAD	2030 Output (VRPs) $CAD	Average Annual Growth Rate	Substitution Rate	New Revenue Attributed to Substitution
As-Is	1,392 million	1,677 million	1.71%	0%	0%
Natural Growth		1,694 million	1.71%	1%	6%
Moderate Action		1,761 million	1.71%	5%	23%
Strong Action		1,845 million	1.71%	10%	37%

All 2019 economic and employment data was retrieved from (Statistics Canada, 2020c). For the expansion of consumer electronics VRP activities, multipliers for Repair and Maintenance (except Automotive) were used. These multipliers are detailed in Annex E. For lost manufacturing revenues due to substitution, the highest multipliers for electronic manufacturing were used to be conservative in the estimates including computer and peripheral equipment manufacturing, communications equipment manufacturing, other electronic product manufacturing, semiconductor and other electronic component manufacturing, electric lighting equipment manufacturing, electrical equipment manufacturing and other electrical equipment and component manufacturing. As the highest manufacturing multipliers in a particular category were used to be conservative, summations for simple and total multipliers may not be applicable.

As no market forecasts were available for growth in this sector in Canada, we estimated growth effects based on the changing rates of disposable income in Canada as reported by Moody's (Singh, 2020). We assume that changes in household disposable income will correlate with spending on consumer electronics. This estimated growth in VRP activities was then annualized to define an intermediate 2030 projection with no substitution effects.

VRP-produced consumer electronics are not considered to be a mature market. Influences such as new technology, changing consumer preferences and policy action may result in the substitution of new manufactured goods by VRP products. Therefore, in addition to growth effects, substitution effects can also be expected. To judge these effects, we applied a substitution rate of 0.72 (an intermediate value between the average value of remanufactured and used electronics (Netto, Bloemhof, & Corbett, n.d.)) to the intermediate 2030 projection defined above.

Further, only 19% of electronics (by value) are produced in Canada. Accordingly, only 19% of the manufacturing output reduction is expected to be borne by Canada.[4]

Annual gains can be expected to vary from year to year, with economic losses in this sector expected in 2020 due to COVID-19. However, the sector is expected to grow in subsequent years. Annual growth rates were not calculated. Instead, an annual average growth rate was considered. Summaries of the scenarios follow with full results shown graphically in Figure 28 and Figure 29.

[4] This was estimated using the national Supply and Use Tables from Statistics Canada. The goods considered included MPG334100 (Computers, computer peripherals and parts), MPG334A01 (Audio and video equipment and unrecorded media), MPG334A02 (Navigational and guidance instruments), MPG334401 (Printed and integrated circuits, semiconductors and printed circuit assemblies), MPG334409 (Other electronic components), MPG335902 (Communication and electric wire and cable), MPG335903 (Wiring devices), MPG335909 (Other electrical equipment and components), and MPG334201 (Telephone apparatus).

'As-Is' scenario

- The 'As-Is' scenario considers the growth of the consumer electronics sector in the absence of substitution effects.
- Direct output increases by $CAD 285 million and the total output increases by $CAD 568 million relative to 2019.
- Contributions to GDP increase by $CAD 344 million relative to 2019, including additional direct GDP contributions of $CAD 174 million.
- Taxes on production increase by $CAD 12.6 million relative to 2019.
- Direct jobs increase by 2,500 generating additional labour income of $CAD 132 million.
- Total jobs, which includes direct, indirect and induced jobs, increase by 4,100 generating an estimated $CAD 213 million in additional labour income.

Natural Growth scenario

- Under the Natural Growth scenario, direct output increases by $CAD 294 million relative to 2019 and $CAD 9 million compared to the 'As-Is' scenario.
- Increased direct output results in an increased total output of $CAD 587 million relative to 2019.
- Contributions to total GDP increase by $CAD 355 million over 2019 levels, including a GDP increase of $CAD 179 million due to direct activities.
- Total production taxes increase by $CAD 13 million relative to 2019, largely due to the induced economic activity.
- Increased direct output results in 2,600 additional jobs with additional direct labour income of $CAD 137 million.
- In total, direct, indirect and induced economic activity result in 4,200 additional jobs with additional total labour income of $CAD 220 million.

Annual returns under the Natural Growth scenario exceed the 'As-Is' scenario as substitution effects increase the annual estimated growth rate for VRP activities. Total output increases by $CAD 18 million due to the net substitution effects with a supplemental **220 jobs** generating additional labour income of **$CAD 7.2 million** relative to the 'As-Is' scenario.

Moderate Action scenario

- Under this scenario, direct output increases by $CAD 330 million relative to 2019 and $CAD 44 million more than the 'As-Is' scenario.
- Total output increases by $CAD 659 million, relative to 2019.
- Contributions to total GDP increase by $CAD 402 million, including a GDP increase of $CAD 203 million due to direct activities.
- Production taxes increase by $CAD 14.7 million relative to 2019, largely due to the induced economic activity.
- Increased direct output results in almost 3,000 additional jobs with additional total labour income of $CAD 155 million.
- In total, increased VRP activity under the Moderate Action scenario results in nearly 4,800 additional jobs with a total additional labour income of $CAD 249 million, relative to 2019.

Annual average gains are expected because of the substitution of new manufactured goods for VRP produced goods. Here, total output increases by $CAD 91 million over the 'As-Is' scenario due to substitution effects with a supplemental **680 additional jobs** with **$CAD 36 million** in additional labour income relative to the 'As-Is' scenario.

Strong Action scenario

- Direct output increases by $CAD 374 million relative to 2019, exceeding all previous consumer electronics scenarios.
- Total output increased by $CAD 750 million relative to 2019 due to the increased VRP direct output.

- Contributions to GDP increase by $CAD 233 million due to direct activities and $CAD 460 million due to all economic activity from VRP expansion under this scenario relative to 2019.
- Total production taxes increase by $CAD 16.9 million relative to 2019, largely due to the induced economic activity.
- Increased VRP activity results in approximately 3,400 additional direct jobs with an additional direct labour income of $CAD 178 million.
- Direct, indirect and induced economic activity result in a total of 5,400 additional jobs with additional total labour income of $CAD 285 million.

Total output increases by $CAD 181 million due to substitution effects with a total of approximately **1,400 new jobs** with a labour income of **$CAD 72 million** due to substitution effects.

Summary

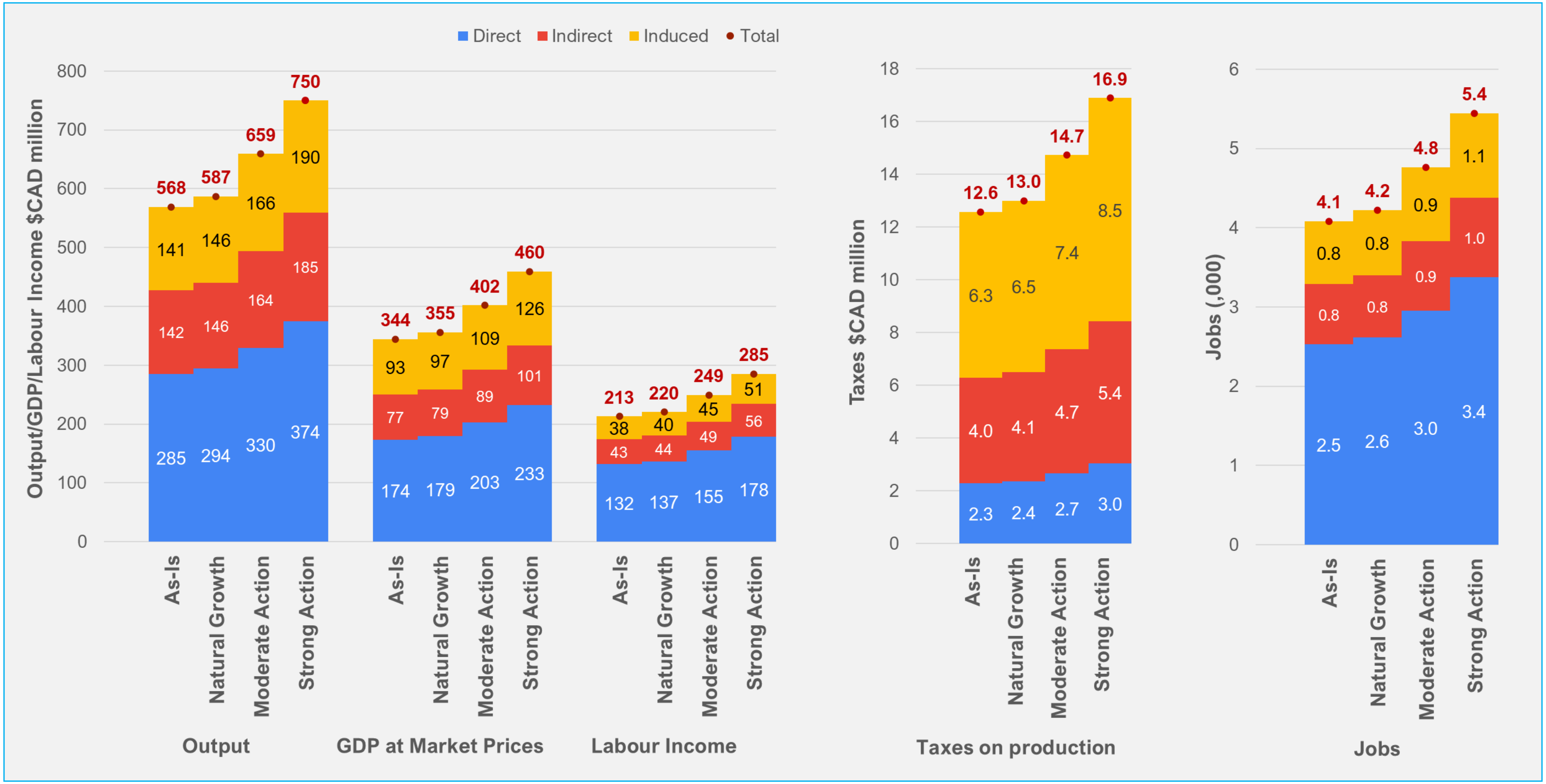
The gross levels (relative to 2019), financial and employment, of the scenarios are shown in Figure 28. Note that these do not include any substitution effects, but the overall net effect of these compared to the 'As-Is' scenario is shown in the subsequent graphic, Figure 29.

Within the consumer electronics sector under all scenarios, economic benefits are expected across all multiplier types and all key metrics. Unlike the automotive sector, this also includes gains across indirect economic activities. The estimated gains due to increase VRP activity can be attributed to a net benefit when considering a multitude of factors including:

- Gains expected due to increased production of VRP produced goods.
- Losses to new goods manufacturers in Canada.
- Output losses driven by reduced output on a per good basis relative to the substitution ratio (0.72 for consumer electronics).
- Gains due to increased reshoring of production as 81% of new manufacturing losses are borne by international manufacturers (consistent with the current import rate for consumer electronics).

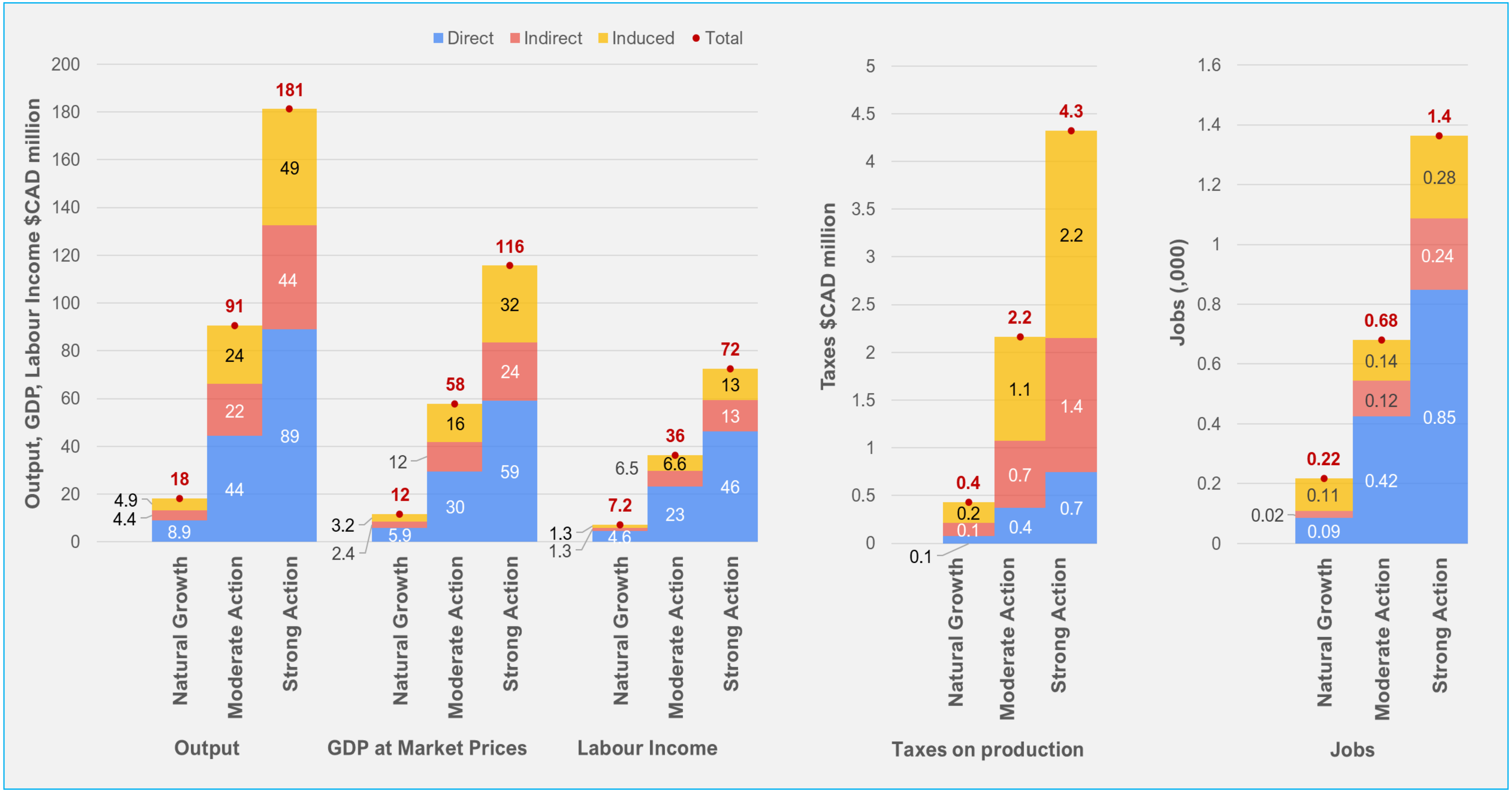
Overall, this means that actions to spur VRP activities should be expected to increase national production in Canada of consumer electronics. These gains in production exceed losses to Canadian manufacturing and the reduced output on a per good basis. Therefore, it can be reasonably expected that socio-economic gains would result from expanding VRP activities in the consumer electronics sector.

Figure 28: Economic impacts in the electronics sector, 2030 – forecasts for the change in the VRP industry relative to 2019, gross levels, not accounting for substitution effects



Note: Totals may not add due to rounding

Figure 29: Economic impacts in the electronics sector, 2030 – net impact of VRPs on Canadian economy over 'As-Is' scenario

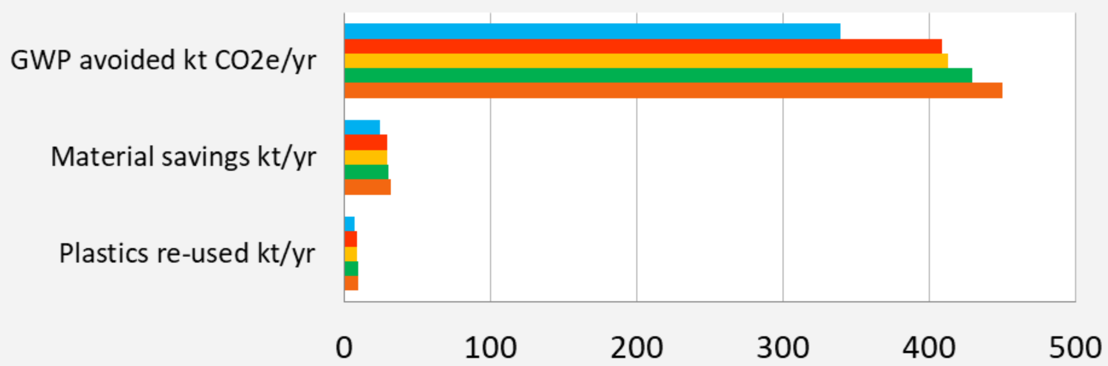


Note: Totals may not add due to rounding

7.3.2 *Estimate of potential environmental impacts*

The potential environmental impacts of the four VRP scenarios described are summarized in Figure 30 below. The impacts have been calculated assuming that they scale with VRP sector revenue.

Figure 30: Environmental impact projections for electronics VRPs to 2030



	Plastics re-used kt/yr	Material savings kt/yr	GWP avoided kt CO2e/yr
Current 2019	7.2	24	339
As Is	8.7	29	409
Natural Growth	8.8	29	413
Moderate Action	9.1	30	429
Strong Action	10	32	450

Notes: Maximum waste diversion does not include mass of components discarded during repair/refurbishment. Maximum plastic impact reduction as plastic components are more likely to be replaced as wear parts during repair/refurbishment. Assumes 30% plastic content as per (Deloitte, 2017).

To place the GWP savings in context, this is equivalent to taking 85,000 cars off the road at current levels and about 110,000 cars following the Strong Action scenario.

To place the materials savings in context, it is equivalent to all the recycling achieved by about 100,000 people at current levels and by about 135,000 people following the Strong Action scenario.

To place the plastics re-use in context, it is equivalent to all the plastics recycling from waste achieved by about 1 million people at current levels and by about 1.3 million people following the Strong Action scenario.

What is very striking about this sector is the high gearing of benefits per device (or unit weight) recovered. Starting from a relatively low level, this sector most likely offers the highest potential gains through transforming supply, use and re-use for life-extension of any. A factor increase of, say, 10, in VRPs might take the sector to around 20% re-use with a further GWP impact reduction of 5 Mt/yr, a serious dent in the required 2030 targets and beyond. Most of these gains could be inspired by purchasing demand pulls, EPR schemes and public, institutional and citizen engagement.

A fuller assessment of the significance of the aggregated results is provided in Section 10.2.

8 Home appliances

8.1 Industry insight

Data obtained through this study suggests that at least one OEM VRP agent (refurbishment/repair) operates in Canada. Additionally, twenty-six independent companies, predominantly in British Columbia, Ontario and Quebec, have been identified that undertake appliance refurbishment, one of which may also undertake remanufacturing activities. A majority of the VRP activity in this sector involves repairs undertaken by small independent companies distributed across Canada.

Table 24: A map of VRP practice in home appliances

Remanufacturing	Comprehensive Refurbishment	Refurbishment	Direct Re-use	Repair	Cascading (C2C)
Insignificant	Insignificant	Largely via charities	Largely via charities		Not quantified

Note: a. Boxes with no comment indicate activity is generally applicable across all markets or requires no caveat.
b. Cascading between consumers – the handing on of goods to users of similar or lower expectations of performance – is not overtly described in the IRP report. However, it is included here as it represents an important option for some products, especially given the geographical challenges identified previously, and one within the bounds of influence of ECCC.
c. Pink = not present or insignificant.

Sales channels for VRP products include appliance retailers, liquidation companies, outlet stores and direct sales via storefronts and on-line channels. There are few known direct competitors for remanufacturing, comprehensive refurbishment and refurbishment in Canada, other than from sales of new products. Given the nature of the work, competition for repair services is likely to be local. However, there is anecdotal evidence that, due to the cost of spare parts and repair services compared to purchasing a new unit, repair services may compete directly with new appliance sales (Pehlken, Kalverkamp, & Wittstock, 2018).

8.1.1 *Motives for undertaking VRP activities and barriers to growth*

Motives cited by respondents as being most important for their VRP activities are securing spare parts, fulfilling warranties, asset and brand protection, increasing profitability and federal legislation. How this last point is driving the sector remains unclear.

Barriers to VRP growth cited by respondents included lack of customer recognition and high labour costs. Respondents also indicated that differences in some energy requirements for certification between the US Department of Environment and the Department of Natural Resources Canada is one barrier to selling their refurbished products within the US.

The literature suggests that there are market and environmental barriers to VRPs in the appliance sector. Previous studies have indicated that, in Canada, appliance recycling is viewed as being more economical than remanufacturing due to the labour intense nature of product disassembly (Deloitte and Cheminfo, 2019). In addition, given that the greenhouse gas (GHG) life cycle impacts of appliances are dominated by their in-service energy use rather than the manufacturing stage (Boustani, Sahni, Graves, & Gutowski, 2010; Gutowski, Boustani, & Graves, 2011), if new technology emerges that is much more energy efficient, remanufacturing older technology may not be environmentally beneficial.

8.1.2 *Predictions for future growth*

Respondents indicated (pre-COVID-19) that they expect moderate annual growth (1–3%) of VRP activities in this sector. Respondents indicated that an alignment of certification standards between countries would increase the export markets to which they could sell. They also suggested that provincial or federal subsidies would incentivize uptake of VRPs in this sector.

8.2 Impact analysis

8.2.1 *Estimate of socio-economic impacts*

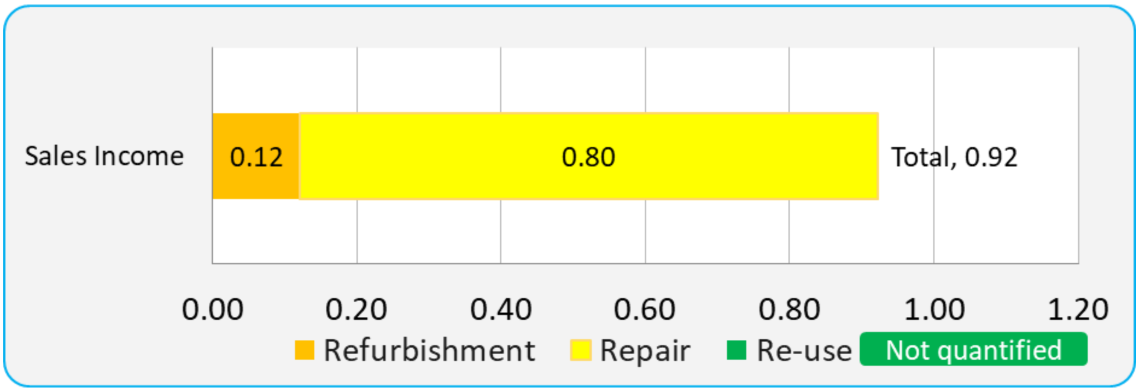
Due to the lack of available data, we used home and garden equipment and appliance repair and maintenance as the best available proxy for home appliance VRP activities within Canada. This sector is defined as comprising establishments primarily engaged in repairing and maintaining home and garden equipment and household appliances. Establishments in this industry repair and maintain products such as lawnmowers, edgers, snow and leaf blowers, washing machines and clothes dryers and refrigerators (Statistics Canada, 2018).

Financial data was available for 4,174 of these firms (Statistics Canada, 2018). There are also 158 home appliance manufacturers, though over 92% have fewer than 100 employees (Statistics Canada, 2018). Some of these firms may undertake VRP activities and may provide insight into the size of the home appliance sector within Canada.

We estimated direct economic impacts using total revenue per firm and the number of firms reporting financial data within home and garden equipment and appliance repair and maintenance as a proxy. The average revenue per firm was $CAD 220,900 which suggests total revenues are $CAD 922 million (see Figure 31).

The data for the breakdown of VRPs in this sector is, though, problematic. The classification of businesses includes not only domestic goods but also those used in an industrial setting, such as printers and laundry equipment, which will go through a very different life cycle journey than domestic items. To illustrate this, we have analyzed available data regarding device disposals from Canadian waste statistics, trade bodies representing home appliances, the report by Deloitte and Cheminfo (Deloitte and Cheminfo, 2019) on plastics content and primary data from appliance refurbishers (as a subset of all devices). A fuller analysis is provided in Annex D, but yields the splits of Figure 31.

Figure 31: Revenue generated by VRP activity in the home appliance sector, 2019 $CAD bn



Notes: Home Appliances also include industrial print stations industrial equivalents of domestic appliances.

It should be noted that domestic refurbishment only accounts for an estimated $CAD24 million of the total refurbishment but dominates the repair estimate. Unusually, we have numbers for refurbished units (60,000 per annum) so we infer that there is thus substantial capacity to expand refurbishment operations above its current level, particularly if they can be embedded in servitized offerings to customers.

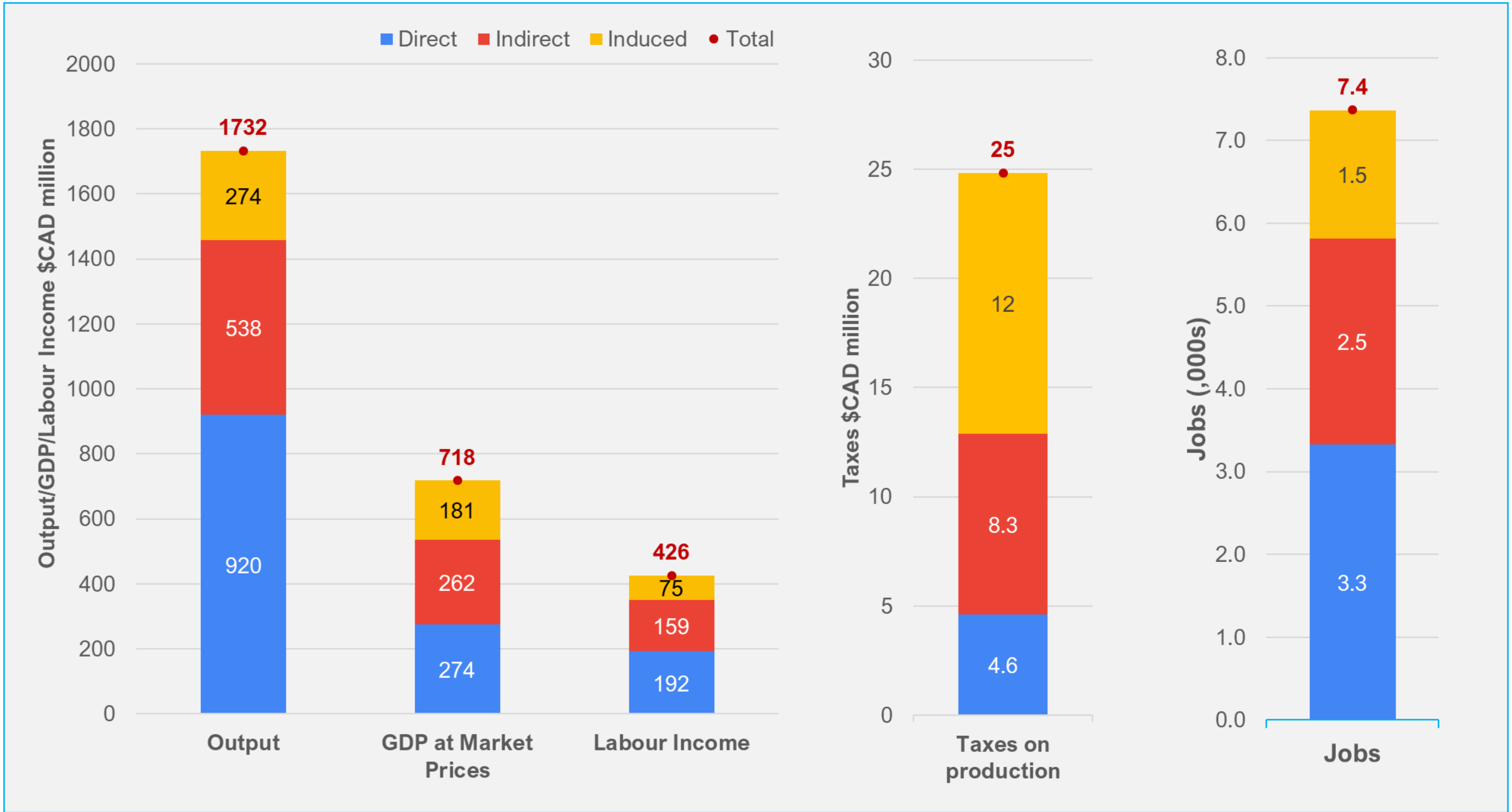
Based on Statistics Canada National Input-Output Multipliers (Statistics Canada., 2016b) for household appliance manufacturing included in Annex F, these activities would generate 3,330 direct jobs (7,400 total) with a direct labour income of approximately $CAD 192 million. Direct taxes on production are around $CAD 4.6 million (see Figure 32).

In addition to the direct economic benefits of remanufacturing in the home appliance sector, there are also indirect and induced economic benefits. Multipliers from Statistics Canada provides an estimate of the total economic benefit of these remanufacturing activities and they are shown in Annex F. We've taken these as a proxy for the economic impacts of VRP activities within the sector.

Indirect and induced economic impacts are based on the estimated total revenues for home and garden equipment and appliance repair and maintenance. The total output for home appliance VRP activities is around $CAD 1.7 billion dollars including $CAD 538 million of indirect output and $CAD 274 million of induced output. Overall, we estimate that home appliance VRP activities contribute $CAD 718 million to Canada's GDP including $CAD 262 million and $CAD 181 million due to indirect and induced economic activity, respectively. Indirect labour income due to VRP activities is estimated to be $CAD 159 million across nearly 2,500 jobs while induced labour income is expected to be $CAD 75 million across 1,500 jobs. VRP activities in the home appliance industry are expected to generate $CAD 8.3 million of indirect production taxes and $CAD 12 million of production taxes on induced activities.

As will be highlighted in Section 10.1, these effects are likely to overestimate the net impacts of VRP activities within the sector. Net impacts are probably low since goods produced through VRP activities may be substitutes for new products, which suggest economic impacts to VRP activities are likely to have corresponding consequences in the new product industry. However, we still believe labour will benefit due to increased VRP activity because these activities are more labour intensive and require more skilled labour.

Figure 32: Economic and employment impacts of home appliance VRP activity, 2019



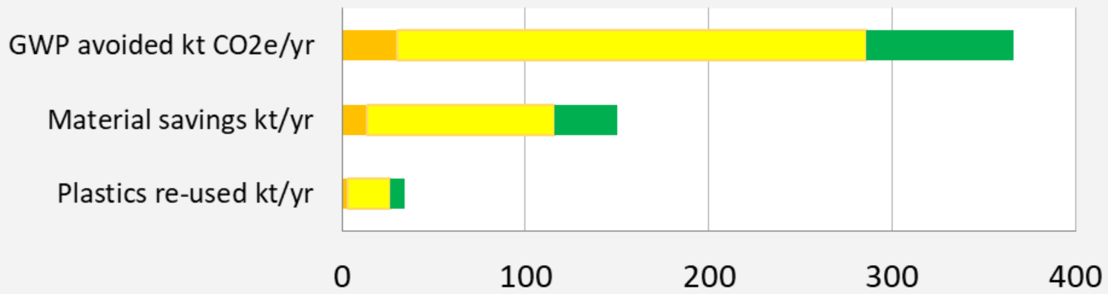
Note: Totals may not add due to rounding

8.2.2 *Estimate of environmental impacts*

Our estimates of the environmental impacts associated with VRPs on home appliances should be considered crude due to the poor discrimination in the actual fates of devices and is therefore presented as a range of values. Extrapolating EoL volume estimates from the Major Appliance Recycling Roundtable's (MARR) 2018 Annual Report to the Director (MARR, 2019) across Canada we estimated that around 970,000 units (51 kt) of appliances are recovered for refurbishment, repair or re-use per year, the split is unknown. The average appliance mass is 53 kg. We do not have a breakdown of product types, so we have assumed, for LCA purposes, that they are all washing machines, and even if they are not, similar benefits accrue on a per kg basis.

A source from Waste & Resources Action Programme (WRAP UK) (WRAP, 2010) disaggregates production effects from in-use energy for refurbishment of washing machines. With repair and re-use data not available, we have extrapolated the typical experience of automotive recorded by Nasr (Nasr, et al., 2018). Next, we have calculated residual life factors using the method of Annex A for each VRP. In addition, as noted above in reporting the socio-economic aspects, we have explored the complexity of this sector further in Annex D.

Figure 33: Breakdown of estimated environmental impacts for home appliances by VRP, 2019



	Plastics re-used kt/yr	Material savings kt/yr	GWP avoided kt CO2e/yr
Refurbishment	3	14	30
Repair	23	102	256
Re-use	8	34	80
Total	34	150	366

Notes: Home Appliances also include industrial print stations industrial equivalents of domestic appliances.

In line with the socio-economic report, domestic refurbishment accounts for a minority of total figure, but the majority of repair.

Further commentary on the significance of these numbers appears as the end of this sector section.

8.3 VRP expansion scenarios

Medium-term scenario

We have found no literature specifically on the expected impact of COVID-19 on the home appliances sector to date. For our analysis, we used changes in real per capita disposable income to act as a proxy for changes in VRP expenditure. We use the same projection of real per capita disposable income in Canada as compiled by Moody's Analytics (Singh, 2020), (and shown in Table 21) for our baseline scenario, equivalent to 1.7% CAGR. While this data is for consumer spending, we consider that business spending is less relevant in the home appliances sector, and as such, consumer spending is a suitable proxy.

Lower disposable income may lead to an uptake of VRP activities for home appliances, particularly repair, where the price of servicing an appliance may be lower than buying new. However, it may be that in the short term, retailers offer reduced prices on goods to stimulate spending. We explore three scenarios of displaced expenditure on new goods to remanufactured goods. The increase in remanufacturing revenue by 2030 explored in the scenarios are 1%, 5% and 10%. The social-economic and environmental impacts of these scenarios are explored in the next section.

Long-term outlook

In the long term, there are several key trends that could influence the uptake of VRP activities.

- **Circular economy business models, e.g. leasing and pay-per-use initiatives**

  Circular economy business models in the home appliances sector may become an important driver for VRP activity where appliances are no longer owned by the user and instead ownership is retained by either the OEM or an intermediary. In these models, the product life extension offered by VRP activities is in the interest of both the user and the appliance provider and may act as a driver towards appliance design for maintenance, repair and durability. A service-based model may be attractive for an OEM with the potential for longer term and higher margins, and to develop customer and brand loyalty. This contrasts with the "distressed purchase" situation most likely encountered today when a consumer is purchasing an appliance to replace a defective device.

  The perceived barrier of transitioning from a conventional transaction-based model to a contract and service-model is likely to be lower for future consumers. These consumers are growing up with service-based business models, such as contracts for electronic devices, pay-per-use offerings for transport and fashion items, along with the development of the sharing economy, underpinned by a narrative of social and environmental responsibility. This narrative is likely to be further reinforced as the urgency of climate change action increases in the future, with approaching legal commitments and increasing climate change effects.

  While examples of service-based business models in the home appliance space are currently limited to independent businesses and more so in Europe (e.g. Bundles, Homie), most of the major home appliance OEMs are engaged in pilot scale activities around circular economy business models. If OEMs decide to pursue these circular economy business models at scale, this could catalyze the large-scale uptake of VRP activity, such as remanufacturing and repair. Another VRP enabler from the servitization model is that the user will not be responsible for selecting replacement parts, and as such, the barrier around lack of customer knowledge of VRPs would be bypassed.

- **Internet of Things and appliance connectivity**

  Home appliance development has historically focused on improvements in energy efficiency in use. An area of future potential development is in connectivity and the Internet of Things, where home appliances may be routinely connected to the Internet, and perhaps other devices within the home. This could have two main impacts on the future uptake of VRP activities. Firstly, device connectivity could provide consumers and/or the appliance provider (if offered on a service-basis as above) with information about how to prolong the appliance life through correct use and anticipate and arrange scheduled maintenance and repair.

  Secondly, a device that has more sophisticated functionality, including connectivity is likely to be more expensive than a basic appliance. The fact that the value that could be retained through VRP activities is higher to start with, makes VRP activity more attractive. Additionally, for consumers to access higher value products, particularly if an OEM wishes to promote a connected system of home appliances (all their own brand), a service-based offering, as described above, would be more affordable.

8.3.1 *Estimate of potential socio-economic impacts*

We calculated three demand shocks for home appliances, summarized in Table 25.

Table 25: Home Appliance VRP Activity Revenue Scenarios

Scenario	2019 Output (VRPs) $CAD	2030 Output (VRPs) $CAD	Average Annual Growth Rate	Substitution Rate	New Revenue Attributed to Substitution
As-Is	920 million	1,109 million	1.71%	0%	0%
Natural Growth		1,120 million	1.71%	1%	6%
Moderate Action		1,164 million	1.71%	5%	23%
Strong Action		1,219 million	1.71%	10%	37%

As no market forecasts were available for growth in this sector in Canada, we estimated growth effects based on the changing rates of disposable income in Canada as reported by Moody's (Singh, 2020). We assumed that changes in household disposable income would correlate with spending on home appliances. This estimated growth in VRP activities was then annualized to define an intermediate 2030 projection with no substitution effects.

VRP-produced home appliances are not considered to be a mature market. Influences such as new technology, changing consumer preferences and policy action may result in the substitution of new manufactured goods for VRP products. Therefore, in addition to growth effects, substitution effects can also be expected. To judge these effects, we applied a substitution rate of 0.4 (as identified in the literature on household appliance refurbishment (Townsend, 2018)) to the intermediate 2030 projection defined above.

Further, only 10% of home appliances (by value) are produced in Canada. Accordingly, only 10% of the manufacturing output reduction is expected to be borne by Canada.[5]

Annual gains can be expected to vary year to year, with economic losses in this sector expected in 2020 due to COVID-19. However, the sector is expected to grow in subsequent years. Annual changes will be closely tied to the business cycle as projections are derived from disposable income forecasts

All 2019 economic and employment data was retrieved from (Statistics Canada, 2020c). Multipliers for Repair and Maintenance (except Automotive) were used. These multipliers are detailed in Annex F. For lost manufacturing revenues due to substitution, the multipliers for household appliance manufacturing were used

'As-Is' scenario

- The 'As-Is' scenario considers the growth of the household sector in the absence of substitution effects.
- Direct output increases by $CAD 189 million relative to 2019.
- The increase in spending on home appliances increases total output by $CAD 376 million.
- Total contributions to GDP increase by $CAD 227 million including an increase in direct GDP contributions of $CAD 115 million.
- Total taxes on production increase by $CAD 8.3 million relative to 2019.

[5] This was estimated using the national Supply and Use Tables from Statistics Canada. The goods considered included MPG335203 (Small electric appliances) and MPG335204 (Major appliances).

- Direct jobs increase by approximately 1,700 generating an additional labour income of $CAD 87 million.
- Total jobs increase by nearly 2,700 generating an estimated additional $CAD 141 million in labour income relative to 2019.

Natural Growth scenario

- Under the Natural Growth scenario, direct output increases by $CAD 192 million relative to 2019 and $CAD 3 million more than the 'As-Is' scenario.
- Increased direct output results in a total output increase of $CAD 383 million relative to 2019.
- Total GDP contributions increase by $CAD 232 million over 2019 levels, including additional GDP contributions of $CAD 117 million due to direct activities.
- Total production taxes increase by $CAD 8.5 million relative to 2019, largely due to induced economic activity.
- Increased direct output results in an additional 1,700 jobs generating additional labour income of $CAD 89 million.
- In total, direct, indirect and induced economic activity results in nearly 2,800 additional jobs generating an additional $CAD 144 million of total labour income relative to 2019.

Annual returns under the Natural Growth scenario exceed the 'As-Is' scenario as substitution effects increase the annual estimated growth rate for VRP activities. Total output due to substitution effects increases by $CAD 6.7 million relative to the 'As-Is' scenario. Further impacts include a total of **88 new jobs** generating **$CAD 2.8 million** of additional labour income relative to the 'As-Is' scenario.

Moderate Action scenario

- Direct output increases by $CAD 205 million and total output by $CAD 409 million relative to 2019.
- The increased output results in an increase of $CAD 250 million to GDP, including additional direct GDP contributions of $CAD 127 million.
- Production taxes increase by $CAD 9.1 million relative to 2019, largely due to increases in induced economic activity.
- Increased direct output results in an additional 1,800 direct jobs generating an additional total labour income of $CAD 96 million.
- In total, increased VRP activity under this scenario results in an additional 3,000 jobs with additional total labour income of $CAD 155 million relative to 2019.

Total output is estimated to increase by $CAD 34 million over the 'As-Is' scenario, due to substitution effects. Further impacts include a total of over **270 new jobs**, generating an additional labour income of **$CAD 14 million** due to substitution effects relative to the 'As-Is' scenario.

Strong Action scenario

- Direct output increases by $CAD 222 million and total output increases by $CAD 443 million over 2019 numbers, a total exceeding all previous household appliance scenarios.
- These increases are $CAD 33 million and $CAD 67 million more than the 'As-Is' scenario for direct and total output, respectively.
- Contributions to GDP increase by $CAD 138 million due to direct activities and by $CAD 272 million due to all economic activity from VRP expansion relative to 2019 under this scenario.
- Total production taxes increase by $CAD 10 million, largely due to the induced economic activity.
- Increased VRP activity results in an additional 2,000 direct jobs generating $CAD 106 million of additional labour income.
- In total, direct, indirect and induced economic activity is estimated to result in over 3,200 additional jobs generating $CAD 169 million of additional total labour income.

Annual returns under the Strong Action scenario exceed the 'As-Is' scenario as substitution effects increase the annual estimated growth rate for VRP activities. We estimate total output to increase by $CAD 67 million relative to the 'As-Is' scenario. This includes a total of nearly **550 new jobs** generating additional labour income of **$CAD 28 million** relative to the 'As-Is' scenario.

Summary

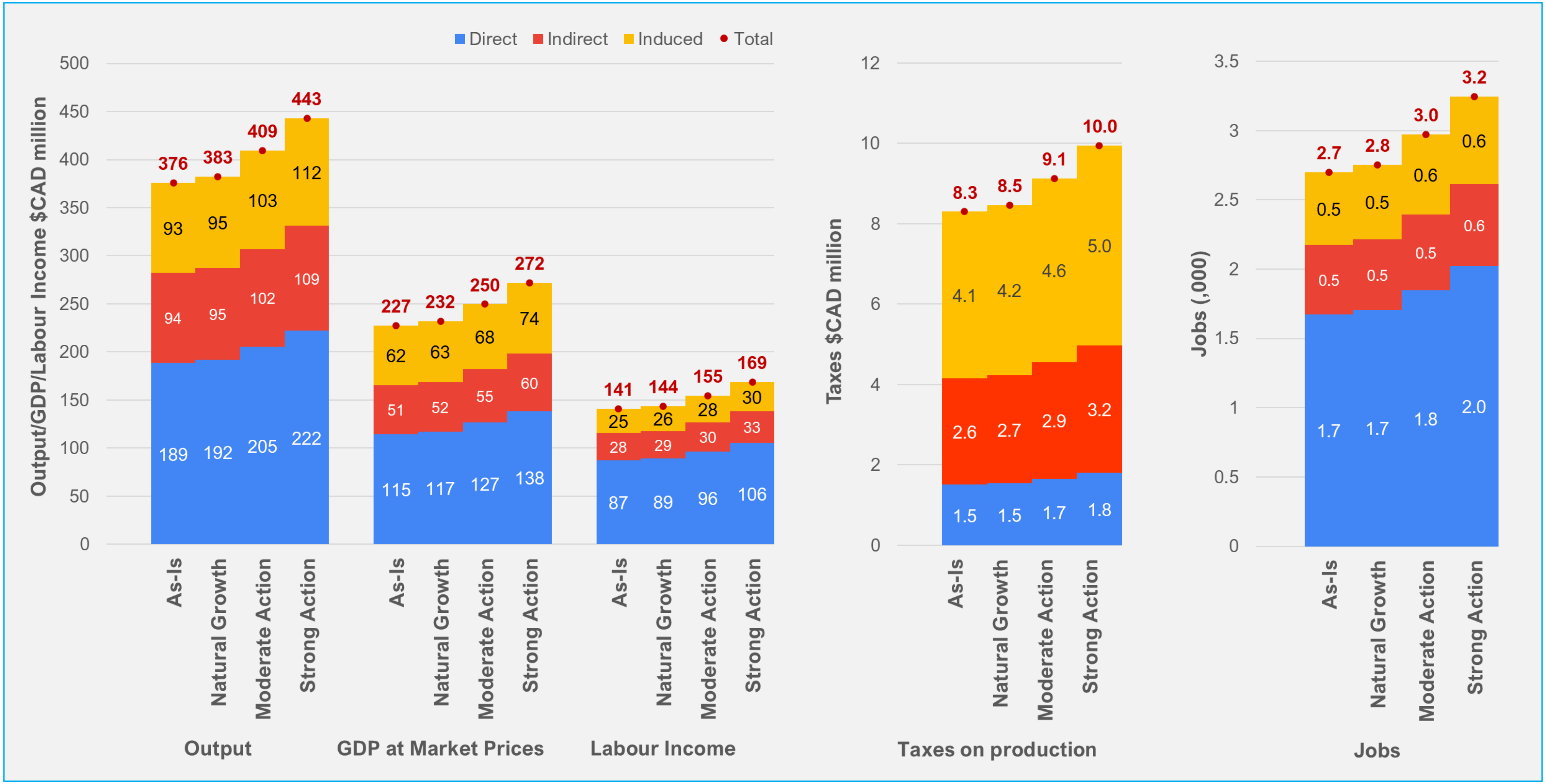
The gross levels (relative to 2019), financial and employment, of the scenarios are shown in Figure 34. Note that these do not include any substitution effects, but the overall net effect of these compared to the 'As-Is' scenario is shown in the subsequent graphic, Figure 35.

Within the home appliances sector under all scenarios, we expect economic benefits across all multiplier types and all key metrics. Unlike the automotive sector, this also includes gains across indirect economic activities. The estimated gains due to increased VRP activity can be attributed to a net benefit when considering a multitude of factors including:

- Gains expected due to increased production of VRP produced goods.
- Losses to new goods manufacturers in Canada.
- Output losses driven by reduced output on a per good basis relative to the substitution ratio (0.4 for household appliances).
- Gains due to increased re-shoring of production as 90% of new manufacturing losses are borne by international manufacturers (consistent with the current import rate for household appliances).

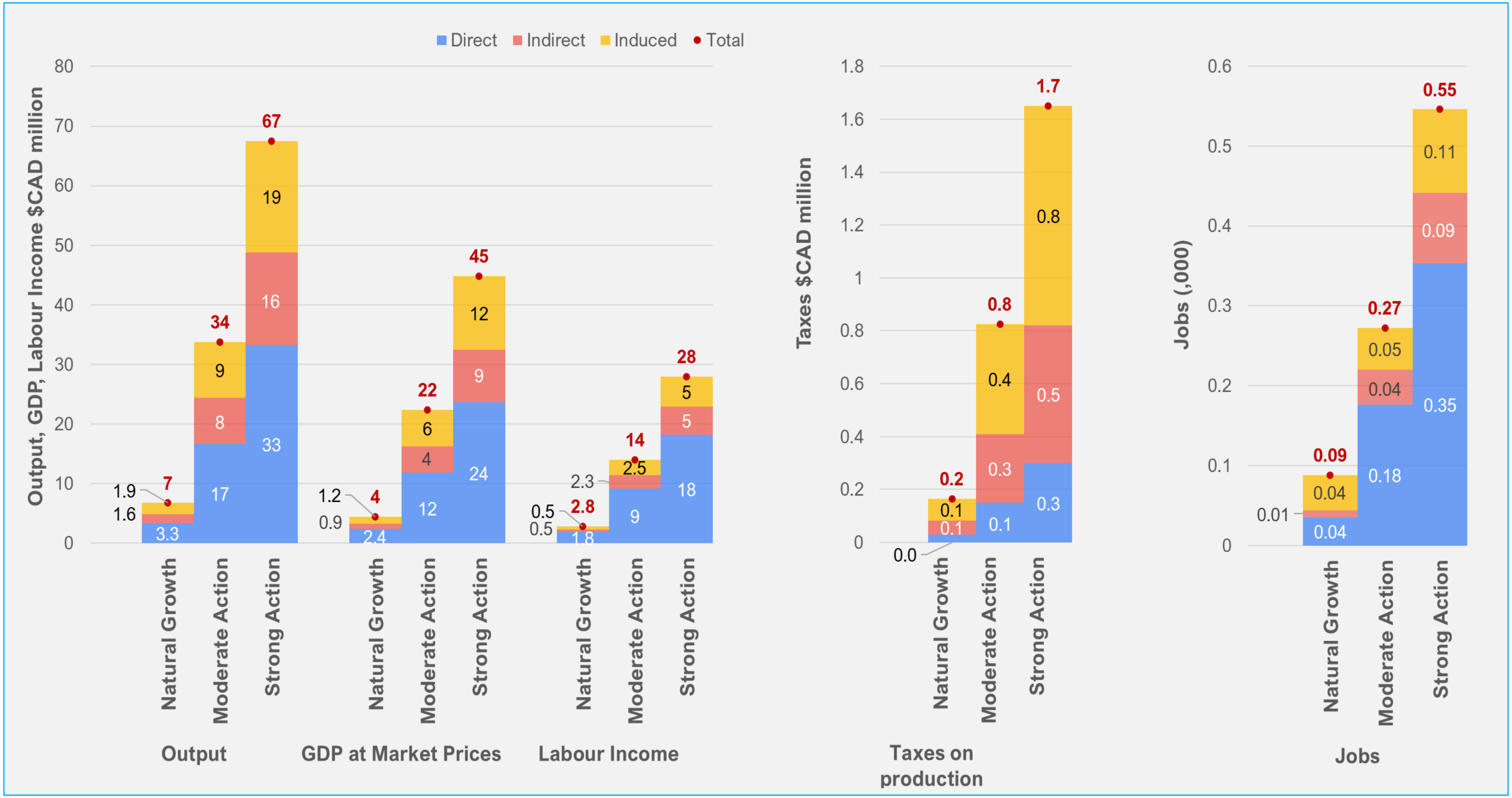
Overall, this means that actions to spur VRP activities should be expected to increase national production in Canada of domestic appliances (which, is assumed to include new manufactured goods and VRP produced goods). These gains in production exceed losses to Canadian manufacturing and the reduced output on a per good basis. Therefore, it can be reasonably expected that socio-economic gains would result from expanding VRP activities in the home appliances sector.

Figure 34: Economic impacts in the home appliances sector, 2030 – forecasts for the change in the VRP industry relative to 2019, gross levels, not accounting for substitution effects



Note: Totals may not add due to rounding

Figure 35: Economic impacts in the home appliances sector, 2030 – net impact of VRPs on Canadian economy over 'As-Is' scenario

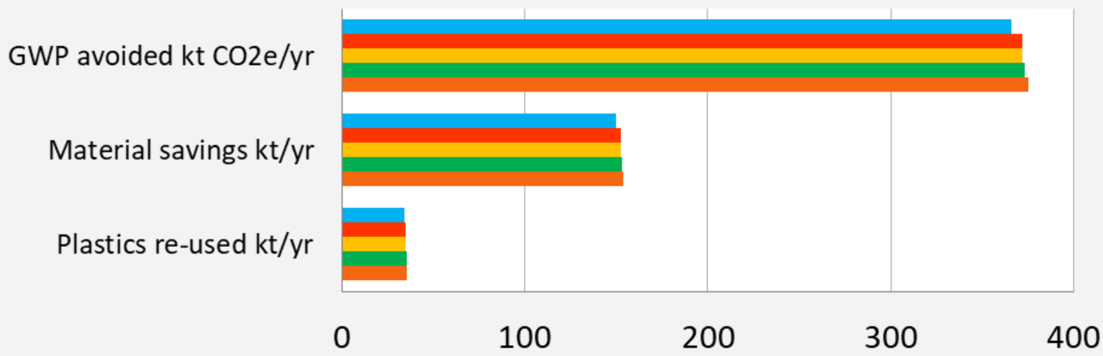


Note: Totals may not add due to rounding

8.3.2 *Estimate of potential environmental impacts*

The potential environmental impacts of the four VRP scenarios described are summarized in the Figure 36 below. The impacts have been calculated assuming that they scale with VRP sector revenue.

Figure 36: Environmental Impact projections for home appliances to 2030



	Plastics re-used kt/yr	Material savings kt/yr	GWP avoided kt CO2e/yr
Current 2019	34.4	150	366
As-Is	35.1	152	372
Natural	35.1	153	372
Moderate	35.3	153	374
Strong	35.4	154	375

Notes: Impacts are assessed with the assumption that only refurbishment-type services grow because of the relative prevalence of repair. Maximum plastic impact reduction as plastic components are more likely to be replaced as wear parts during repair/refurbishment. Assumes 23% plastic content as per (Deloitte and Cheminfo, 2019)

Note that the relatively small growth projected in this sector is because of the small base level of refurbishment coupled with the assumption that repair and re-use will not expand significantly.

To place the GWP savings in context, this is equivalent to taking 80,000 cars off the road at current levels and about 82,000 cars following the Strong Action scenario.

To place the materials savings in context, it is equivalent to all the recycling from waste achieved by about 565,000 people at current levels and by about 580,000 people following the Strong Action scenario.

To place the plastics re-use in context, it is equivalent to all the plastics recycling achieved by about 4.5 million people at current levels and by about 4.6 million people following the Strong Action scenario.

A fuller assessment of the significance of the aggregated results is provided in Section 10.2.

Supplementary commentary

Life cycle assessments conducted by others suggests that the environmental benefits associated with remanufacturing end of life appliances is not straightforward. Many LCA studies (Boustani, Sahni, Graves, & Gutowski, 2010; Gutowski, Boustani, & Graves, 2011) show that the GHG life cycle impacts are dominated by energy in the use phase of life, indicating that remanufacturing appliances that are less efficient than newer models does not have net positive energy savings. This implies that the remanufactured equipment will need to be nearly as energy efficient as the new model that the consumer is looking to purchase. This would seem to indicate that the cores worth remanufacturing from an energy savings perspective would be the high efficiency appliances. Assuming that the capital cost of a high efficiency remanufactured machine would be similar to a lower efficiency new appliance, then the potential substitution of a higher efficiency remanufactured machine for consumers who would normally purchase a low efficiency new machine would hold potential energy savings.

In the appliances sector, new technology emerges that is much more energy efficient, from an energy point of view. The decision lies in whether to get rid of the old device rather than having it fixed or buying a remanufactured version. For example, the efficiency of many new appliances — such as refrigerators and washing machines — are improved over older models that, in terms of energy use, a new model may be the better choice.

9 Furniture

9.1 Industry insight

Information obtained during the course of this study suggests that there are at least two OEM VRP agents operating in Canada, two independent remanufacturers, one contract VRP agent (re-use) and approximately nine independent VRP companies located primarily in Ontario and Quebec. In addition, approximately 20 furniture banks exist across Canada. There are also approximately 1,954 businesses engaged in re-upholstery and furniture repair, primarily in Ontario and Quebec (~1,107 businesses) (Statistics Canada, 2018).

Table 26: A map of VRP practice in furniture

Remanufacturing	Comprehensive Refurbishment	Refurbishment	Direct Re-use	Repair	Cascading (C2C)
Insignificant	Insignificant	Largely via charities	Largely via charities		

Note: *a. Boxes with no comment indicate activity is generally applicable across all markets or requires no caveat.*
b. Cascading between consumers – the handing on of goods to users of similar or lower expectations of performance – is not overtly described in the IRP report. However, it is included here as it represents an important option for some products, especially given the geographical challenges identified previously, and one within the bounds of influence of ECCC.
c. Pink = not present or insignificant.

There are two seemingly distinct sub-sectors - one for consumer furniture, which focuses primarily on direct re-use and repair and is dominated by peer to peer re-use models and not for profit organizations, and one for commercial furniture, where remanufacturing and refurbishment activities by, generally, for profit businesses, such as Refurb Canada, are apparent. The potential to increase remanufacturing, given its current low market penetration, is high and, based upon responses in our survey, the pursuit is highly profitable. The roadmap to setting up remanufacturing for domestic furniture may be more complicated, especially for independent VRP agents: the variety in the design and composition of domestic furniture increases the variability of feedstock and reduces economies of scale (both of which reduce profitability), a lack of ongoing customer relationships past the point of sale for most furniture manufacturers complicates reverse logistics, and much domestic furniture is designed and manufactured cheaply, reducing its viability for a second (or more) lives.

Sales channels for VRP products appear to be primarily through storefronts and direct business to business sales. Respondents indicated that their sales are primarily domestic with one respondent indicating that they also sell their products in the US. Information provided by survey respondents suggests that Canadian remanufacturing activity captures less than 0.01% of the current North American office furniture market.

Respondents indicated that their main competitors are Canadian OEMs. At least one independent VRP agent indicated that they have a synergistic relationship with their US remanufacturing counterparts

9.1.1 *Motives for undertaking VRP activities and barriers to growth*

Motives for undertaking VRP activity cited by respondents included customer demand, environmental responsibility/benefits, social responsibility, brand protection and profitability. Primary data received indicates that gross profits on VRP products in this sector can be as high as 20–50%.

Barriers cited included lack of customer recognition, lack of available cores and variable quality of feedstock, lack of adequate sales channels, high labour costs, cost pressure from low cost foreign imports and lack of access to skilled personnel. One not for profit VRP agent which focuses on repair and re-use indicated that the capital cost to set up a remanufacturing enterprise – as well as feedstock variability – was a significant barrier.

9.1.2 *Predictions for future growth*

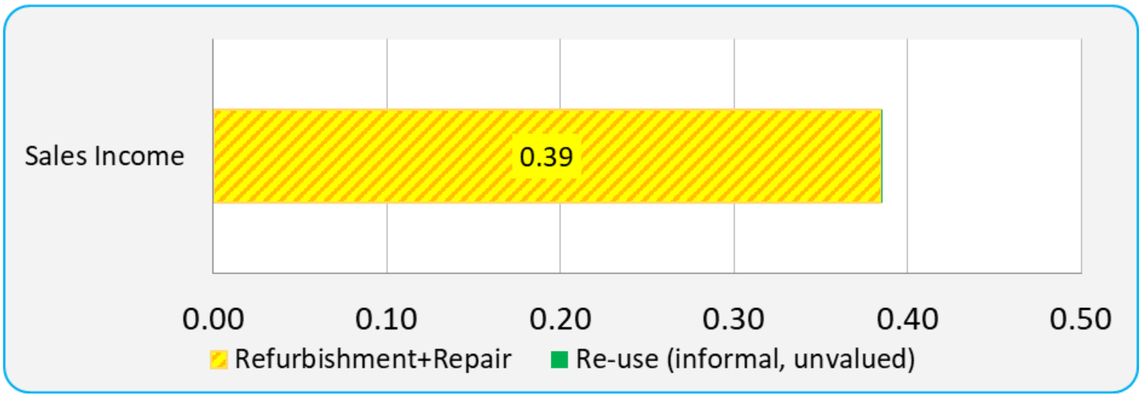
The for-profit enterprises indicated that they expect strong annual growth for their products in the next 5 to 10 years. However, responses may reflect pre-COVID-19 conditions. Not for profit enterprises indicated that VRP activities in this sector will likely grow if there are incentives for consumers to purchase used, remanufactured or refurbished furniture and if EPR legislation includes furniture and appliances. They indicated that there are synergistic opportunities for OEMs to partner with local small and social enterprises to increase activity in this sector.

9.2 Impact analysis

9.2.1 *Estimate of socio-economic impacts*

Using the re-upholstery and furniture repair industry as a proxy, direct economic impacts due to furniture VRP activities can be estimated. The average revenue per firm is $CAD 197,100, which suggests the industry has approximate revenues of $CAD 385 million (Statistics Canada, 2018).

Figure 37: Revenue generated by VRP activity in the furniture sector, 2019, $CAD bn



Notes: Re-use is important but largely in the consumer-to-consumer domain so value not quantified in this work.

Annex F tabulates the input-output multipliers for furniture manufacturing in Canada. As multipliers are not available for the furniture manufacturing industry but subdivided into three subgroups covering home furniture, office furniture and other furniture, a range was used to estimate economic impacts. Within the range, minimum multipliers are between 48% and 100% of maximum multipliers. However, ranges are typically tighter for non-labour factors. Additionally, direct impacts vary more than indirect or induced impacts. This is likely due to differences in production processes but similar supply chains.

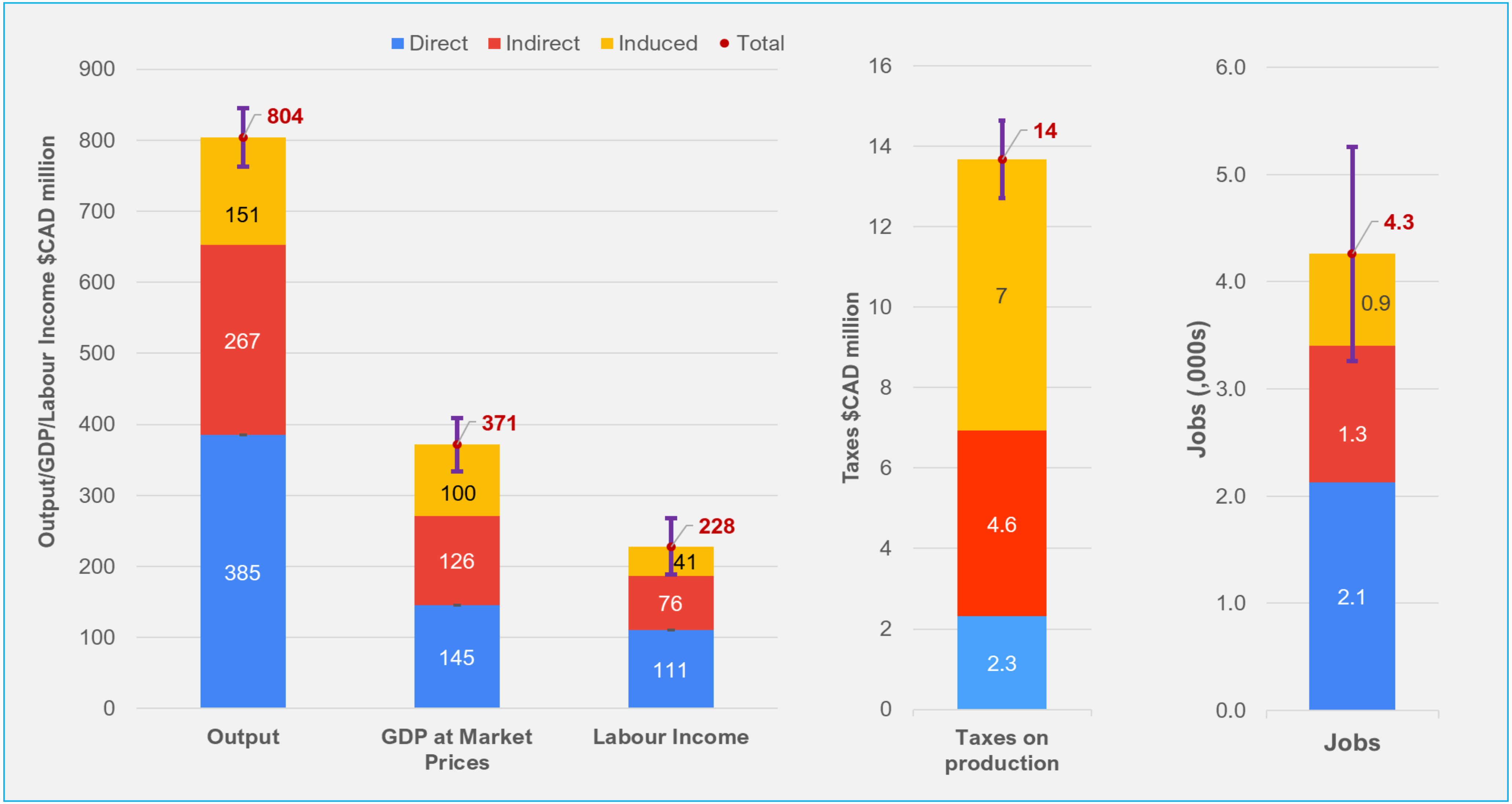
Based on the ranges provided, direct labour income is between $CAD 82 million and $CAD 139 million supporting between 1,380 and 2,878 jobs. Typically, household furniture is much more labour intensive than office furniture or other furniture as direct jobs and income are both approximately twice as high. Production tax revenues are estimated to be between $CAD 1.9 million and $CAD 2.7 million for direct activities. Overall, VRPs in the furniture industry are estimated to contribute between $CAD 129 million and $CAD 160 million to Canada's GDP.

Primary data collected from five respondents (two social enterprises and three independent VRP agents) indicated that their combined revenue is approximately $CAD 58.75 million and that they generate an estimated 819 FTEs. Therefore, each firm on average employs around 35 individuals with revenues of approximately $CAD 12 million annually. These firms are likely accounted for in the sector estimate. Based on Statistics Canada data, both firms would be within the top quartile of businesses within the industry. As a result, the characteristics of these firms are unlikely to be indicative of the overall industry as the cost of sales and operating expenses are typically much lower for larger firms in the industry due to economies of scale (Statistics Canada, 2018).

Indirect and induced economic impacts are estimated using the multipliers in Annex F.

Like direct impact, a range was used due to the nature of Statistics Canada data. Total output associated with furniture VRPs was estimated to be between $CAD 778 million and $CAD 813 million including between $CAD 242 million and $CAD 292 million in indirect output. These activities contributed between $CAD 356 million and $CAD 397 million to Canada's total GDP. The total jobs associated with these activities were between 3,577 and 5,085 including between 1,118 and 1,437 indirect jobs. Labour income on indirect jobs was estimated to be between $CAD 69 million and $CAD 84 million. Production tax revenue for furniture VRP activities were estimated to be between $CAD 12 million and $CAD 15 million with approximately $CAD 5 million attributed to indirect economic activity.

Figure 38: Economic and employment impacts of furniture VRP activity, 2019



Note: Totals may not add due to rounding

9.2.2 *Estimate of environmental impacts*

For some kinds of products, such as furniture, the benefits of remanufacturing are unequivocal. It makes clear sense to remanufacture anything that consumes an insignificant amount of energy when it is being used such as office or household furniture.

Davies Office, which operates in Canada and the US, provides a case study of the environmental benefits of VRP activities in the furniture manufacturing sub-sector. Davies remanufactures office furniture for use by businesses based on their specifications. According to research conducted by the National Center for Remanufacturing and Resource Recovery at the Rochester Institute of Technology, Davies remanufacturing process provides a variety of environmental benefits. Energy savings from the remanufacture of one office workstation uses 82% less energy than traditional manufacturing (Davies Office, 2020). Annually, these energy savings could power 342 typical households. It is anticipated that material savings in this sector will primarily consist of wood, metals (steel and non-ferrous) and plastics.

Respondents to this study indicated that, on average, they completed VRP activities on 63,000 units each per year.

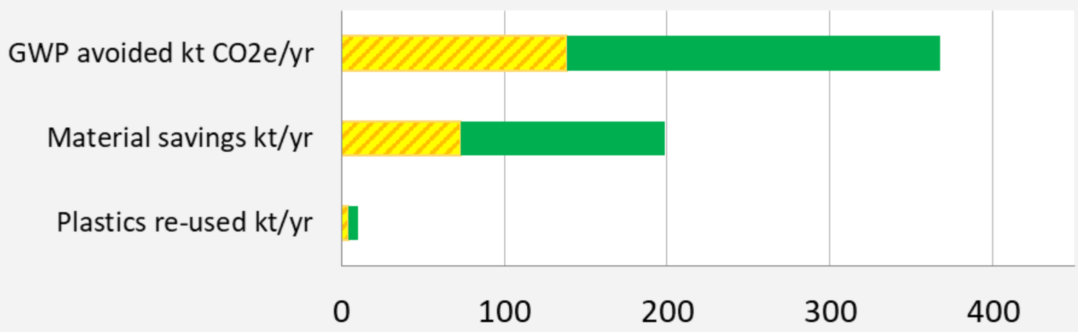
Figure 39: Surveyed flows of Canadian furniture at end-of-use, 2019

Note: Data above is from Canadian survey data obtained in this study except estimates of informal re-use. Products re-used via informal channels such as on-line sales, small ads, peer-to-peer donations and direct sales from businesses to homeowners are unknown. However, estimates have been made of such furniture flows by WRAP in the UK and so, by analogy, these have been estimated at 20 kt/yr in Canada. (Bojczuk, Parker, Eatherley, & Fryer, 2013)

The conclusion that furniture re-use is overall beneficial, however, highly predicated on critical assumptions, most notably that re-used furniture displaces purchase of new furniture. This is by no means certain: A WRAP UK furniture study (Fisher, James, & Maddox, 2011) observed that, in practice, only around 20% of new sales are displaced. Because of this, net benefits are far lower than expected and indeed result in a net increase in total furniture impact. To a large extent this is because the prevailing method of disposal for non-metallic components is to landfill. Wood, in particular, has a large GWP because of degradation to methane. As a policy, therefore, a much more beneficial tactic for policymakers would be to ensure that wooden furniture is properly collected and recovered for energy recovery of material recycling where it has a high chance of displacing virgin material.

Figure 40 summarizes the estimated environmental benefits due to furniture VRPs.

Figure 40: Breakdown of estimated environmental impacts for Furniture by VRP, 2019



	Plastics re-used kt/yr	Material savings kt/yr	GWP avoided kt CO2e/yr
Refurbishment+Repair	4	73	139
Re-use	7	126	229
Total	11	199	368

Notes: *Totals may not add due to rounding.*
Averaged over all furniture, assumed to be office furniture in ratio 2 chairs (30 kg): 1 Desk (60 kg). The residual life model has not been applied because as Nasr notes, furniture inherently has an extraordinarily long use life and is generally disposed of well before failure. Includes estimates of 'informal' re-use of 80 kt/yr materials. Repair and refurbishment have been aggregated.

As mentioned previously, VRP activities associated with furniture do not sit comfortably with the definition of remanufacturing emanating from the 'hard' engineering sectors, hence the lack of true remanufacturing. There is a mix of activity across refurbishment and re-use with which the citizens of Canada are likely familiar. In our analysis, because they cannot be differentiated statistically, we have arbitrarily split them equally across categories, simply to obtain a moderated view of impacts. In doing this, we acknowledge that statistical data is not collected on furniture re-use – predominantly in the office and institutional rental markets, but it is known to be important, most likely hidden within the service sector (leasing, rental) reporting codes.

Environmental impacts appear high as a proportion of all sector activity, but is reflective of the high use of furniture, that they are substantial items and a seemingly active recovery market. The plastics re-use element is low largely because – in chairs – these are wearing elements which are replaced, and do not comprise a large element of desks.

Further commentary on the significance of these numbers appears as the end of this sector section.

9.3 VRP expansion scenarios

Medium-term scenario

No literature specifically on the expected impact of COVID-19 on the furniture sector has been found to date. For our analysis, we used changes in real per capita disposable income to act as a proxy for changes in VRP expenditure. We use the same projection of real per capita disposable income in Canada as compiled by Moody's Analytics (Moody's Analytics, 2020), (and shown in Table 21) for our baseline scenario, equivalent to 1.7% CAGR. While this data is for consumer spending, without further data we consider consumer spending to be a suitable proxy.

Lower disposable income may lead to an uptake of VRP activities for furniture, particularly re-use, where the price of a used item may be considerably lower than buying new. However, it may be that in the short term, retailers offer reduced prices on goods to stimulate spending. We explore three scenarios of displaced expenditure on new goods to remanufactured goods. The increase in remanufacturing revenue by 2030 explored in the scenarios are 1%, 5% and 10%.

Long-term outlook

The largest VRP activities in the furniture sector are re-use and refurbishment. We expect this to continue in the future, albeit with opportunities for the development of formalized office furniture remanufacturing operations. Section 13.7 highlights some of the main barriers encountered to greater VRP uptake and provides an initial assessment of possible options to mitigate them.

9.3.1 *Estimate of potential socio-economic impacts*

Based on the aforementioned scenarios, three demand shocks were identified for furniture. These shocks are shown in Table 27.

Table 27: Furniture VRP Activity Revenue Scenarios

Scenario	2019 Output (VRPs) $CAD	2030 Output (VRPs) $CAD	Average Annual Growth Rate	Substitution Rate	New Revenue Attributed to Substitution
As-Is	385 million	464 million	1.71%	0%	0%
Natural Growth		469 million	1.71%	1%	6%
Moderate Action		487 million	1.71%	5%	23%
Strong Action		511 million	1.71%	10%	37%

As no market forecasts were available for growth in this sector in Canada, we estimated growth effects based on the changing rates of disposable income in Canada as reported by Moody's (Singh, 2020). We assume that changes in household disposable income would correlate with spending on furniture. This estimated growth in VRP activities was then annualized to define an intermediate 2030 projection with no substitution effects.

VRP produced furniture is not considered to be a mature market. Influences such as changing consumer preferences and policy action may result in the substitution of new manufactured goods for VRP products. Therefore, in addition to growth effects, substitution effects can also be expected. To judge these effects, we applied a substitution rate of 0.6 (an average of other sectors) to the intermediate 2030 projection defined above.

Further, about half of furniture used in Canada is produced domestically. Accordingly, we expect only 49% of the manufacturing output reduction to be borne by Canada.[6]

Annual gains can be expected to vary year to year, with economic losses in this sector expected in 2020 due to COVID-19. However, the sector is expected to grow in subsequent years. Annual changes will be closely tied to the business cycle as projections are derived from disposable income forecasts. As the year-to-year growth is uncertain, the annual contributions are an average annual impact.

All 2019 economic and employment data was retrieved from (Statistics Canada, 2020c). Multipliers for Repair and Maintenance (except Automotive) were used. These multipliers are detailed in Annex F. For lost manufacturing revenues due to substitution, the multipliers for household furniture manufacturing were used.

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[6] This was calculated using the Supply and Use Tables from Statistics Canada for 2016. Products considered were those under MPG337102 (Household furniture), MPG337103 (Institutional and other furniture), and MPG337203 (Office furniture).

'As-Is' scenario

- The 'As-Is' scenario considers the growth of the furniture sector in the absence of substitution effects.
- Direct output increases by $CAD 79 million, and total output increases by $CAD 157 million relative to 2019.
- Total contributions to GDP increase by $CAD 95 million while direct GDP contributions increase by $CAD 48 million.
- Total taxes on production increase by $CAD 3.47 million relative to 2019.
- Direct jobs increase by approximately 700 jobs, generating an additional labour income of $CAD 37 million.
- Total jobs increase by over 1,100 generating an estimated $CAD 59 million in additional labour income relative to 2019.

Natural Growth scenario

- Direct output increases by $CAD 79 million relative to 2019 and $CAD 0.5 million relative to the 'As-Is' scenario.
- Increased direct output results in an additional total output of $CAD 158 million relative to 2019.
- Total GDP contributions increase by $CAD 96 million, including GDP contributions of $CAD 49 million due to direct activities.
- Total production taxes increase by $CAD 3.51 million relative to 2019, largely due to the induced economic activity.
- Increased direct output results in over 700 additional jobs generating an additional $CAD 37 million of total labour income.
- In total, direct, indirect and induced economic activity results in around an additional 1,150 jobs generating an additional total labour income of $CAD 59 million relative to 2019.

Total output increases by $CAD 0.6 million relative to the 'As-Is' scenario due to the net substitution effects. We project negative substitution effects for all indirect multipliers except taxes on production. These negative impacts were not apparent for other consumer goods (such as electronics and appliances) where a higher percentage of goods were imported. This is because the transition to VRP activities will have relatively greater impact on new goods production in Canada. In import-heavy sectors, we expect fewer losses compared to sectors, such as furniture, which have more national production.

Moderate Action scenario

- Direct output increases by $CAD 82 million and total output by $CAD 160 million relative to 2019.
- This results in additional total GDP contributions of $CAD 100 million, including direct GDP contributions of $CAD 52 million.
- Production taxes increase by $CAD 3.66 million relative to 2019, largely due to the induced economic activity.
- Increased direct output results in an additional 740 direct jobs with an additional total labour income of $CAD 39 million.
- In total, increased furniture production and VRP activity under the Moderate Action scenario results in nearly 1,200 additional jobs generating an additional total labour income of $CAD 61 million relative to 2019.

Annual average gains are expected in excess of the 'As-Is' scenario because of substitution effects. Taking these into account, total output increases by $CAD 2.8 million relative to the 'As-Is' scenario as a result, as well as generating almost **50 new jobs** and **$CAD 2.5 million** in additional labour income.

Strong Action scenario

- Direct output increases by $CAD 84 million and total output increases by $CAD 163 million over 2019 numbers, exceeding all previous furniture scenarios.
- These increases are $CAD 5 million and $CAD 6 million more than the 'As-Is' scenario for direct and total output, respectively.
- Contributions to GDP increase by $CAD 55 million due to direct activities and $CAD 105 million due to all economic activity from VRP expansion relative to 2019 under this scenario.
- Total production taxes increase by $CAD 3.84 million, largely due to induced economic activity.
- Increased VRP activity results in nearly 800 additional direct jobs generating additional labour income of $CAD 41 million.
- Direct, indirect and induced economic activity is estimated to result in over 1,200 additional jobs with a total additional labour income of $CAD 64 million.

Annual returns exceed the 'As-Is' scenario because substitution effects increase the annual estimated growth rate for VRP activities. Taking these into account, total output increases by $CAD 5.6 million over the 'As-Is' scenario, with as generating over nearly **90 additional jobs** and an additional labour income of **$CAD 5 million**.

Summary

The gross levels (relative to 2019), financial and employment, of the scenarios are shown in Figure 41. Note that these do not include any substitution effects, but the overall net effect of these compared to the 'As-Is' scenario is shown in the subsequent graphic, Figure 42.

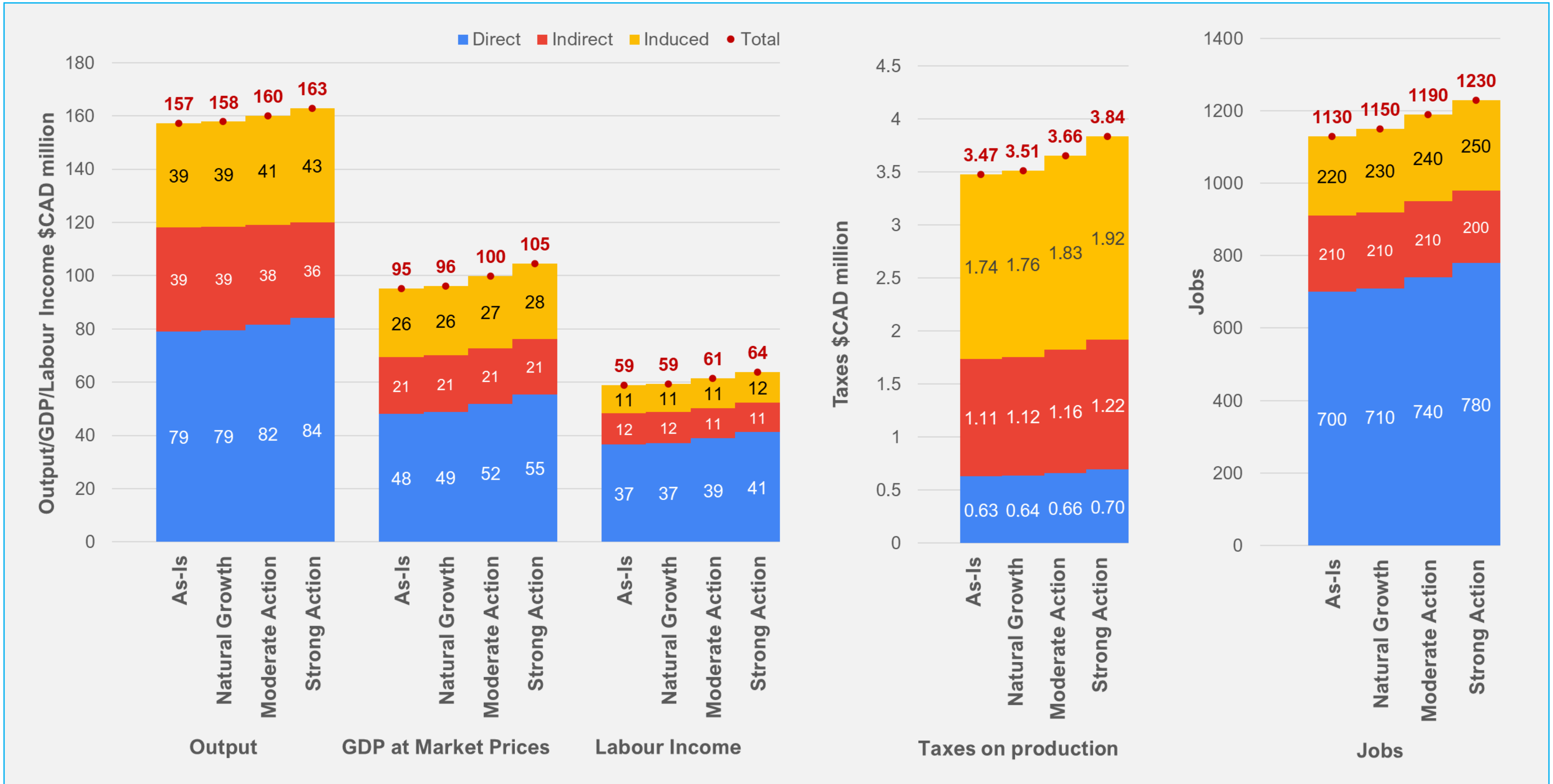
Within the furniture sector, under all scenarios analyzed, economic benefits are anticipated across direct and total multipliers and all key metrics. Unlike other consumer goods sectors, economic losses are expected for indirect economic activities. The estimated overall gains, as measured by total multipliers, due to increased VRP activity which can be attributed to a net benefit when considering a multitude of factors including:

- Gains expected due to increased domestic production of VRP produced goods.
- Losses to new goods manufacturers in Canada, assuming the losses borne by domestic manufacturers will be proportional to the percentage of domestic manufacturing versus imports.
- Output losses driven by reduced output on a per good basis relative to the substitution ratio (0.6 for furniture).
- Gains due to increased re-shoring of production as 51% of new manufacturing losses are borne by international manufacturers (consistent with the current import rate for furniture).

Economic losses for indirect activities are expected, despite the net economic benefits. These negative impacts were not apparent for other consumer goods but are similar to the automotive sector. Based on the differences between these sectors, increased domestic production of VRP activities is a key determinant of negative effects to supplier industries. In import-heavy sectors, fewer losses are expected compared to sectors with more domestic production. VRP activities have less reliance on suppliers, which make up indirect economic activity, and are higher value-added activities. In other household goods sectors, these losses were offset by increasing domestic economic activity at the expense of international producers. However, in this case where national production is higher, more of the negative effects are borne by Canadian suppliers. It should be noted that negative effects to suppliers are relatively small and are reflective of existing economic relationships. As VRP activities expand, it is reasonable to assume new opportunities may be present for Canadian firms within these supply chains.

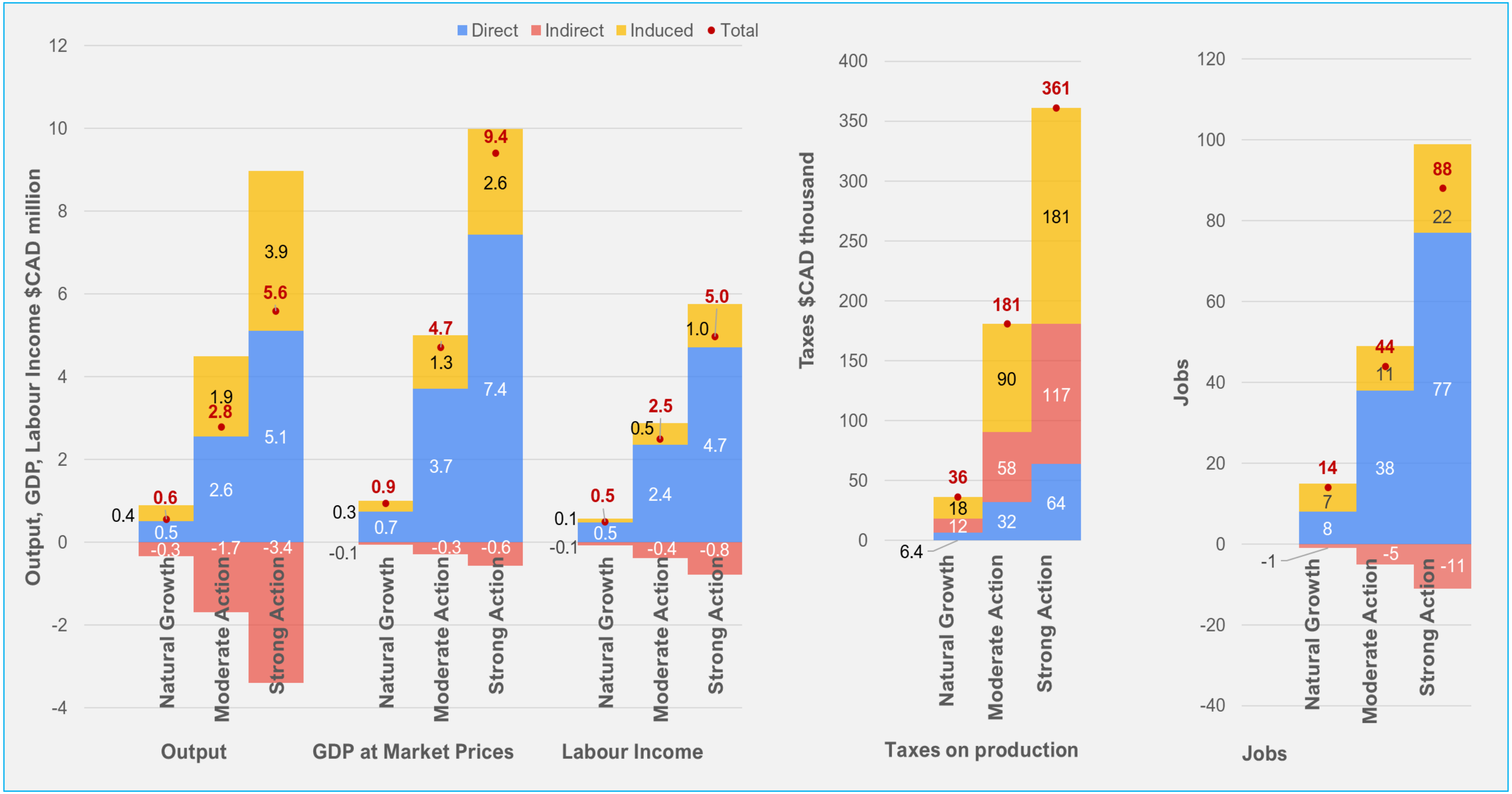
Overall, actions to spur VRP activities should be expected to increase domestic production in Canada of furniture (which, is assumed to include new manufactured goods and VRP produced goods). These gains in production exceed losses to Canadian manufacturing and the reduced output on a per good basis. Therefore, it can be reasonably expected that socio-economic gains would result from expanding VRP activities in the furniture sector.

Figure 41: Economic impacts in the furniture sector, 2030 – forecasts for the change in the VRP industry relative to 2019, gross levels, not accounting for substitution effects



Notes: Totals may not add due to rounding

Figure 42: Economic impacts in the furniture sector, 2030 – net impact of VRPs on Canadian economy over 'As-Is' scenario

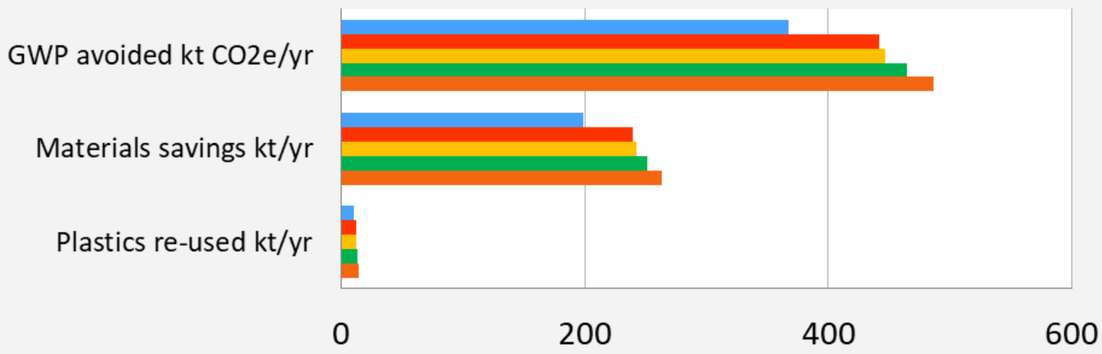


Notes: Totals may not add up due to rounding

9.3.2 *Estimate of potential environmental impacts*

The scenario estimates have been projected into associated VRP impacts. This assumes the same VRP mix as in the current position ('as-is') and not accounting for development of new markets if they are not within the modelled scenario.

Figure 43: Environmental Impact projections for furniture to 2030



	Plastics re-used kt/yr	Materials savings kt/yr	GWP avoided kt CO_2e/yr
2019	11	199	368
As-Is	13	240	442
Natural	13	242	447
Moderate Action	13	252	464
Strong	14	264	486

To place the GWP savings in context, this is equivalent to taking 80,000 cars off the road at current levels and about 105,000 cars following the Strong Action scenario.

To place the materials savings in context, it is equivalent to all the recycling achieved by about 740,000 people at current levels and by about 980,000 people following the Strong Action scenario.

To place the plastics re-use in context, it is equivalent to all the plastics recycling from waste achieved by about 1.4 million people at current levels and by about 1.8 million people following the Strong Action scenario.

A fuller assessment of the significance of the aggregated results is provided in Section 10.2.

Supplementary commentary

The assumptions of displacement used by WRAP can, of course, themselves be called into question. The subsequent report (Bojczuk, Parker, Eatherley, & Fryer, 2013) identified that a significant fraction of used office furniture was sold to households: it is understandable, therefore, that it did not offset new business purchases but may indeed have offset domestic purchases of new items.

In the home/domestic domain, behaviours are more complicated than in the business domain, with more actors, interests and motives rather than simple performance and price drivers. This makes understanding both what is happening and what might be done much more problematic.

It is likely that the figures on total volume of waste collected are too low, judging on a comparison with other countries. Without improved information on the Canadian supply chain, the results generated here in total benefits should be used with caution.

10 Summary of benefits

10.1 Socio-economic returns

We can reasonably forecast that labour intensity is higher in VRP activities than in traditional production. As a result, expansion of VRP industries can be assumed to increase the number of employment opportunities available in the production of goods with a corresponding increase in labour income.

We caution that this assessment is on a per dollar basis rather than a per good basis. Given that remanufactured goods and goods that enter a VRP process are typically sold for less than new goods, we do not know for certain what the comparative gain would be on a per good basis. However, taking a typical sales price of a remanufactured good to be 70% of new, this implies a relative revenue-per-good ratio of 0.7, manufacturing/remanufacturing so that the substitution of one manufactured good for one remanufactured good would generate only 70% of the revenue output.

On the other hand, the input-output multipliers indicate that the labour requirements of VRPs are higher per good than for manufacturing and there are indications from the survey that profit margins are higher for remanufacturing and refurbishment implying that, even with higher labour, there is a net benefit per good. The summary of current 2019 and the range of future 2030 projections is captured in Table 28.

Table 28: Summary of direct socio-economic impacts of VRP expansion based on various growth scenarios

Sector	2019 Current VRP Market		2030 Projections	
	Revenue $CAD billion	Direct Jobs	Revenue $CAD billion	Direct Jobs
Aerospace	8.02	19,000	7.29–9.65	12,000–33,000
Automotive	32.8	341,000	35.83–36.54	372,000–392,000
HDOR	0.85	2,800	1.08–1.11	4,800–5,300
Electronics	1.39	3,800-9,600	1.68–1.76	6,400–13,000
Home Appliances	0.92	3,300	1.11–1.14	5,000–5,400
Furniture	0.39	1,400–2,900	0.47–0.55	2,100–3,700
Total	**~44**	**371,000 to 379,000**	**47 to 51**	**402,000 to 452,000**

Note(s): *The numbers in this table are reflective of summations from other tables in the report. For methods, please refer to the sector-specific tables. Only direct revenues are reported and considered for their jobs impact. Projected jobs are reflective of the lowest possible number of direct jobs and the highest number of direct jobs given the baseline scenario ranges and the scenarios considered for each type of VRP.*

The immediate benefits of VRPs are indicated by the economics and impact on jobs. A further nuance is that the jobs are higher skilled than manufacturing, typically entailing greater input of knowledge and technique, especially in the diagnostic phase of remanufacturing.

From the complementary view, the clear benefit to purchasers or users is either a cost-effective extension of product life or an as-new-or-better product with a full new life – in the case of remanufacturing. Particularly for remanufacturing and comprehensive refurbishment, these should not be considered as producing second-rate products, which could well be the perception of potential purchasers. This forms a real barrier to expansion and is considered important enough for action to improve awareness and understanding of consumers and institutional purchasers alike.

10.1.1 *Economic costs*

VRP activities reduce the volume of waste and may impact the demand for new manufactured products in Canada. Due to a reduction in demand for waste management services and manufacturing, there may be negative impacts on these sectors as well as any upstream raw material suppliers.

Additionally, demand for products that have undergone VRP activities or the general extension of product life cycles because of VRP activities is likely to reduce demand for new products. As these products can be viewed as substitutes, it is likely increased demand for goods produced by VRP industries will reduce demand for new products. Therefore, these industries may suffer corresponding losses (whether relative or nominal). It is unknown what the magnitude of economic costs is likely to be, particularly within Canada.

This, of course, is a long-term view of when remanufactured products occupy a significant fraction of the same market. It is perhaps not unexpected – the whole point of VRPs is to avoid the need for new purchase after all. But clearly some shift of 'power' will take place. In the short term, remanufactured and other VRP'd products can open new low-price point markets for customers unable or unwilling to take newly manufactured items as has been seen in HDOR, for example.

It is illustrative of a short-term issue of business shifts. It arises because – in general – new VRP market entrants are independents who 'threaten' the established linear models of OEMs. If OEMs subsequently offer their own VRP goods, they can reclaim their market share and maintain profitability with the whole economy showing a move towards more skilled labour-intensive workforces with higher circularity and lower virgin materials demand. The bigger picture is that such raw material supply industries are, ultimately, the ones that will see some decline.

As many new products are manufactured externally to Canada, it is possible that costs to the Canadian economy may be reduced. Many consumer goods, most notably automobiles and electronics are manufactured abroad and imported into Canada. Undertaking VRP activities in these industries are likely to have fewer economic costs since there is less risk of cannibalizing domestic production.

While these costs are expected, considerations of net economic impacts have been included in the forecasts of net benefit within each sector analysis.

10.1.2 *Reduced economic diversification*

Further intensification of activities in a sector in localized areas may have economic consequences for communities and nationally by increasing the volatility of the business cycle. For example, manufacturing is a primary economic sector in many cities such as Oshawa, in Ontario. Increased remanufacturing intensity may further the intensity of manufacturing in these areas due to supply chaining as VRP activities are dependent on the new goods for cores.

10.1.3 *Adverse environmental impacts*

For many products, VRPs have substantial benefits when assessing the energy, materials and associated impacts amortized over the multiple life cycles of a rejuvenated product. This is undeniably true for non-energy using products, or for technologies which are technologically mature. This applies to much static infrastructure and large numbers of basic products such as motors and machine tools in the business-to-business (B2B) context.

The situation is far less clear where energy-using products are involved, particularly those where efficiencies are improving rapidly. In the case of such energy-using products, a life cycle calculation would need to be done to determine if the environmental benefits associated with product life extension outweighs the efficiency of a new product (Gutowski & al., 2011). This applies largely to products in the home appliances and electronics categories where many jurisdictions have mandated continually tightening performances: energy and water use for washing machines; lower in-use and standby powers for electronics, etc. Such calculations are complicated for life cycle experts, let alone consumers, so there is a task to ensure correct end-of-use signals are sent to users to inform beneficial action.

Further environmental impacts may arise if VRP products are cascaded for re-use into secondary markets, perhaps in developing nations where technology demands are lower, though this is a diminishing driver. Cascading VRP'd goods can be a benefit in developing nations as long as they displace worse performing goods or have an overwhelming role in improving access to life-enhancing services. Of course, this consideration is not dissimilar to the domestic situation in opening access to goods to disadvantaged communities.

An often-cited example of negative environmental impacts is rebound, or the Jevons Paradox, first noted by economist William Jevons in 1865 (Jevons, 2017). Ignored for much of the following century, this text has provided an important platform for modern environmental economics (see, for example (Herring, 1999)). If financial savings are made through, say, resource efficiency, the savings are then spent on alternative activities whose impacts decrease or negate the prime benefit. An example is a homeowner who replaces all lighting with low-energy bulbs, enjoying a measurable reduction in electricity bills. The savings are then spent on a flight for a break, a mode of transport which has impacts which will certainly reduce the positive impacts of the lighting.

We have no evidence to suggest that this is a measurable effect in VRPs although there can be cost savings associated with remanufacturing-based lifetime cost of ownership models e.g. Caterpillar Inc. quote a lifetime saving of ten percent. It is arguable as to whether it would be desirable to maintain implementation of VRPs as near cost neutral to avoid such effects, but this would likely make the case to change less clear cut from a purchaser's perspective.

A rigorous analysis requires an economic and environmental examination of the elasticity of competing uses of resources and their weighted environmental effects. This would be a fruitful and topical research area which is beyond the scope of this project, but which could inform an impact-based fiscal policy. Disparities in carbon pricing between say, transport and electricity (according to their relative pollution potential) may be obvious sources of such elasticity.

10.2 Assessment of material, energy and CO_2 impacts

The following discussion presents a high-level summary of the environmental benefits of remanufacturing and other VRP practices as it relates to various industry sectors and their products in Canada.

10.2.1 *GWP benefits*

The following tables summarize our findings for reductions in GWP, solid waste and plastics. The weight of these activities is aligned to the economic splits summarized equivalently in the respective sector sections.

Table 29: GWP avoided kt CO_{2e} per year, 2019 for six sectors studied in depth

Sector	Reman	Refurb	Repair	Re-use	Total
Aerospace	22	84	77	n/a	**183**
Automotive (non-tires)	111	73	85	(Of order 600)[a]	**269 (869)**
Automotive (tires)	1.7	not applicable	negligible	negligible	**1.7**
HDOR (non-tires)	70	negligible	2.4	2.4	**75**
HDOR (tires)	19	not applicable	negligible	negligible	**19**
Electronics	negligible	65	108	167	**339**
Home Appliances	negligible	30	256	80	**366**
Furniture	negligible	139	negligible	229	**368**
Total	**224**	**391**	**528**	**478 (1,078)[a]**	**1621 (2,221)[a]**
	~0.62 Mt CO_{2e} /yr		**1.0 Mt CO_{2e}/yr**		

Notes: a. Bracketed because it is a notional benefit or is a total with notional benefit. See Automotive section for details.

We estimate that current VRP activity is saving at least 1.6 million tonnes (Mt) per year of CO_{2e} from entering the atmosphere. This figure is a minimum estimate because of the conservative approach taken, the scope of what has been included, what has been reasonably claimed and not least because data is not available for many of the sectors. (This is especially true of materials and plastics savings, below.) On top of this, the scope is a partial view of only six sectors in detail: our preliminary work suggested that all ten sectors account for around 70% by value of the total sectoral opportunity for VRPs, so there is headroom for increase in the estimate.

The superior value of aerospace VRPs is weighted by the inherently higher parts value in this sector for a given overall mass of parts processed. In addition, due to the higher complexity and regulation on these activities, net energy benefits are also likely to be reduced in the manner seen in the table.

Relatively small savings are seen in the HDOR (non-tires) sector.

It should be noted that the life cycle energy savings associated with remanufactured components and products is not straightforward for those products and components that have a substantial 'in use' energy demand. Life cycle energy benefits will be highest for high-efficiency cores and, studies suggest, there may be negative net energy benefits to remanufacturing low efficiency cores (Boustani, Sahni, Graves, & Gutowski, 2010).

Significance of GWP figures

These figures should be put in the context of Canada's overall emissions. According to the Government's own figures (ECCC, 2020), in 2017, industrial emissions accounted for around 70 Mt and the overall economy around 720 Mt of CO_2. Even allowing for errors in the assessment of the benefits of different VRPs, the contribution is measurable and worthwhile. A large fraction of the benefit is attributable to transport-based VRPs, furniture and electronics.

A better comparator is in regard to the question of how remanufacturing and other VRPs can contribute to the 'pathway to net zero' – the global challenge to decarbonize our economies and our lifestyles to stay within climate change limits of CO_2 in the atmosphere. To this end, many nations have evaluated their current and future emissions limits against horizons of 2050 to be net zero or – on the way to this – intermediate targets, for example at 2030 such as Canada has done.

In a recently published progress report on 2030 decarbonization targets, (ECCC, 2020) reports that the heavy manufacturing sector needs to reduce its GWP impact by around 27 Mt/yr. This is around half of the net-zero requirement. In this context, the contribution of VRPs is significant:

extrapolating the findings of this work out to other sectors suggests a contribution in excess of 2 Mt/yr, over 8% of the target.

This offset is already being achieved. What is more exciting is the size of the opportunity, given that remanufacturing+comprehensive refurbishment is at such a generally low level as a proportion of manufacturing – 2 to 4% or so. Various industry contributors to this study – and others – have expressed much higher potentials for their sector, often more than 20%. This is not far-fetched when considering that aerospace is certainly above 20% now and has been for some time. **Therefore, it is conceivable that an overall challenge target of an overall tenfold increase in remanufacturing+comprehensive refurbishment could be adopted.** Progress to such a target would meet a very large fraction of the industrial reduction target, excluding any other process improvements such a program might induce. This issue is explored later in Section 10.3.

10.2.2 *Material savings*

Table 30 below shows the estimated annual mass of products that were diverted in 2019 from non-VRP activities, such as landfill, incineration, and recycling, and are instead subject to some form of value-retention. For remanufacturing, refurbishment, and repair, we expect that there is some element of disposal as worn or broken parts are replaced, while for re-use, 100% of the mass is typically retained.

Table 30: Material savings for focus sectors (kt per year), 2019

Sector	Reman	Refurb	Repair	Re-use	Total
Aerospace	4	>15	>14	not applicable	**33**
Automotive (non-tires)[a]	12.3	>8.1	>9.4	not available	**30**
Automotive (tires)	1.7	not applicable	negligible	negligible	**1.7**
HDOR (non-tires)	7.8	0.3		0.3	**8.4**
HDOR (tires)	19	not applicable	negligible	negligible	**19**
Electronics	negligible	12		12	**24**
Home Appliances	not applicable	14	102	34	**150**
Furniture	negligible	73	negligible	126	**199**
Total[b]	**~45**	**~420**			**~470**

Notes: a. This excludes the four other sectors covered in the initial analysis.
b. This excludes notional benefits of automotive re-use.
c. Any differences between totals and components are due to rounding (to 2 significant figures).

With limited data on the mass of materials retained through the different VRPs, the table shows a reasonable assessment of the mass of such savings.

Significance of materials figures

To place these numbers in context, one comparison is with the amount of material recycling currently being achieved in Canada. The benchmark numbers of Section 2.4.4 indicate that recycling (from post-consumer waste) stands at around 10 Mt/yr. VRPs achieve around 5% of this level.

Our estimates are largely based on steel content of industrial products. A perhaps appropriate comparison is to consider related flows of steel. Canadian steel producers recycle approximately 7 Mt/yr of steel so VRP materials recovery equates to 7% of this figure (Canadian Steel, 2020).

It is important to note, however, that these materials savings are not equivalent to recycling since they are materials in products that are used – in effect as-is with very little energy input. Their net benefit is far more than that which their mass would suggest, given that many non-metallic recyclates barely break-even in GWP terms.

On the basis of our figures, it is interesting to note the CO_{2e} avoided per kg saved for each VRP class. In effect, this gives the ‘bang per buck’ of the activity. Although the analysis is crude, remanufacturing saves about 5 kg.CO_{2e}/kg (or higher if the plastics component is discounted) and the entire suite of VRPs about 4 kg.CO_{2e}/kg. This should be compared to basic steel manufacture which is around 1.8 kg.CO_{2e}/kg emitted. Higher steels and processed forms might be, say 4kg.CO_{2e}/kg emitted, so if recycling saves half of this emission, VRPs are at least twice as CO_{2e}-effective as recycling.

A further point is that this analysis considers only those materials which **are** re-used. For other materials recovered during VRP processing, it is highly likely that they enter the recycling system – especially for metals which have higher value – in addition to the direct benefits quoted above. We are confident in this statement because remanufacturing requires a thorough understanding of product and material values and is highly indicative of a resource efficiency culture. Major manufacturers often operate triage systems which blend a range of VRP and resource efficiency approaches to maximize value recovery.

This analysis is for only six selected sectors. Extrapolating to all manufacturing, we can with reasonable confidence suggest that actual materials savings are at least 900 kt/yr (9% of Canadian recycling).

10.2.3 *Plastics re-use*

Table 31 summarizes the estimates of the annual mass of plastic that may be diverted from VRP activities. Data here is sparser, but we estimate that a minimum of 74 kt/yr of plastic may be diverted from disposal through VRP activity.

Table 31: Estimated plastics re-use (kt per year), 2019 for six sectors examined in detail

Sector	Reman	Refurb	Repair	Re-use	Total
Aerospace	no data	no data	no data	no data	**no data**
Automotive (non-tires)	1.8	1.2	1.4	-/-	**4.4**
Automotive (tires)	1.3	-/-	-/-	-/-	**1.3**
HDOR (non-tires)	1.1		<0.1	<0.1	**1.2**
HDOR (tires)	15	-/-	-/-	-/-	**15**
Electronics	negligible	0.6	2.9	3.7	**7.2**
Home Appliances	negligible	3	23	8	**34**
Furniture	negligible	4	negligible	7	**11**
Total	**~74 kt/yr (minimum)**				

Notes:
a. This excludes the four other sectors not covered in detail for reporting here.
b. This excludes notional benefits of automotive re-use.
c. Any differences between totals and components here and in sector tables are due to rounding.
d. By analogy with HDOR, aerospace savings might be expected to be around 5 kt/yr.
e. The figure for Home Appliances reflects the high plastic content of these devices and their overall bulk. In addition, it includes a proportion of domestic-like appliances used in industrial variants.

Significance of plastics numbers

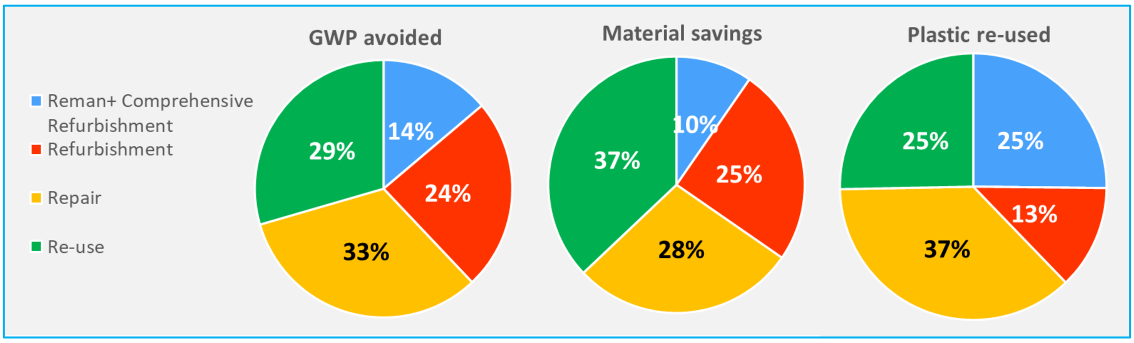
These numbers seem small in the context of plastics used and discarded in Canada. However, in line with our benchmarks, this number corresponds to about 25% of the current Canadian plastics recycling performance. Again, the caveats applied above to other routes for the recovery and valorization of un-re-used plastics are valid. The actual material recovery will be higher when applied across unquantified sectors. Further, as noted above, the figure does not include conventional recycling of un-remanufacturable components. On this basis, it is feasible that recovered plastics are up to 100 kt/yr in 2019 across all 10 sectors of the study and 150 kt/yr in 2019 across all manufacturing sectors in this study plus those not included (1% of Canadian recycling).

It should be acknowledged, however, that widespread understanding of the materials flows within the industrial ecosystem – other than for some commodity metals, for example – is poor. This severely hampers attempts at contextualizing and indeed assessing the impacts of specific practices. It is also important to note that, in relative terms, plastics are generally low in manufacturers' concerns because of their relative cost, which in large part reflects their CO_{2e} impact at point of manufacture. Their value and GWP benefits in recovery fall far below those of the dominant metallic components.

10.2.4 *Summary of impacts by VRP*

The information from the above tables can be reorganized to illustrate how each VRP contributes to achieving the GWP, materials and plastics impacts in 2019.

Figure 44: Impacts split by contribution of each VRP, 2019



10.2.5 *Summary of expansion scenarios*

Table 32 provides a summary of the potential environmental impacts that could be realized through the range of growth scenarios evaluated in our analysis.

Table 32: Summary of the environmental impacts of VRP expansion based on growth scenarios

Sector	GWP avoided kt CO_{2e}/yr		Materials savings kt/yr		Plastics re-used kt/yr	
	2019 Current	2030 Projections	2019 Current	2030 Projections	2019 Current	2030 Projections
Aerospace	183	166 – 220	33	29 – 39	No data	
Automotive (non-tires)[a]	269	286 – 306	30	32 – 34	4.4	4.7 – 5.0
Automotive (tires)	1.7	not projected	1.7	not projected	1.3	not projected
HDOR (non-tires)	75	95 – 104	8.4	11 – 12	1.2	1.5 – 1.7
HDOR (tires)	19	not projected	19	not projected	15	not projected
Electronics	339	409 – 450	24 max	29 – 32	7.2	8.7 – 10
Home Appliances	366	372 – 375	150	152 – 154	34	~35
Furniture	368	442 – 486	199	240 – 264	11	13 – 14
TOTAL[b]	**~1,620**	**~1,790 – 1,960**	**~465**	**~514 – 557**	**74**	**79 – 82**

Notes: a. Excludes notional benefits of auto repair/ re-use (~GWP 600 kt/yr currently) and associated materials savings etc. Repair and re-use will not be affected in growth scenarios.
b. Totals may not add up due to rounding of figures abstracted from sector tables.
c. Where "not projected", assumed to be same as Current 2019.

The important point to note about expansion is that there is plenty of headroom to grow VRPs. As noted above, industry operators tend to be relatively bullish about the ultimate levels of VRPs despite current concerns over the effect of COVID-19. To some extent, the expansions we propose in this work appear modest in relation to those transformations, but for good reasons also described above. However, they should be achievable using the suggested actions described in later sections, so progress towards them will be a good test of both understanding of barriers and the effect of policy in response.

10.3 Considering a transformation of remanufacturing

Above, we asserted that there was room to grow VRPs, but more specifically this refers to the 'new life' processes of remanufacturing and comprehensive refurbishment. Repair and re-use take place currently to a much greater extent so radical expansion of their use is not feasible. More in-use failure will not occur as a result of policies supporting VRPs but there will still be plenty of core to feed remanufacturing at end-of-life. With this in mind, we have considered expansion of remanufacturing (taken to include comprehensive refurbishment, shortened to R+R in this section) to a high level starting from an assessment of its current level as a proportion of (new) manufacturing by sector.

Table 33 shows the results of this analysis, which is admittedly crude, but indicative. Overall, R+R lies between 2 and 4% of manufacturing depending on how flexibly we consider the bounds of (comprehensive)/refurbishment in various sectors. This analysis considers raising all R+R to 20% as a proportion of manufacturing as a 2050 aim. As shown, GWP avoided rises 9-fold to around 9 Mt/yr, and materials savings to around 1.7 Mt/yr. The plastics data is much less robust so we report only that the total R+R plastics saving might exceed 200 kt/yr in this scenario.

These numbers are only for the 10 sectors covered in the study but excluding medical (where insufficient data had been found to estimate the environmental impacts of VRP activities). Other sectors might also show similar benefits uplifts over their current position and they do not include the residual benefits from repair and re-use which are not expected to expand to this extent. Crudely accounting for the repair and re-use puts the transformation benefits at:

- around 9 Mt/yr for GWP avoided;
- around 1.7 Mt/yr for materials saved; and
- around 200 kt/yr of plastics

These are across the 9 sectors in the table below.

Table 33: Projection of benefits for a transformation of remanufacturing and comprehensive refurbishment by 2050

		Considering GWP avoided for R+R [kt CO_{2e}/yr]		Considering materials savings for R+R [kt/yr]	
Sector	**Current 2019 R+R as % of manufacturing**	**Current 2019**	**Assuming they reach 20% of manufacturing**	**Current 2019**	**Assuming they reach 20% of manufacturing**
Aerospace	at least 20%	106	106	19	19
Automotive	1.5%	184	2453	20.4	272
HDOR	10%	70	140	7.8	16
Electronics	1%	65	2600	2	80
Home Appliances	~1%	30	600	14	280
Furniture	2%	139	1390	73	730
Industrial Equipment	2%	102	1022	14	140
Rail	4%	20	102	3	15
Marine	2%	68	681	10	100
Total		**~800**	**~9,000**	**~160**	**~1,700**

Notes: *a. Figures in orange are highly approximate as they are gross interpolations/extrapolations of the initial analyses.*
b. Excludes tires.

How does this help to achieve the 2050 net-zero GWP reduction targets?

Once again these 'challenge targets' can be set in the context of Canada's 2030 and 2050 heavy manufacturing GWP reduction targets. To recap, the current intermediate reduction target is 27 Mt/yr, so the challenge target represents 33% of this. In the context of a full 2050 net zero (around

70 Mt/yr of emissions eliminated), the challenge target would represent around a 13% contribution.

This target of 20% of manufacturing is well beyond the expansion scenarios outlined in the sector sections. Largely this is because the challenge target might need to be set further out at, say 2050, as part of a 'net zero' target, a widely accepted Paris Agreement date (UNFCCC, 2020). The expansion scenarios require near-term shifts in practice and attitude within the limits of current imagination about what is possible. Making progress on the expansion scenarios will likely precede an accelerated response at the end of this decade when the climate change imperative achieves a more widespread level of urgency in public consciousness.

The transformative targets no doubt require an underlying – and global – shift in attitude to the use of products and materials in industry and in the consumption cycle, something which will only come as environmental pressures (in the widest sense of the phrase) begin to bite.

10.4 Assessment of costs associated with VRP expansion

In general, the expansion of businesses into VRPs is, as a production activity, financially little different from any other investment decision. This may be easier for OEMs if they are leveraging existing facilities and reverse logistics or integrating new and remanufacturing (say) into common flow processes.

The costs associated with transforming the business model or associated supply chain could be more acute. For example, many VRPs can be enabled by OEMs retaining ownership and moving to pay-per-use since this retains the contact with the owner, guarantees the location of the product and drives efforts to maximize the life and, if necessary, redesign for re-use. However, this requires large up-front capitalization to build the inventory of goods for rental.

Since VRPs are easier to manage through short supply chains with more direct connections to the customer, some intermediaries may be eliminated from the supply chain. This will result in job and revenue losses, but it is questionable whether they are truly adding value or enabling a more circular economy. They can be replaced, as this work has shown, by life-extension-adding service jobs either at point of use or at centralized facilities.

In the UK, a US-based home appliance company has made exploratory moves in direct-to-customer sales and service because of frustrations with the current retail chain. Another appliance company – Dyson – has already gone down this route in a move accelerated by COVID-19; they already offer parts on-line and device refurbishment services at very reasonable prices.

Economies are moving to become more 'circular'. It would therefore be strange if there were no impacts on waste collection, recycling and other traditional end-of-pipe management activities. Success in expanding VRPs would reveal itself in ways such as longer average product life and reduced demand for EoL treatments; higher percentage recycling rates (but hopefully lower absolute levels) due to improved design for deconstruction at disposal; and possibly spin-off benefits in reduced demand for virgin materials and critical raw materials. Two key affected sectors are:

- **Waste management:** reduced waste demand but re-engineered to support genuine EPR and product recovery for servicing, perhaps incorporating triage services and processing. An example of this is Syncreon.
- **Mining and extraction:** Canada is a prime player in mining and resource extraction. Depending on the sector and composition of products, some producers may be negatively affected by reductions in raw material demand caused by increased VRPs and longer-lived products.

10.5 Consideration of factors affecting choice of remanufacturing over alternative VRPs

Throughout this study, we have identified several economic barriers to remanufacturing that may hinder the expansion of remanufacturing into new products and sectors. These economic barriers act to raise the cost of undertaking remanufacturing and therefore make a remanufactured product less economically attractive to consumers than alternative options, such as purchasing a new or second-hand product.

Labour costs – remanufacturing is generally a more labour-intensive process than manufacturing due to the variability of core conditions and types received, and thus the more limited application of automation. When remanufacturing occurs in a location with high labour rates, as in Canada, the US and the EU, the economic feasibility of remanufacturing is greatly influenced by both the amount of labour required to remanufacture and the original product price. The lower the labour requirement, e.g. through the use of automation, remanufacturing products that are easy to disassemble, etc., the lower the economic barrier to remanufacturing. The higher the original product price and complexity (and by implication the value of the materials embodied in the product), the greater the 'window of economic feasibility' for investing in remanufacturing labour. For example, remanufacturing a $CAD 10 product would only be feasible with a very limited amount of labour, while remanufacturing a $CAD 1,000 product has a greater opportunity to undertake remanufacturing operations while still turning a profit.

Reverse logistics – the input into the remanufacturing process is core, and the economic feasibility of remanufacturing is influenced by the cost-effectiveness of the logistics involved in identifying, collecting and transporting core, either directly from customers, or via a core broker. The lower the cost of the product, the greater the dispersion, and the weaker the knowledge of core location and condition, the greater the cost and economic barrier of reverse logistics. It is for this reason that remanufacturing of aircraft tires, with high value, concentrated and well-known locations and conditions are more commonly remanufactured than, for example, passenger vehicle tires with their low cost, wide dispersion and weak return channels.

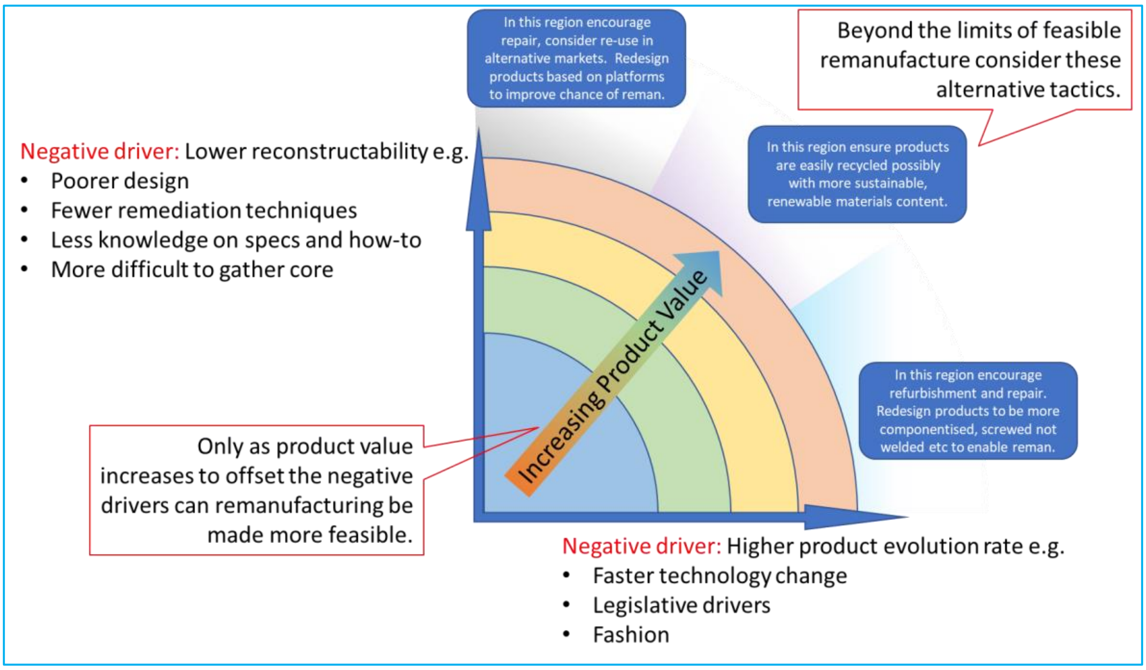
The cost of reverse logistics compared to product value is an important feature in many home appliances and electronics products. This again pushes towards VRP models which at least facilitate community, self- or in-home repair (by others) and at best offer servitized appliances. In this respect it shows how effective VRP delivery can be strongly bound to particular business models.

Remanufacturing know-how – before any product can be remanufactured, the remanufacturer must develop a process for undertaking the remanufacturing process and testing the final product's performance. This requires investment in R&D, tooling, jigs and fixtures, process development, and for independent remanufacturers, may also require development of software interfaces and reverse engineering. This investment can be significant, and for products with a fast technology cycle and/or low value, the investment may not be worth the return.

While some of these economic barriers may be influenced by changes in technology (e.g. automation), policy (e.g. tax reductions for VRP activities) and business models (e.g. product servitization), some will persist due to factors such as product value and technological evolution and so there will continue to be some products for which remanufacturing is not an appropriate VRP.

A visual summary of the 'feasible zone' for remanufacturing in particular is shown in Figure 45.

Figure 45: Map of remanufacturing 'feasible zone' and alternative tactics



Viability is a competition between the amount of value at stake in the product in question and the twin forces of 'reconstructability' and 'evolution'. The larger these factors are, the higher the value of the product must be to make the venture worthwhile. There is a limit where remanufacturing is not viable and beyond this other VRPs come into play and, failing that, other approaches to redesign the product to affect evolution or reconstructability, or to make sure they can be recycled and with lower material impacts.

11 Assessment of differentiating factors associated with business characteristics

As part of this study, we examined the differences between large and small operators in undertaking VRPs, since differences between operators are apparent in other aspects of business by size and type. Operator sizes include Small-Medium Enterprises (SME) versus Large Enterprises (LE). Operator types include Independent Operators, contract agents, and OEMs.

To see if different VRP operators experience similar differences by size and type as other aspects of business, this section explores two queries:

- Does company size between SME and LE play a role in the challenges faced by VRP operators or the type of support they might need?
- Are the differences in the challenges faced by independents, contract agents and OEMs and the types of support they might need to initiate, maintain or grow VRPs?

11.1 Small versus large enterprise

The general observation is that just because a business is small, compared to larger businesses it does not face any issues in remanufacturing which are not also apparent within normal manufacturing. For example, the ability to establish new ventures and raise capital will always be easier for large companies which may well be publicly quoted and have diverse operational income streams. Small companies may well have less margin to undertake supporting activities such as training. Therefore, the conclusion is that whatever measures have traditionally been taken to support micro and small businesses should be continued to boost VRPs.

We believe that there are other differences between small and large companies which imply different needs and different support: Large companies have become large by growth or acquisition; many small companies are early stage, growing and taking advantage of an opportunity which larger companies cannot or choose not to exploit. In essence, small companies have a role in initiating new activities and in moving into areas – possibly niche and localized – which larger companies reject and possibly are antagonistic to. This has been observed within the automotive sector for the current work, where smaller businesses both found it easier to recruit and had higher labour productivity (see Section 5).

This study has shown that VRPs are not unknown in Canada, but they are not high-profile practices, particularly remanufacturing and comprehensive refurbishment. How these might be supported and developed will, of course, vary by sector and by type of VRP.

Considering that small companies are a strong engine for driving novelty in business practice, it is well worth ensuring that they are not disadvantaged or unfairly squeezed. Even better, they should be actively supported in delivering objectives that are environmentally and economically desirable from Canada's national viewpoint.

Related to this, large companies in established economic areas benefit from systems and infrastructure which support the status quo ranging from the available personnel skills through to the fiscal treatment of value added versus value retained. By this, we mean that conventional value-added taxation (GST) assumes the cumulative addition of resources to produce goods of higher worth than their inputs, which uplift is taxed. In value-retention, it is implicit that that value has not disappeared therefore the uplift in value ought to be classed as zero or at least lower due to the lesser input of resources. This is not necessarily reflected in the conventional GST calculation of output price less input cost and could therefore receive some alternative treatment, for example based on simpler taxation of added energy and materials (see Section 15.3).

However, past performance suggests that small enterprises may have certain advantages over larger ones when it comes to adopting the servitization business models which frequently accompany VRPs. According to an analysis by Neely (Neely, 2007), which compared the financial performance of service-based companies to all companies, moving to a service model resulted in higher bankruptcy rates in general, but it was lower for small companies. This may be because more small companies form specifically to be service companies and dedicate themselves to the mission in a way that larger companies find difficult to accommodate within their traditional structures; and, similarly, smaller companies may be more adaptable as learning organizations in balancing supply chain, manufacturing and customer needs.

11.2 Independents versus Original Equipment Manufacturers

The issues of independent agents versus OEMs are more fundamental than company size when considering VRPs. The following factors are relevant and could be influenced by policy or other intervention:

- Independent agents do not necessarily have access to the design specifications of original equipment. Often, this means they expend a substantial effort to reverse engineer designs before rebuilding. This requires a particular engineering skill set, often hard-won by time-served engineers and technicians.

  Other jurisdictions, such as the European Union, have introduced a Right to Repair which at least permits third parties or owners to attempt repair. However, on the whole, OEMs still guard their design information zealously, which offers a significant barrier to confidently embarking on any repair VRP.

  While some jurisdictions have taken steps to mandate minimum product life and support – including spares – virtually none has mandated that design information be made available. A notable exception is the US state of Massachusetts where a "Right to Repair" law was introduced in 2013 in order to ensure access for independent repair and service technicians to automobile repair and diagnostic information accessible via a universal interface system. Such a possibility might be introduced more widely to come into effect at least once the warranty period has ceased, for example.

- On the positive side, a substantial industry has sprung up to offer both original or compatible parts for home appliances and electronics, and web-enabled home repair tutorials. For example, iFixit, a user-originated website, has collated 'tear-down' information on over 4,000 products, largely in the form of videos but with linked access to spares providers. iFixit also rates products by their ability to undergo repair – to be non-destructively disassembled, parts replaced and reconstructed. This 'name and shame' action has been highly influential in motivating OEMs to improve their designs to facilitate disassembly and repair, for example, the HP's Elitebook 840 G6 which scored an iFixit 10 compared to a 2 scored by its predecessor (Purdy, 2019).
- There are clear distinctions between what is passed off as 'own brand' and what is 3rd party equipment. Certain jurisdictions, such as Germany, forbid resale of remanufactured goods under the OEM brand, which must be defaced or removed. Independent agents must not claim unwarranted endorsement of the brand unless they are acting on behalf of an OEM.

These points will be picked up in Section 13.

The following factors are pertinent but are inherent features of being an OEM and are not amenable to intervention:

- OEMs have the choice of making their VRP goods explicit or implicit within their brand; independent agents must be explicit about their service. By this we mean that – in an implicit service – repair or replacement under a warranty or guarantee might be delivered in any manner the OEM seems acceptable, by either a new or remanufactured device, without consulting the customer or client. The brand of the OEM is at stake and defends the customer since it is not in the OEM's interest to jeopardize its reputation (this generally features in a whole-life contract). An explicit service means that the supplier and purchaser engage in a transparent transaction regarding the nature of parts and the performance it should yield.

- Independent agents face issues of sourcing core material: particularly for industrial equipment, OEMs are likely to maintain contact with customers or at least know where their products are being deployed. This implies the possibility of a direct route for return of products at end of life. Independent agents may need to spend substantial effort in locating used equipment or incur the expense of 'core brokers' to collect, aggregate, sort and transact, with perhaps lower control over the types and quality of goods received.

12 Assessment of current policy and action

This section provides a review of supporting or hindering actions being taken at all levels together with a report of related international trade arrangements. The subsequent section tackles the issue of what interventions might be needed by these various agencies to promote VRPs and realize the benefits previously outlined.

12.1 VRPs and the Canadian context

There is a substantial body of work from abroad on foreign national and regional practice of remanufacture. This work is highly informative of the sectoral prevalence and attitudes and broadly indicative of the barriers and policy perspectives apparent, a number of which translate across boundaries. However, these insights are not necessarily embedded in the Canadian experience. Therefore, it is necessary to be aware of and adaptable to the Canadian economic, political and social environment and especially to its unique features. These include its relatively sparse population relative to other geographies where VRP sectors are strong, its proximity to the US which has a strong manufacturing and remanufacturing sector, etc. any of which could invalidate transferable learning from elsewhere or require bespoke local solutions.

Our analysis has been informed by insights from an event under the ECCC mandate, the Circular Economy (CE) Experts Roundtable, held March 5 & 6 2019 in Ottawa (Intersol & Stratos, 2019). Delegates, including representatives from federal government, academics, researchers and consultants with applicable expertise, and industry representatives from across Canada identified six characterizing factors where the Canadian context needed taking into account in decision-making and planning. These are briefly summarized:

- **Cities and urban centres** – Canada has a few dense cities spread far apart across the country. Canadian cities are growing, placing demands on materials. However, they demonstrate broad diversity of geography, economies, regional attitudes, etc. This is both a challenge for developing local CE strategies and an opportunity to foster local innovation through experimentation.
- **North American market and trade integration** – In Canada, the cost of transporting goods across large distances is high. Approximately 70% of the economy is strongly influenced by the US, so opportunities to look at global markets for local ideas related to the circular economy would be welcome. The idea of scalable local solutions which might be exported was attractive, but better systems of tracking CE-related values and flows were highly apparent.
- **Remote, rural and northern economies** – Canada's unique context related to its remote, rural and northern economies was addressed. Small, dispersed communities are often not well supported with the services and infrastructure they require as well as difficulties of logistics year-round. There is a need for solutions that meet this local context and develop sustainable capabilities and are not simply imported.
- **Canadian values, beliefs and behaviours** – Though hard to articulate, participants discussed a sense that Canadians have a broad interest in the environment and enjoy a high standard of living, but this is fuelled by the abundance of Canada's large supply of natural resources and land. The CE transition is likely to prove challenging to this world view. Technology, education, product certification and leadership would play important roles in modifying behaviour.
- **Unique socio-economic considerations** - The socio-economic considerations related to the CE are an area that is under-researched globally, let alone in Canada. Participants discussed the challenge of understanding the purpose of pursuing CE if we do not understand its social considerations e.g. the impact CE could have on issues such as poverty. They were also

interested in opportunities for branding a Canadian-style CE which could have knock-off effects e.g. support for tourism and business investments.

- **Jurisdictional fragmentation** – Canada has a division of powers and roles between federal, provincial/territorial and municipal governments with respect to resource extraction, waste management and environmental protection, but resources do not always match this split. However, participants acknowledged the need for a strong centre in a CE transition, providing guidelines and incentives, as well as to reinforce provincial/territorial/municipal initiatives.

12.2 Summary of Canadian jurisdictional context

12.2.1 *The role of the federal government*

While the Canadian federal government has an important role in horizon scanning and obtaining consensus on policy direction, save for a few reserved powers, the implementation of policy strategies and tactics, for example of waste management, is largely devolved to the provincial and territorial administrations. Without prejudicing the commentary which follows, the findings of this study suggest that a stronger steer from the centre may be beneficial in setting priorities and targets, coordinating education and messaging and harmonizing policy and action with respect to VRPs in the devolved governments. An acceptable forum for initiating this process is the pan-provincial Canadian Council of Ministers of the Environment (CCME) for federal-provincial/territorial matters and the Federation of Canadian Municipalities for municipal interventions. Canada is also currently involved in the Organization for Economic Cooperation and Development's (OECD) working group on waste management and resource efficiency, thus connecting Canada with international best practices and research in this space.

12.2.2 *What is already happening?*

In summary, the policies and actions of the provinces and territories are almost exclusively focused on waste management and materials recycling. These are certainly components of the circular economy – which is recognized amongst respondents – but are actions taken after items have been consigned as waste and thus under the jurisdiction of waste management authorities. Overall, VRPs intercept products before this fate so, particularly in the case of domestic re-use, they do not fall onto the radar of provinces and territories, are not routinely measured and thus do not attract concerted attention.

Initiatives around packaging and plastic waste (often associated with packaging) are much in evidence.

Ontario provided a comprehensive response, detailing via reference to its annual report (Resource Productivity and Recovery Authority, 2018) on activities across materials and wastes such as printed paper and packaging (Blue Box Program), beer and alcohol containers, used tires, waste electronics and electrical equipment (WEEE Program), municipal household or special wastes (MHSW Program) and other materials such as paints, pharmaceuticals and sharps. While these comprise a broad attack on waste, only the tires program and possibly the WEEE program might tackle VRP opportunities rather than lower impact CE options.

However, the lack of widespread action on VRPs does not mean that they are considered unimportant. For example, Nova Scotia reports that repair and re-use is the largest category of employment in the province. It is, therefore, more likely the case that jobs and industry in VRPs benefit from existing business development actions, but simply have not been examined through the lens of Circular Economy and its more holistic stance. This is supported by information from Northwest Territories which forwarded links to business directories. On scanning the companies mentioned, several of them were clear candidates for VRP services and indeed may already be partaking.

One respondent provided an example in Vancouver of a leading public sector approach to product and material handling that places it amongst foremost regions of the world. The Building De-construction and Re-use Initiative has been summarized neatly in one article as follows:

> *'In Vancouver, homes built before 1950 must have 75% of non-hazardous materials recycled. That minimum is 90% if the home is deemed a 'character house.' It's only for houses from 1910 and older that* ***must be deconstructed*** *and have a minimum wood salvage of three metric tonnes.' (Paterson, 2020)*

While this refers explicitly only to the recovery of wood, the process of deconstruction can yield reusable building components and sub-systems – doors, windows, lintels, air-con, flooring – all targets for re-use as a minimum. Other countries have viable independent businesses based on this practice, which might form a relatively easy target for regional or local intervention.

Table 34 summarizes leading examples which might be developed locally.

Table 34: Leading examples of VRP-supporting policies in provinces and territories

Location	Policy or Activity
Nova Scotia	Has in place **trade agreements that incorporate environmental footprints**. This is a good measure for rational comparison of service impacts and is a strong signal to suppliers.
New Brunswick	**Government website** has suggestions for citizens on re-use and reduction. This could be extended to a host of VRP-related support services.
Quebec	**Repair cafés** and **on-line sharing platforms** are in operation. This is a useful model for home- and community-based VRP operations such as repair and re-use. A **Residual Materials Management Policy** gives priority to reduction and re-use. The **Regulation Respecting the Recovery and Reclamation of Products by Enterprises** requires EPR programs to consider re-use before recycling for electronics, batteries, household appliances. The academic base, through organizations such as Institute EDDEC (IEDDEC) and the Centre d'études et de recherches intersectorielles en économie circulaire (CERIEC), is also active in CE research.
Ontario	The **EPR and Resource Recovery and Circular Economy Act, 2016** (RRCEA) set targets for retreading of tires, incentive for refurb/re-use of EEE.
British Columbia	**Repair Cafés**, **Turo C2C car sharing**, **Tool Library on-line** sharing platforms all feed into extended use of products or better utilization of them. The **Building Deconstruction and Re-use initiatives** (Vancouver Economic Commission (VEC) Upcycle Design Project) mandate extraction of valuable sub-systems before demolition.
Yukon	Yukon is engaging the public on CE with **communications campaign** "Do the Heavy Lifting" to raise awareness on reduction/re-use. This shows openness to changing public perceptions and behaviours. **Using LCA** to determine best practice for dealing with wastes. This could be extended to products to inform policy.
Various	**EPR and product stewardship programs** (tires, WEEE…). Particularly those with a product focus should be examined for their impacts, strengths and transposability.

Some other commentary from the research is relevant:

- The clearest message arising from this work is the lack of clarity in distinguishing VRP activities from waste activities. Some education and guidance may be appropriate.
- Not unlike other countries, building a coherent approach to VRPs and CE while still respecting local autonomy, is difficult, but may involve building a common framework for analyzing current impacts, potentials, common approaches to incentivizing, motivating and reporting, factors to consider in change and a nationwide messaging of Canada's 'value-retention culture'.

- Northwestern Territories expressed an interest in a branding or logo for VRPs. This is an excellent ambition but may require federal coordination to ensure correct messaging and correct identification and assessment of the impact factors relevant to different VRPs so they might be fairly compared. We should also be aware of international efforts to harmonize e.g. remanufacturing standards.
- One respondent indicated that they had heard that there is a policy in Alberta that is meant to spur investment in VRPs in that province. No evidence of such a policy was identified during the course of this study. However, if such a policy does exist, it should be examined in more detail for its wider applicability.
- Some provinces were aware of initiatives abroad which might be copied. The EU 'Right to Repair' Directive was quoted. This would certainly liberate consumers to home repair some types of domestic goods, but further signposting to enable good decisions, obtain spares and use safe practices as well as stimulating local repair services is needed. More detail on responses is provided in Annex G.

12.3 Potential or actual enablers of VRPs

12.3.1 *Synergies and relationships*

This section reports on any synergies and relationships between Canada and other countries which impact positively or negatively on local remanufacturing or trade in remanufactured (or other VRP) products.

As the host of the 2018 G7 Value Retention Policies workshop held in Montreal, Canada demonstrated its credentials as an emerging leader in the Circular Economy (European Commission & International Resource Panel, 2017). Building on the previous leading economies workshop held in Brussels in 2017, a strong cross-ministry cohort, together with the EU delegation, drove a highly engaging agenda, with a distinctly practical edge. Participants subscribed to a range of actions including:

- Working with international partners to support the expansion of VRPs.
- Expanding the global potential for VRPs with China, Brazil and other emerging economies.
- Updating product-related policies to support VRP expansion and enable frameworks which reward innovation.
- Clarifying definitions in existing international frameworks dealing with waste and end-of-life products.
- Pressing for the development of standards for (i) remanufactured and refurbished products and (ii) product design standards in national and international standardization bodies.
- Ensuring that regulations and standards balance concerns for consumer safety and privacy with the need for third-party access to product information and parts.
- Incorporating value-retention considerations as part of procurement and asset management practices.

The findings of this work agree with these recommendations.

Formalized relationships

The most overt relationship for Canada is the trade agreement between Canada, the United States and Mexico (CUSMA[7], previously the North American Free Trade Agreement – NAFTA). Article 2.11-12 of CUSMA makes explicit reference to remanufacturing (United States International Trade Commission, 2012b). No equivalent reference to refurbished goods or core is made in the now

[7] Entered into force July 1, 2020

superseded NAFTA text, implying a partner nation could have, in theory, place restrictions on movement of refurbished goods or core.

Sector analysis quoted previously reveals that there is a significant trade into and out of Canada to the North American partners to feed offshore remanufacturing particularly, in automotive and HDOR.

The Agreement is a clear attempt to reduce friction[8] in trade in remanufactured products but is not explicit in its treatment of core which could cross borders in either direction. Such transactions might be subject to different controls depending on classification of core as waste or – potentially – hazardous material. In other jurisdictions, such as the EU, such interpretations (which may well be incorrect) have hampered trans-shipment even between Member States. Further investigation of this point in the Canadian context is required.

Review of CUSMA for its relevance to VRPs

The text of the 2018 Canada – United States – Mexico (CUSMA) agreement makes explicit reference to remanufacturing and remanufacturing related materials. However, assessments of the likely overall impact of CUSMA place its effects as modest across all activities, for example increasing US GDP by only 0.35% (Wragg E. , 2019). The CUSMA does differ from NAFTA in ways that broadly impact importers, exporters, and manufacturers. These include an increase in the de minimis threshold – the percentage of a good that must be produced in a CUSMA market in order to qualify as an originating good – from 7% to 10%, as well as changes to the rules of origin for the automobile sector (Wragg E. , 2020). However, it does enforce a change whereby bans on used goods cannot be applied to remanufactured goods.

A summary of changes under CUSMA is available from this US document: (USCBP, 2020), but we outline here the areas of the agreement text relevant to remanufacturing and other VRPs and draw out the key implications for Canada. Further analysis can be found in Annex C.

The CUSMA text contains the following references to the trade of remanufactured goods.

Article 2.12: Remanufactured Goods

1. For greater certainty, Article 2.11.1 (Import and Export Restrictions) applies to prohibitions and restrictions on a remanufactured good.

2. Subject to its obligations under this Agreement and the WTO Agreement, a Party may require that a remanufactured good:

> *(a) be identified as such, including through labelling, for distribution or sale in its territory, and*
>
> *(b) meet all applicable technical requirements that apply to an equivalent good in new condition.*

3. If a Party adopts or maintains a prohibition or a restriction on a used good, it shall not apply the measure to a remanufactured good.

Article 2.11.1 requires that “no Party shall adopt or maintain any prohibition or restriction on the importation of any good of another Party or on the exportation or sale for export of any good destined for the territory of another Party”. This text is a clear attempt to reduce friction in trade in remanufactured products, although it does allow for a Party to require that a remanufactured

[8] “A frictionless market is a theoretical trading environment where all costs and restraints associated with transactions are non-existent.” (Downey, 2019)

product is identifiable as remanufactured (e.g. through labelling) and meets the same technical requirements as "an equivalent good in new condition".

In the US, the Manufactured Again Certification scheme, operated by MERA (The Association for Sustainable Manufacturing) offers a certification and labelling scheme for remanufactured products. The Remanufacturing Industries Council (RIC) in the US, who led the development of American National Standards Institute (ANSI) RIC001.1-2016 - Specifications for the Process of Remanufacturing, have also developed a three-tier remanufacturing accreditation program using the standard:

- Level 1 Compliant – self-regulated
- Level 2 Verified – desk-based validation of documentation showing remanufacturing processes are in line with ANSI RIC001.1-2016
- Level 3 Certified – site visit by third-party validator. Certification to this level is intended to "prove to customers that they meet the same quality and safety standards as OEMs" (RematecNews, 2020)

Currently, this accreditation program is only available to Remanufacturing Industries Council (RIC) members. The existence of these schemes indicates that the US is currently well-placed to support remanufacturers should they need to demonstrate their products "*meet all applicable technical requirements that apply to an equivalent good in new condition*", as per Article 2.12. It would be efficient to buy into these programs rather than create anew.

Canadian remanufacturers may also use the MERA and RIC certification programs, but currently there is no equivalent offering in Canada.

If remanufactured goods under NAFTA were considered to have undergone "repair or alteration" as per the definitions in Article 318, then Annex 307.1: *Goods Re-Entered after Repair or Alteration* implies that there could be customs duties liable. By including a distinct definition for remanufactured goods in the CUSMA text, it makes it explicit that remanufactured products do not fall under the "repair or alteration" activity. NAFTA did not explicitly define remanufacturing or refurbishment.

The CUSMA text contains the following article relevant to the treatment of core (or "recovered material", as defined in the agreement text):

Article 4.4: Treatment of Recovered Materials Used in the Production of a Remanufactured Good

1. Each Party shall provide that a recovered material derived in the territory of one or more of the Parties is treated as originating when it is used in the production of, and incorporated into, a remanufactured good.

2. For greater certainty:

> *(a) a remanufactured good is originating only if it satisfies the applicable requirements of Article 4.2 (Originating Goods); and*
>
> *(b) a recovered material that is not used or incorporated in the production of a remanufactured good is originating only if it satisfies the applicable requirements of Article 4.2 (Originating Goods).*

Article 4.4 states that core originating from one or more of the Parties is "treated as originating when it is used in the production of, and incorporated into, a remanufactured good" and so can be given preferential tariff treatment.

Article 2.8: Goods Re-Entered after Repair or Alteration

1. No Party shall apply a customs duty to a good, regardless of its origin, that re-enters its territory after that good has been temporarily exported from its territory to the territory of another Party for repair or alteration, regardless of whether that repair or alteration could have been performed in the territory of the Party from which the good was exported for repair or alteration or has increased the value of the good.

2. Paragraph 1 does not apply to a good imported under a duty deferral program that is exported for repair or alteration and is not re-imported under a duty deferral program.

3. Notwithstanding Article 2.5 (Drawback and Duty Deferral Programs), no Party shall apply a customs duty to a good, regardless of its origin, admitted temporarily from the territory of another Party for repair or alteration.

4. For the purposes of this Article, repair or alteration does not include an operation or process that:

(a) destroys a good's essential characteristics or creates a new or commercially different good; or

(b) transforms an unfinished good into a finished good.

This clause might be seen as prejudicial to Canada given that many goods used in Canada originate from other CUSMA member countries and there is no tariff barrier to exporting imported end of life/end of use products back to the originator (typically to the US) for remanufacturing. In effect this leads to a bleed of core away from the point of use. A response to this would be to stimulate domestic manufacturing in conjunction with remanufacturing. A related point indicated by a study participant was that – in practice – even core originating in Canada is not penalized on export, which represents a loss.

The addition of Articles 2.12 and 4.4 are constructive developments compared to the previous NAFTA agreement and supports the trade and movement of both remanufactured products and core. The CUSMA text also refers to repair activities in Article 2.8 and prohibits the application of customs duties on a good re-entering a country after repair:

At a sectoral level, aerospace MRO activities are included in Chapter 15 – Cross-border trade in services. This means that Canadian aerospace MRO companies should have unimpeded market access to service contracts in the US and Mexico.

Provincial and Territorial relationships

The Waste Management Task Group of the CCME, a forum comprising the provincial, territorial and federal environmental departments, undertakes collective action on waste management issues in Canada. In the past, the CCME Waste Management Task Group has worked together on various Canada-wide strategies around reducing packaging in Canada (2012) and developing a Canada-wide strategy for EPR (2009) (Giroux Consulting, 2013). In 2018, the Group endorsed the Aspirational Canada-Wide Waste Reduction Goal and in 2019, the *Canada-wide Action Plan on Zero-Plastic Waste: Phase 1* as a first step to implementing the Canada-Wide Strategy on Zero Plastic Waste with the focus areas (CCME, 2019) summarized in Table 35. An update to this plan – Phase 2 – has been issued in the summer of 2020 (CCME, 2020).

Table 35: Action items undertaken by CCME as part of their Zero Plastic Waste Strategy, 2019

Item	Response
Extended Producer Responsibility	CCME will facilitate consistent EPR programs for plastics through the development of guidance and tools that can be used by jurisdictions to implement EPR programs.
Single-use and disposable products	CCME will facilitate action by developing a roadmap to manage single-use disposable plastics and identify sustainable alternatives, where available.
National performance requirements and standards	CCME will compile existing guidelines for designing single-use items to improve recyclability and develop recommendations for jurisdictions to consider during implementation.
Incentives for a Circular Economy	CCME will develop best management practices for disposal bans, facilitating economic and fiscal incentives for greater value recovery (i.e. repair, remanufacture/refurbishment, recycling).
Infrastructure and innovation investments	CCME member jurisdictions will promote the use of incentives to transition to a circular economy for plastics including targeted investments for infrastructure and innovation in the areas of plastic design, production and recovery, and/or for transitioning current operations to circular economy practices.
Public procurement and green operations	CCME will facilitate information and best practice sharing between member jurisdictions to strengthen their sustainable procurement policies and practices to support a more circular economy for plastics.

12.3.2 *Technological innovations*

Technological innovations that could facilitate remanufacturing and other VRPs include:

- Additive manufacturing technologies.
- Internet of Things and connectivity.
- Automation and autonomous systems.

Additive manufacturing

The developments in additive manufacturing technologies such as 3D-printing and hybrid manufacturing are of increasing interest to VRP practitioners as they have the potential to overcome several barriers to their operations. The ability to selectively add material to worn parts gives VRP practitioners a more efficient process route to return the part to original specifications, compared to conventional subtractive manufacturing processes. Other benefits include reducing dis-economies of scale when producing low volumes of components – the cost per part of additive manufacturing is largely independent of volume, unlike conventional manufacturing. Additive manufacturing can also help reduce the time and cost associated with reverse engineering VRP processes. Developing the tooling and fixings for remanufacturing and VRP other operations can be a significant investment if the original OEM specifications are not available. Technologies like 3D-printing can help reduce the development cost and lead-time of producing this equipment.

Internet of Things

The trend for greater connectivity and the Internet of Things has potential applications for VRP activities. Real-time condition monitoring could help predict when maintenance and servicing activities should be scheduled to maximize product life and reduce downtime. This is particularly important for sectors like the industrial equipment and HDOR sectors, where unexpected downtime can result in significant costs. GE Healthcare is using the cloud and machine learning to understand their core for example, for MRI scanners, building a “digital twin” with information on the number of scans performed and part replacement history to help predict failure and monitor core value, which will inform VRP interventions. These technologies may also help encourage changes to customer behaviour that could support VRP activities, for example, prompting scheduled and ad hoc servicing and facilitating communication between the customer and VRP practitioner to arrange take-back.

Automation

The development of automation including autonomous systems could have useful applications for VRP activities. These include eliminating less desirable manual tasks, e.g. heavy lifting, handling dirty core and facilitating the development of remanufacturing and other VRP processes for new high-voltage products, like electric vehicle batteries. Automation is currently best suited to repetitive and high-volume tasks, such as assembly processes. Automating the disassembly process is more challenging due to the variety of core types and conditions in which they may arrive. Developments in visual systems for core identification, handling and in automated unscrewing processes (which has far greater variability compared to the assembly process) are key areas of active research. High equipment, development and training costs are also a challenge for small and medium-sized companies wishing to incorporate automated processes into their operations.

12.4 Perspectives on trans-national aspects of VRPs

This study has included input from federal government departments with interest in international trade. This complex area is partitioned into functions with a sector focus and those aimed at overarching functions such as tariffs, market access and product standards. All these are of interest to this work.

It is our understanding that international trade is monitored and governed by voluntary subscription to the authority of the World Trade Organization (WTO), which covers over 150 countries. A general principle is that there should be no trade quotas except where national imperatives such as security, environmental protection or plant or public health override. (In practice, the health considerations are often used to justify barriers.) If this is the case, the WTO must be notified formally, and this remains as a public record. In theory, it should be possible to locate relevant trade restrictions by interrogating this record though, often, notifications are not complete.

These 'default' rules are frequently reinforced within country-specific free-trade agreements (FTAs) though the right to object remains. Many agreements do include obligations for the free exchange of remanufactured goods but, strangely, the European Union is not one of them despite its apparent interest as expressed in its Circular Economy Strategy.

Goods may be labelled under CUSMA as remanufactured but need to meet as-new performance. However, there does not appear to be a means of testing how or what process of remanufacturing – if any – has been applied to such goods; this should be an area of future work.

Other VRPs are not routinely discussed or covered within agreements. This is largely because of the difficulty of establishing the status and provenance of partially or wholly used goods. The case of so-called e-waste dumping into developing nations makes it a sensitive issue which is unlikely to be overcome soon. However, specific FTAs – such as between Canada, US and Mexico – do recognize that legitimate trade in used goods – core – is possible, legitimate and desirable; provisions exist to waive tariffs on the cross-border transfer (or temporary import) of remanufacturing 'work in progress' provided that the finished product is returned to its point of end-of-life (see also Section 12.3.1).

12.5 Comparison with other nations

International comparisons can be made in three respects: an assessment of the relative level of activity; how the quality of that activity stands up to international comparison; and, at the governance level, how coherent are policies and initiatives to support VRPs.

With respect to comparisons on the level of activity, this is complicated by the fact that the data we have collected relates to all VRPs, something no other country has attempted. Fair comparison might only be made on levels of remanufacturing, which is hard to disaggregate, but it appears to be in the region of $CAD 5–6 billion in Canada on a like-for-like basis. This is somewhat below the US on a per capita basis, but broadly in line with the UK. However, activity is dominated by aerospace and automotive, and it is likely that the automotive component, which is under-represented in Canada, reflects the relative lack of domestic auto manufacturing.

The consumer goods sectors may also be under-represented. This is hard to confirm quantitatively but this is the indicator from interviews. However, a similar story prevails in other jurisdictions reflecting the difficulty of stimulating high-end VRPs, such as remanufacturing and comprehensive refurbishment, in highly price-sensitive markets. Given the generally low prevalence of VRPs, the consumer goods area is a good target amenable to boosting both by improving collection infrastructure and enabling local or assisted home repair. In this respect, several provinces were aware of the European Union 'Right to Repair' Directive. This would certainly liberate consumers to home repair some types of domestic goods, but further consumer signposting to enable good decisions, obtain spares and use safe practices as well as stimulating local repair services is needed.

At the high end, aerospace and automotive are global sectors which must hold their own technically and by maintaining critical mass. Their practices appear to match those of international competitors but being close to a large trading partner – the US – Canada should likely focus on growing existing centres of practice in these sectors to avoid dilution and diseconomies of scale.

Regarding policies and initiatives to support VRPs, there is currently very little taking place in Canada at the provincial or federal level which could be described as a coherent approach to VRPs in the context of the Circular Economy. Canada's efforts on extended producer responsibility do, however, have the flexibility to incorporate some of the ideas proposed within the policy section, notably a graduation of 'End-of-Life (EoL) tariffs'. We refer to a similar idea proposed for the European Union.

Canada is not alone in this, but there are fragments of good policy from elsewhere. For example, China has a good policy framework, founded on the 2009 Circular Economy Promotion Law. Circular Economy has been included in the 13th five-year plan, in which the Chinese Government stated their intention to develop remanufacturing and implement extended producer responsibility (EPR) systems. This is perhaps a good starting point given the objective to formulate VRP components of an analogous Canadian CE policy framework.

Neighbouring USA is further advanced and indicates practical actions which can be taken at federal and state level. For example, to boost purchaser confidence, programs such as the 'remanufactured in the USA' label created by the Federal Trade Commission (FTC) in 1998 (Guidat, Seidel, Kohl, & Seliger, 2017) are in place. The feasibility of tax credits is demonstrated by roughly 20 States which have instituted tax credits and embedded the public procurement of remanufactured products (Kang, Jun, Kim, & Jo, 2016).

Within the EU there has also been support for VRP activity firstly via placing re-use within its Waste Directives and more recently as part of the Circular Economy Action Plan (2015 – 2019, revised 2020) (European Commission, 2015; European Commission, 2020). The latest revision includes a broad range of actions relevant to this work targeting cross-cutting themes and high-impact sectors and with intent to support remanufacturing. For example, the Commission intends to pursue the use of EPR and to strengthen ecodesign standards via an ecodesign working plan, to improve product efficiency, durability and repairability and with better point-of-sale information on environmental credentials and lifetimes. Actions are most clear cut in the area of electronics and information and communications technologies (ICT) where a product repairability scoring system has already been implemented. It also envisages strengthening the right to repair legislation with access to parts and upgrades, inhibiting premature obsolescence and encouraging products-as-a-service.

Given the low domestic research base, Canada should explore buying into a number of foreign VRP-oriented research programs in order to keep abreast and transfer leading edge thinking, as its agricultural sector has done with the UK's Innovate UK collaborative research support program. The EU Horizon program is also a strong candidate.

The jurisdictional structure of Canada is not unlike the EU, but with lower centralized policy making. In this area, however, for the sake of coherency and gaining traction, the case appears strong for emulating the central commonly agreed 'Directive' approach and support for this should be sought via existing forums.

13 Strategic action areas for key sectors

The analysis of key remanufacturing and other VRPs sectors highlighted barriers and opportunities according to businesses active in those sectors. These are varied and a recommendation is that they should be explored and actioned by dedicated sector focus groups. In this section, we draw together a view of the strategic imperatives for each of these sectors but also in summary to identify any common themes.

Here, we introduce the concept of five approaches: Grow, Sustain, Transform, Defend and Leverage, in Table 36.

Table 36: Description of basic strategic approaches

Strategic Thrust		Scope
	Grow	The sector, or a product/VRP service within it, is not at saturation, and there is headroom for growth. E.g. electronics, home appliances, automotive, office furniture.
	Sustain	The sector is unlikely to grow significantly, but is beneficial, with a positive effect on the skills pool of Canada. Its decline would be a loss of capability. E.g. aerospace, automotive.
	Transform	The sector requires a radical change in its attitude, business models or supply chain to realize beneficial environmental impacts. E.g. home appliances, electronics and other consumer goods.
	Defend	The sector may be threatened by, for example, foreign competition which is not subject to the same constraints. High-level or international action may be needed to create level playing fields. E.g. tires, home appliances.
	Leverage	The sector has capabilities which are leading edge and could either be applied in less mature sectors or could be used to kick start related high-value sectors such as renewables. E.g. aerospace, automotive. Also applied in the reverse direction to indicate required boost from R&D support or infrastructure development e.g. centralized collection, design for re-use.

13.1 Summary map of sector approaches

Table 37 offers a highly condensed view of the actions which are suggested for each of the six key sectors. In subsequent sub-sections, the issues facing sectors and proposed responses are expanded in more detail, but this table gives a one- or two-word summary of the responses in parentheses. For example, under Automotive/Sustain, (skills, Lean) means focus on 'developing future-proofing skills, such as electric technologies' and 'implement Lean (re) manufacturing techniques widely adopted in new-build production'.

Table 37: Summary of suggested actions and approaches per sector

Sector	Policy Thrust				
Aerospace		✓ (Accreditation)	✓ (low carbon skills)	✓ (COVID support, foreign policy)	✓ (skill share)
Automotive	✓	✓ (skills, Lean)	✓ (Electric)	✓ (tires, some components)	✓ (skill share)
Heavy-Duty & Off-Road		✓ (skills)	✓ (Additive man.)	✓ (Lean-ify)	
Electronics	✓	✓ (skills)	✓ (infrastructure)	✓ (benefits)	
Home Appliances	✓		✓ (business model)	✓ (imports)	
Furniture	✓				

This is a rather short-cut analysis of the method proposed in section 14.3.3 in that it reveals some common issues that could form priority targets for assistance.

13.2 Aerospace

The dominant VRP in this sector is remanufacturing, which is a mature market. The primary barriers to future growth are global competition, labour costs, a lack of bilateral agreements to accept VRP work conducted in Canada, and the current reduction in air travel. Strategies for the foreseeable future are Sustain and Defend. The sector needs sustaining both economically and as a pool for high skill labour which can foster future high-tech talent; it can also provide transferable skills to other VRP sectors and emergent sectors pertinent to sustainable futures such as renewable technologies. Accordingly, we have highlighted 'Leverage' as a subsidiary strategy. A further subsidiary is 'Transform' because of the environmental drivers in the industry related to low carbon and electrified aircraft as reported in Table 38.

Table 38: Barriers to greater uptake of aerospace VRP activities and suggested tactics

Strategic / Policy thrust	Barrier or Opportunity	Supporting actions
	The COVID-19 pandemic has presented a severe shock to aerospace, the effects of which could be severe in the long term	Support MRO operators facing challenges arising from the COVID-19 pandemic to avoid loss of critical skills and capabilities in the short to medium term. This support could be through **continuing and extending the range of fiscal measures** already put in place as part of the COVID-19 response.
	Being global, aerospace cites international legislation as restricting operations	The exact detail of this needs examination. In the meantime, **monitor policy** to ensure MRO activities are not unintentionally hampered through any new regulations.
	There may be issues of customers not recognizing the value of some VRP services	This may be an issue of accreditation, which is a trans-sectoral problem. This needs further exploration in a **sector focus group** and may lead to the **development of an accreditation service**, however the industry is already highly regulated through parts qualification.
	Availability of skilled personnel with the required degree of product knowledge	In addition to current needs, the anticipated long-term transition to low carbon aircraft may result in new technologies and components for MRO activity. Policy should **support training and investment in MRO activity** to keep up with these developments. This may involve establishing a sector-focused R&D hub or facilitating exchanges of personnel between companies via collaborative projects in knowledge transfer efforts.
	Diffuse capabilities into less developed sectors	Aerospace is a repository of advanced engineering techniques, testing methods and through-life auditing and tracking systems. This could be leveraged to assist other sectors. **Encourage cross-sectoral transfer of knowledge of best practice VRP operations**, with aerospace MRO as an exemplar, for example as above through a sector hub, co-projects, or personnel exchanges.

13.3 Automotive

The dominant VRP in this sector is repair, which is a mature market. The main barriers to future VRP growth include decreased road travel due to COVID- 19, cost of labour, difficulty achieving economies of scale, the high cost of transporting cores, product design (for example, the incorporation of telematics and the increased use of plastics), lack of customer recognition, lack of access to skilled labour and inadequate product knowledge (for non-OEM affiliated companies). Automotive finds itself in a similar position to aerospace though somewhat better placed for recovery when consumer confidence returns. Long term, given the activity in the aftermarket, the dominant strategy is to 'Grow' in that market and in fleet markets, and to 'Sustain' and 'Defend' the core activity base as reported in Table 39 .

Table 39: Barriers to greater uptake of automotive VRP activities and suggested tactics

Strategic/ Policy thrust	Barrier or Opportunity	Supporting actions
	Limited engagement in VRPs	While there is significant VRP activity in the automotive sector, the level of activity is lower than other nations, leaving room for growth. While in-warranty OEM-based activities may be limited by the number of OEMs operating in Canada, aftermarket activities could be expanded and would be supported by pull mechanisms such as preferential **public procurement of remanufactured components for fleet vehicles,** as in the US.
	Labour intensive nature of VRP activities	The labour-intensive nature of many VRP operations may make these businesses more vulnerable to changing market forces and reduce their competitiveness. Opportunities to level the playing field include exploring fiscal measures to reduce the cost of labour as well as supporting initiatives to apply **lean manufacturing principles** to VRP activities, including, where appropriate, the **deployment of automation**. This support could be through **business grants or loans**, or development of **collaborative industry-academia programs** looking at lean implementation and automation.
	Limits to skills and infrastructure	The status of the automotive VRP industry could be defended by creating a critical mass of activity concentrated in **clusters of competence**, where both new manufacturing and remanufacturing activities could take place. This could support the development and access to skills and infrastructure for efficient and high quality VRP activity, particularly in areas such as Electric Vehicle (EV) battery manufacturing and remanufacturing.
	Rapidly evolving powertrain technology	The transition away from traditional internal combustion engine powertrains could rapidly impact upon businesses currently engaged in remanufacturing, particularly independent operators. Policy could seek to promote the development of VRP skills for new vehicle technologies through **research funding**. Harmonizing end of life requirements such that they support VRP activities preferentially to landfill, incineration, and recycling, could include **impact-based targets and best practice guidance.**
	Diffuse capabilities into less developed sectors	The automotive industry has a wealth of knowledge and experience in undertaking VRP activities. This could be leveraged to assist other sectors. **Encourage cross-sectoral transfer of knowledge of best practice VRP operations**, with automotive examples as practical case studies, for example as above through a sector hub, co-projects, or personnel exchanges. While the aerospace sector may be considered an exemplar, the automotive has many best practice examples that may be more easily transferred into other sectors.
In respect of automotive tires		

	Low price imports	Respondents cite the import of cheap tires which are incapable of sustaining a second life as undermining business. Many countries have an up-front fee on tires which notionally pays for disposal costs. However, this vastly outweighs the true costs and is probably not needed if they are used as a fuel substitute. If such a system is in place, the fee could be reclaimed by retreaders for carbon abatement benefits for example. A cruder way to bolster the market could be through **life cycle impact criteria in purchasing** or even **mandatory public procurement**.

13.4 Heavy-duty and off-road equipment

The primary VRPs in this sector are remanufacturing and comprehensive refurbishment. The main barriers to growth of VRPs in this sector include a lack of available skilled labour and high labour costs, lack of competency in additive manufacturing, lack of adequate product knowledge (for independent VRP agents) and access to feedstock and the high cost and effort required to export VRP goods. The dominant strategy for HDOR is to 'Sustain' the sector with elements of 'Defence'.

Table 40: Barriers to greater uptake of HDOR VRP activities and suggested tactics

Strategic / Policy thrust	Barrier or Opportunity	Supporting actions
	Availability of skilled personnel with the required degree of product knowledge	Policy should **support training and investment in HDOR VRP activity** to safeguard the effectiveness of the sector. This may involve establishing a sector-focused R&D hub or facilitating exchanges of personnel between companies via collaborative projects in knowledge transfer efforts.
	Poor core access and quality	For the mining and mineral extraction industries, VRP activities for HDOR equipment should be **promoted as good environmental practice**. **Public procurement** of VRP components for public-sector, or contracted fleet vehicles could provide a market pull for the supply and access to core.
	High labour costs	The labour-intensive nature of many VRP operations may make these businesses more vulnerable to changing market forces and reduce their competitiveness, especially compared to low cost imports. Opportunities to level the playing field include exploring fiscal measures to reduce the cost of labour as well as supporting initiatives to apply **lean manufacturing principles** to VRP activities, including, where appropriate, the **deployment of automation**. This support could be through **business grants or loans**, or development of **collaborative industry-academia programs** looking at lean implementation and automation.
	Additive manufacturing	Support for businesses targeting the deployment of advanced manufacturing technologies, like additive manufacturing, could assist, for example through **low interest rate loans or grants**. Policy could also look to **support and coordinate** businesses looking to collaborate with academic researchers to develop their additive manufacturing knowledge.

13.5 Consumer and other electronics

The dominant VRPs in this sector are refurbishment and repair. The barriers to growth of VRPs for this sector include global competition for sales through on-line channels and competition with new, cheap electronics that are entering the market. The dominant strategies for this sector are 'Grow' and 'Sustain'. These strategies are aligned with other forces relevant to the electronics sector, including concerns over inappropriate treatment of end of life products, the high environmental impacts of making electronics and issues of resource scarcity.

Table 41: Barriers to greater uptake of electronics VRP activities and suggested tactics

Strategic/ Policy thrust	Barrier or Opportunity	Supporting actions
	Lack of market pull	**The further development and harmonization of EPR schemes** could encourage manufacturers to consider VRP activities as positive strategies to valorize EoL electronics and so better promote these to their customers. Other strategies to increase market demand could be the development of **refurbishment standards and/or labelling schemes**.
	Availability of skilled personnel with the required degree of product knowledge	Policy should **support training and investment in electronics VRP activity** to safeguard the effectiveness of the sector. This may involve establishing a sector-focused R&D hub or facilitating exchanges of personnel between companies via collaborative projects in knowledge transfer efforts.
	High logistics costs	The **development of effective and harmonized collection infrastructure** for EoL electronics could help transform the feasibility of VRP activities. With effective infrastructure, the public should be encouraged to return the large number of EoL devices that are currently hoarded through **information campaigns and publicity drives**.
	Promotion of whole life benefits	**Research and analysis of the life cycle impacts** of VRP activities on electronics should be supported. Where evidence shows that there are whole life benefits of longer-lived electronic devices, facilitated by VRPs, this should be made transparent, for example through a **publicity campaign.** This type of analysis may also help motivate the uptake of **Right to Repair** style regulations.

13.6 Home appliances

The dominant VRP for home appliances is repair. The barriers to VRP growth in this sector include lack of access to spare parts, the high costs of repairs compared to purchasing a new unit and the low profit associated with refurbished products. Strategies for this sector are 'Grow' and 'Transform'. There are opportunities for growth in the less formalized refurbishment sector; however, the VRP industry could be transformed by the wide-spread adoption of circular economy business models for home appliances. This transformation would more likely be realized in the long term.

Table 42: Barriers to greater uptake of home appliance VRP activities and suggested tactics

Strategic/ Policy thrust	Barrier or Opportunity	Supporting actions
	Lack of market pull	**Funding local social enterprises** to provide employment and training opportunities to socially excluded communities through refurbishing home appliances could help raise the profile and awareness of this activity. The development and **harmonization of EPR schemes** could also encourage manufacturers to consider VRP activities as positive strategies to valorize EoL home appliances and so better promote these to their customers. Other strategies to increase market demand could be the development of **refurbishment standards and/or labelling schemes**.
	Breakthrough of sharing and other servitization business models	The transition away from traditional product-based business models towards service-based ones could catalyze home appliance VRP activity. This transformation could be supported by **policy that promotes and normalizes communal facilities**, for example, in Sweden, apartments have communal laundry facilities and people do not have laundry appliances in their flats (MISTRA, 2019). Barriers to leasing and service-based business models should be reviewed, for example, a **survey of perspectives and experiences** from nascent companies operating in this area.
	Promotion of whole life benefits	**Research and analysis of the life cycle impacts** of VRP activities on home appliances should be supported. Where evidence shows that there are whole life benefits of longer-lived appliances, facilitated by VRPs, this should be made transparent, for example through a **publicity campaign**. This type of analysis may also help motivate the uptake of **Right to Repair** style regulations.

13.7 Furniture

The dominant VRPs in the furniture sector are repair and refurbishment. The main barriers to future growth include a lack of consumer recognition, lack of available cores, a highly variable quality of feedstock, lack of adequate sales channels, high labour costs, cost pressure from low cost foreign imports and lack of access to skilled personnel. The dominant policy direction for furniture is 'Grow'. The supporting actions of Table 43 are relevant to this sector.

Table 43: Barriers to greater uptake of office furniture VRP activities and suggested tactics

Strategic/ Policy thrust	Barrier or Opportunity	Supporting actions
	Lack of customer recognition	Office furniture manufacturers should be encouraged to offer a full lifetime service including maintenance and **end of life take back schemes** to make the re-use of reclaimed parts in new designs easier. If these schemes are accredited, that would help to build consumer trust. Further, **requirements for proper EoL management** would ensure material segregation and diversion from landfill thus reducing landfill GWP emissions from wood, for example.
	Lack of market pull	**Public purchasing policies and procurement** should include purchasing guidelines for office furniture that has undergone VRPs. **Funding local social enterprises** to provide employment and training opportunities to socially excluded communities through reclaiming and/or remanufacturing office furniture could help meet increases in demand driven by public procurement strategies. The development and **harmonization of EPR schemes** could also encourage manufacturers to consider VRP activities as positive strategies to valorize EoL furniture and so better promote these to their customers.
	High logistics costs	Options to reduce logistics costs include **establishing centralized waste management organizations** to reclaim and sort office furniture for distribution to manufacturers for re-use. **Take-back schemes**, whether they are voluntary or enforced would help increase volumes to support economies of scale.
	Product design	Promoting design for disassembly strategies to furniture designers and manufacturers and encouraging or mandating the long-term supply of spare parts could increase the suitability of furniture products from VRPs. Modular designs are considered an enabler to remanufacturing and could be promoted through a **design awareness campaign**.

Home furniture re-use is currently at a very low level. Re-use is hampered by the relatively high cost of refurbishment (and possibly by evolving safety standards which render old stock non-compliant and thus not sellable) which might be supported by better product design, a long-term solution which might be frustrated by imports not being to the same standard. In the short-term therefore, the tactics of Table 44 could be employed.

Table 44: Barriers to greater uptake of home furniture VRP activities and suggested tactics

Strategic/ Policy thrust	Barrier or Opportunity	Supporting actions
	Lack of customer recognition	Home furniture manufacturers should be encouraged to offer a full lifetime service including maintenance and **end of life take back schemes** to make the re-use of reclaimed parts in new designs easier. If these schemes are accredited, that would help to build consumer trust.
	Lack of market pull	**Funding local social enterprises** to provide employment and training opportunities to socially excluded communities through reclaiming and/or refurbishing home furniture could benefit disadvantaged communities as a source of employment and quality goods. The development and **harmonization of EPR schemes** could also encourage manufacturers to consider VRP activities as positive strategies to valorize EoL furniture and so better promote these to their customers.
	High logistics costs	Options to reduce logistics costs include **establishing centralized waste management organizations** to reclaim and sort furniture for distribution to manufacturers for re-use. Much re-usable furniture is lost because of 'curbside spoilage' i.e. not having accessible collection agents who can protect recovered goods from the elements and physical abuse. **Take-back schemes**, whether they are voluntary or enforced would help increase volumes to support economies of scale.
	Product design	Home furniture is typically more complex and multi-material than office furniture. This hampers repair and disassembly for recycling. Promoting design for disassembly strategies to furniture designers and manufacturers increase the suitability of furniture products for VRPs. Modular designs are considered an enabler to remanufacturing and could be promoted through a **design awareness campaign**.
	Poor EoL practice (as a component of CE)	**Requirement for proper EoL management** would ensure materials segregation and diversion from landfill thus reducing landfill GWP emissions from wood, for example. LCA studies indicate the high GWP of furniture in landfill due to high natural materials content – more so for Home Furniture than Office. This makes responsible collection and segregation of materials a high priority and within the control of provincial and territorial governments. Such action will also assist in addressing plastics (fiber) recovery. **Product Design** would substantially assist this objective.

14 Actions to support and promote VRPs

The previous section considered sector barriers and possible actions to address them. These are relatively high level and need further development outside of this project. This section considers more broadly the actions that may be taken by the federal, provincial and territorial administrations to encourage, support and grow remanufacturing and other VRPs in the context of the CE. In this latter respect, the actions are, in effect, pertinent to much of the CE.

14.1 Generic barriers to VRPs

Table 45 provides a broad clustering of barriers to the expansion of remanufacturing and other VRPs.

Table 45: Barriers to the expansion of remanufacturing and other VRPs

Types of barriers	Examples	Description of barrier impact
Regulatory and access barriers	• Complicated regulatory definitions for remanufacturing that affect import, export, and domestic production-consumption activities. • Lack of clear understanding and differentiation between remanufacturing and other value-retention processes. • Inputs to remanufacturing (product cores) often reflected as 'waste' under regulatory definitions.	• Affects flows of finished remanufactured products from producers to customers in domestic and/or international markets (forward-logistics).
Market structure barriers	• Intermediaries between (re)manufacturers and end-users frustrate ability to implement VRPs.	• Particularly with consumer goods, retailers have no interest in boosting the remanufacturing market as this negates new sales, despite willingness of some manufacturers to explore VRPs.
Collection infrastructure barriers	• Lack of policy requiring diversion of EoU products from entering the waste stream. • Lack of efficient and/or effective diversion and collection infrastructure. • Cost-burden of reverse-logistics if left to individual organizations.	• Affects flows of EoU products and components from the customer/user back into the secondary markets and/or to the OEM to be used as inputs to remanufacturing (reverse-logistics)
Customer market barriers	• Lack of awareness of VRP offerings and benefits. • Lack of standards/certifications for remanufacturing and remanufactured products. • Perceived lower-price = lower-quality of remanufactured products. • High customer risk-aversion. • High perceived cost of repair. • Lack of support in self-repair. • Consumer 'ick' factor for 'used' consumer goods.	• Creates capacity constraints for the domestic remanufacturing/repair customer market.
Technological barriers	• Increased production complexity with reverse-logistics and supply-chain considerations. • Specialized labour and equipment requirements. • Cost-burden of investment and R&D on individual organizations.	• Creates adoption and capacity constraints for domestic remanufacturers.

These factors have all been cited variously by the sectors consulted in this study and appear little different to those seen in the rest of the world. Canada's sparse population, especially in the north, does present novel challenges from other nations.

A number of barriers are rarely made explicit:

- The misguided assumption that the country's administration recognizes VRPs and their value.
- That they are measured and regulated for desired outcomes.
- That all agents within the administrative network are equally informed on these aspects and share a strategy to support and encourage them.

This work, and this section, forms part of this last aspect – the formulation of policy – but the research suggests very strongly that the first two aspects should be immediate targets for action.

14.2 An outline map for action

An important element of this work is how the foreign experience learning summarized in Section 12.5 can be combined with the Canadian context to produce a coherent approach to remanufacturing and other VRPs in the context of CE through the entire administration.

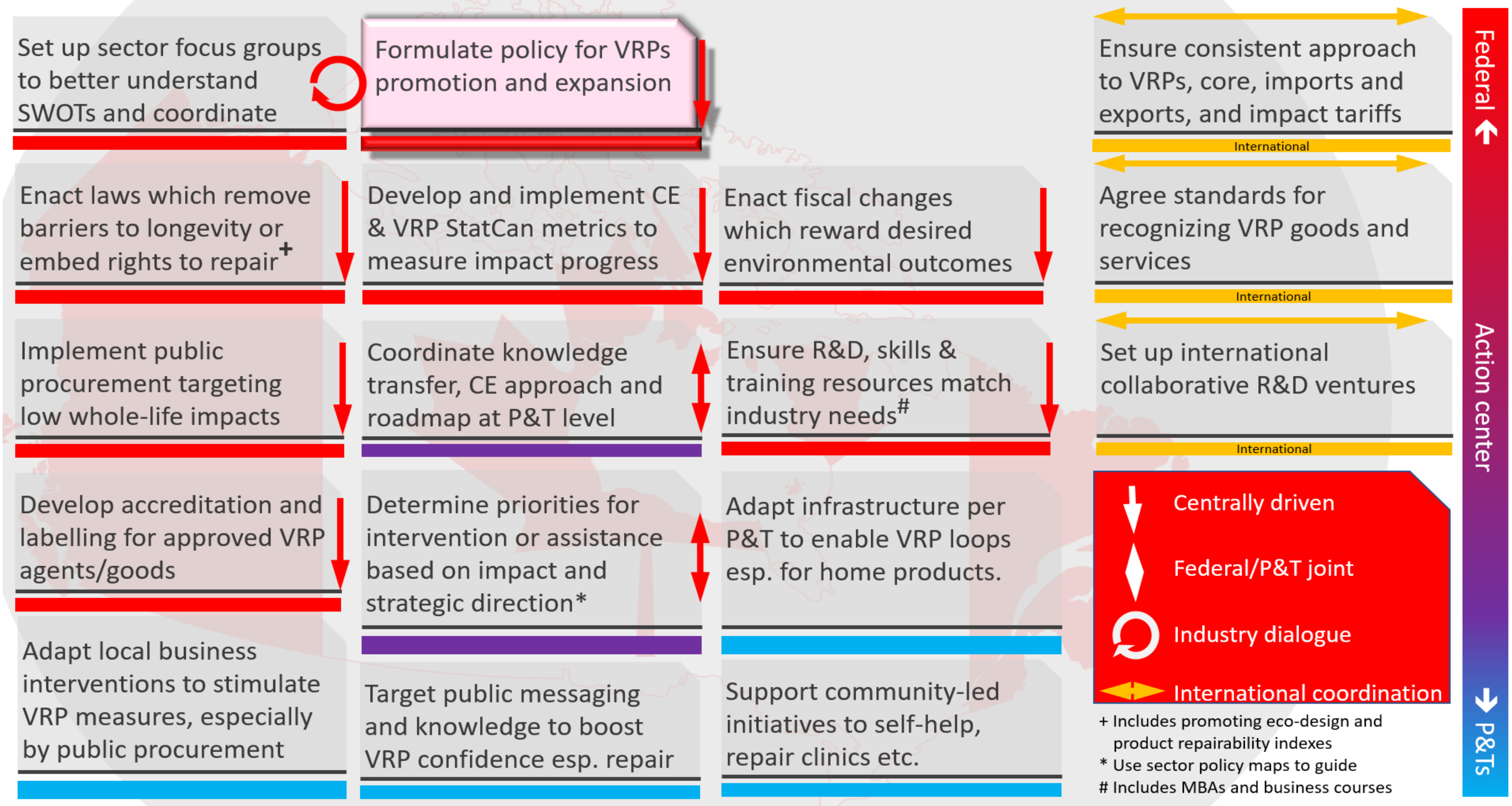
In Figure 46 we have synthesized a range of core actions (highly condensed) which address the thematic issues presented in Table 45. To interpret this map, the colour-coding is indicative of federal-centric actions in red, through blue for provinces and territories (purple is a joint coordination); amber represents transnational actions requiring international negotiation with a range of departmental involvements: trade, treasury, environment…

There is a broad stratification from top to bottom of overarching or 'platform' actions down to more practical implementation – especially infrastructure – consumer and business involvement at the territorial and provincial, not to say municipal, level. In general, actions which underpin the coordinating principles within which provinces and territories will operate will need to be prioritized. However, this should not prevent the strengthening of planned or ongoing local action in respect of encouraging establishment or boosting of VRPs.

The top-centre (pink) box relates to the creation of a strategy for remanufacturing and other VRPs, of which this work is an element. Such a strategy should be compatible with other CE actions and is a necessary precursor to coordinated actions flowing from it, implemented in provinces and territories and engaging with remanufacturing companies.

This mapping of actions is created as a one-page overview as a point for discussion and development both within and beyond the current study. An expansion of greater or lesser length is provided for each of the elements. At the conclusion of the expansion we consider action prioritization which begins to answer more the question of prioritization.

Figure 46: Summary of CE actions by actor: Federal and Provincial/Territorial (P&T)



Note: SWOT = Strengths, Weakness, Opportunities & Threats analysis

14.3 Direction and control

The elements identified in Figure 46 constitute actions which are coordinated at – even if not exclusively implemented at – the federal level.

14.3.1 *Formulate policy which incorporates VRPs into CE on an outcome basis*

Having a clear understanding of the outcomes Canada wishes to achieve is a necessary first step to determining if it is making progress towards a goal.

This current work contributes to the development of a Canadian strategy to encourage the remanufacturing of products and other VRPs. The formulation of the strategy, and particularly its implementation, should draw strongly on underlying analyses of the net impact of different choices of action with respect to the manufacture, use, re-use and disposal of goods, and even where they are made. From related projects, it is our view that the strategy should take this approach and consider a range of measures to motivate productive behaviours.

There are several international examples which could inform the creation of a layered approach here. China's approach is worthy of further investigation as summarized in Table 46.

Table 46: Overview of China's CE policy framework

Area	Micro (Enterprise)	Meso (Inter Firms)	Macro (Province, Region, State and Cities)
Design	Ecodesign	Environmentally friendly design	Environmentally friendly design
Production	Cleaner production	Eco-industrial park	Eco-city Eco-municipality Eco-province
Consumption	Green purchase and consumption	Environmentally friendly park	Renting service
Waste management	Product re-use and recycle system	Waste trade market industrial symbiosis	Urban symbiosis

This is a process which needs to recognize that there are individual winners and losers. For example, CE efficiencies imply a reduction in virgin materials requirement. This is a clear concern for the domestic mining and extraction sector, and even the waste management sector. Part of the strategy should therefore address how impacts on these sectors can be mitigated. For example, a change in thinking can realign the sector as a part of the CE. Waste management companies in Europe are recognizing the need to leverage their infrastructure; they are converging with logistics companies who themselves offer collection and repair services. Mineral extraction companies are exploring the idea of chemicals as a service, already embedded by effect chemical manufacturers in the automotive and engineering sectors, where there is a motivation to reduce use and waste with benefits to all. Mining companies can restructure to deal in secondary resources and migrate into elemental recovery systems, for example.

14.3.2 *Coordinate knowledge transfer, CE approach and roadmap at P&T level*

There are good indications that the provinces and territories are receptive to a stronger central role in laying out the path in this area. For certain, the research shows that they are, on the whole, only superficially aware of VRPs, but there is no distinction between materials recovery and product recovery – all seem to be treated as a waste management exercise.

Provincial and municipal governments tend to focus on the back-end processes where wastes enter their jurisdiction. That is natural, particularly as this is the only point at which resources are measured. However, VRPs – by definition – are being carried out before products become waste and become recognized by these systems. There is a question of visibility of these processes most notably in the business domain, but also in the domestic domain. Because of the limited resources at their disposal (which they have highlighted), provincial and territorial administrations may therefore struggle to cover the multitude of individual enterprises they could potentially engage with. Therefore, there is a good case for a top-down approach which acts equally on candidate VRP businesses and reduces the burden of engagement or even policing at the local level.

Good coordination between the policy level and the action level will be necessary to avoid feelings of being burdened, but also to identify hotspots per locality where most productive intervention could be made. A necessary precursor to this is the industry engagement to determine possibilities and candidate regions for experimentation, say.

14.3.3 *Determine priorities for intervention or assistance based on impact and strategic direction*

A researcher who has spent any time examining the practice of remanufacturing will quickly realize that segmentation by sector is at best a crude approach to understanding where benefits accrue and where opportunities may lie. This is because sectors embrace, typically, a host of different products, by value, size, mass, complexity, componentization, de-constructability, evolutionary trajectory, aesthetics, distribution and, not least, customer type. The products in the electronics and home appliance sectors are most recognizable in this respect, but it applies no less to aerospace and automobile: there are orders of magnitude difference between a jet engine and a fuel pump for that engine, for example.

These enormous variations make a sectoral analysis of prevalence of one or other VRP an extremely blunt tool. Certain products will be more amenable to remanufacture, say, and others to cascaded re-use or home repair. Ultimately this comes down to issues of both design (including expected life) and trade-offs between utility and cost of passing on, repairing etc. at end of use.

Our analysis of sectors and actions to address barriers has, to some extent, taken account of the difference between B2B and B2C domains. However, we strongly recommend a much more focused approach, through engagement per sector, which unpicks issues in detail, looks for cross-cutting themes and formulates policy approaches which tackle specific market failures. In this sense we mean failures to achieve movement in an environmentally beneficial direction. This process will underwrite government actions and make them more defendable.

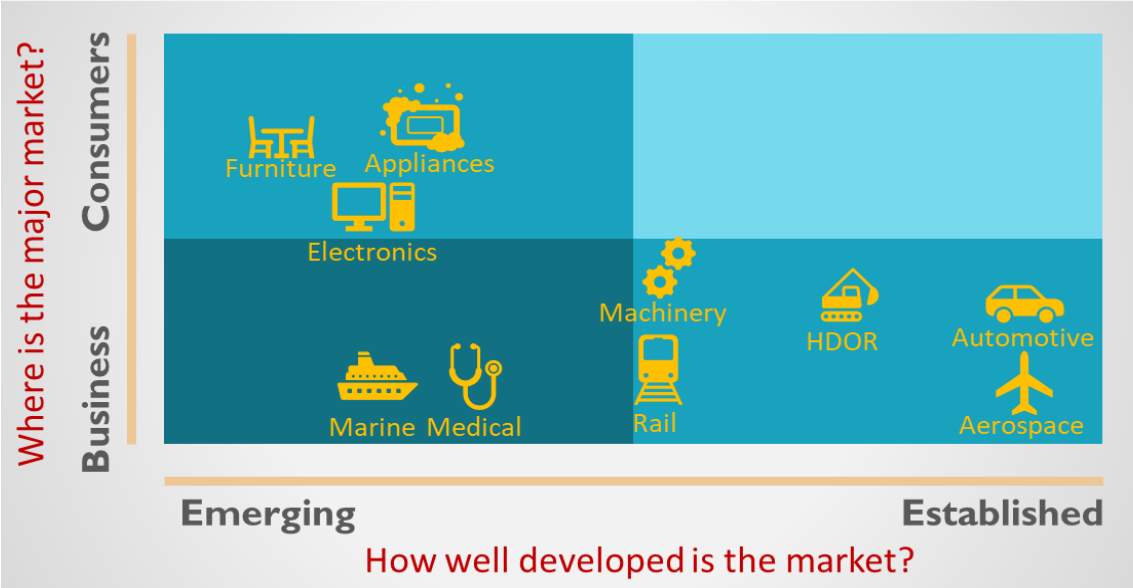
At this point we should be honest in saying that VRPs may not be an appropriate solution to some instances. For example, in the case of furniture, there is a good potential for office and institutional furniture remanufacturing and re-use facilitated by changed business models and inherent construction features of this type o furniture. But home furniture is more problematic in these respects; it may be more beneficial (in the short term) to ensure there is at least robust collection segregation and recycling processes in place to eliminate the negative effects of organics in landfill, rather than directing effort to encourage VRPs other than re-use for a potentially far smaller proportion of items. This underlines the need for an evidence-based approach to examining the consequences of different options.

14.3.4 *Set up sector focus groups to better understand strengths, weaknesses, opportunities & threats and for coordination of action*

To an extent, our research has uncovered sector barriers and possible actions in response. These are reported in the previous section. However, we acknowledge that a sector-based view can be simplistic since it hides a range of complexities as reported in the text. The range of products covered is one such issue, but so too is the issue of customer type. This aspect will be critical for growth in the electronics, home appliances and furniture sectors.

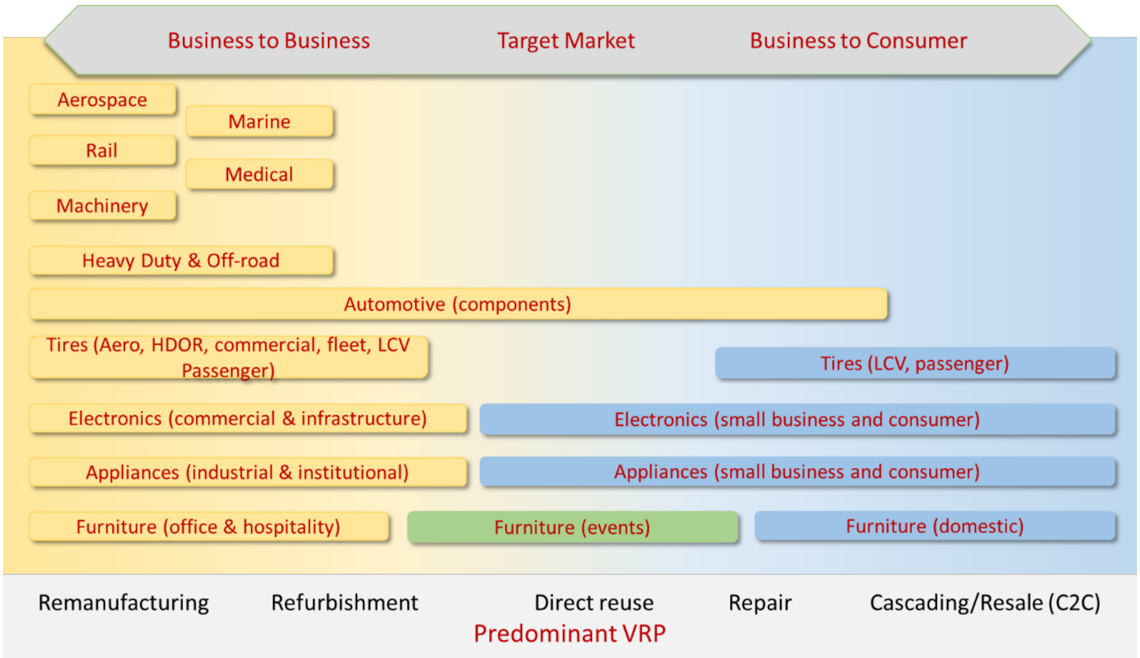
Figure 47 presents a view of the perceived view of the maturity of the various sectors with respect to VRPs mapped against the domain in which they primarily operate (B2B or B2C). This illustrates where some clustering of approaches might be appropriate. For example, home appliances and electronics, and to some extent furniture sit together; aerospace and automotive share similar maturity characteristics, even if the degree of development of their markets is different.

Figure 47: Possible segmentation of VRP policy approach based on customer and sector



Taking this a step further, Figure 48 shows the broad types of VRPs which are being employed by sector mapped against customer type, again hiding a great deal of diversity at the product level. This is critical for selecting point of intervention for maximum impact.

Figure 48: Simplified map of focus of activity by customer by sector



Options for intervention in the B2B area are generally at a national or international level to ensure a fair competitive environment which rewards desired environmental impacts and stimulates a demand for such products. Our experience shows that blanket solutions are not possible, and it is necessary to drive down to a sector-based or sub-sector-based approach.

Although sectors have their unique issues, there are many in common as identified in the previous section. In the interests of efficiency of action and to generate a critical mass of action, but also to be perceived as equitable, it will be wise to go to the next level of detail regarding nature of and action on issues. Where issues are related to B2C, it is likely that systemic change (for remanufacturing) will be required in the sector, and will be emergent; other VRPs, such as repair and re-use are amenable to local action either by persons, communities or businesses and can be enacted at the municipal or provincial/territorial level.

14.4 Statistical, legal and skills framework conditions

This section considers aspects related to measurement, auditing, oversight of, and legal, fiscal and training policies related to VRPs. These create the 'level playing field' necessary for assessing the impact of other policies, and ensuring the impacts of new manufacturing and VRPs are fairly compared or motivated for their desired economic and environmental outcomes.

14.4.1 *Develop and implement CE & VRP Statistics Canada metrics to measure impact progress*

Metrics are necessary to monitor progress and determine where points of effective intervention might lie. Much work has been done across the globe on proposals for CE metrics, particularly for businesses, but has typically required a large amount of data to support it. More recently, the Ellen MacArthur Foundation has promoted its own tool for self-assessment, which is lighter and more practical, so methods are evolving.

Nations, though, require metrics which offer both a view on the level above this, the aggregate impacts on the nation's use of resources and energy and the wastes and other impacts associated with them; and an insight into the processes within the nation that are contributing positively or negatively to those impacts.

To some extent, gross measurement of impacts is already available via import/export/ extraction data, energy consumption and the like. More qualitative views of impacts – resource depletion, effect on biodiversity and natural capital, eco-footprint and the like are published periodically by governments and third parties. But the issue of measuring internal processes is much harder and even if measured, how to discern the attribution to impacts, causality and repeatability i.e. a change in X today would have the same effect tomorrow, are less well-founded.

We identify this as an issue in a research topic below, Section 15.5. Some prior work has been conducted for ECCC on this by (Smith, 2020). Smith identifies remanufacturing and re-use, but the treatment is light and needs substantial development in the context. As a former Statistics Canada employee however, his advice on the features of useful metrics is excellent.

14.4.2 *Enact fiscal changes which reward desired environmental outcomes*

With metrics in place and a clear view of desired outcomes, the trickier task of determining how fiscal and taxation measures can be exploited to promote desired outcomes arises. Several approaches are in action or have been debated:

- **Reduction of GST for re-use products.** This might be graduated depending on the extent of life left in the product, crudely reman➔repair➔re-use. For example, it might be argued for remanufactured goods that since the value is retained, there is no added value and hence no GST due. This is an extreme position; it would be more consistent to argue for relief on the embedded materials recovered since they are a high-impact component at the point of first extraction, recovery and processing into products.
- **Use of tariff-based EPR schemes.** These, again, may be graduated depending on the end of life treatment employed, penalizing landfill (full) over re-use (zero). They might be implemented either by end of year accounting, or by a GST-like recovery. EPR schemes are widely recognized and increasingly practiced in the provinces and territories, so their use would dovetail with existing mechanisms.

The issue of correct pricing of impacts of manufacture and use is another question more widely relevant to CE. This issue is often raised by OEMs in relation to low-performing goods which may be being ‘dumped’ into markets and under-cutting VRP-ready goods which are costlier but more robust. Such steps need to be taken in step with foreign nations to avoid unfair economic advantage by nations which do not adopt such measures.

14.4.3 *Enact laws which remove barriers to longevity or embed rights to repair*

A number of respondents from the provinces and territories, when asked on transportable foreign practice, quoted the EU’s Right to Repair legislation (technically a Directive to be implemented at Member State level, but the analogy for Canada is good). To some extent this tracks previous B2B-related Directives, such as the Automotive Block Exemption, which stopped vehicle manufacturers prohibiting non-OEM parts being used in-warranty with the threat of invalidating the warranty. Whether this constitutes a real barrier to expansion of VRPs in Canada has not been confirmed at the time of writing.

In parallel, there are moves in, for example, France to mandate a minimum lifetime of goods. This should be considered with care as it might prove counter-productive for energy-using products. A better route might be to mandate a minimum period of spares availability to ensure support, making repair information available on-line with product user manuals. An interesting crossover here is the advancing technology of 3D printing which removes the barriers to ‘batch of one’ manufacture if the right information is available. These are strong candidates for housing in community or business-led repair hubs.

Other measures being brought to bear include eco-design legislation, notably design for disassembly and repair as well as longevity, and also the publication or declaration of product repairability indices. France, for example, has implemented a suite of regulatory initiatives aimed at tackling obsolescence, starting with the National Waste Prevention Program in 2014 (Government of Quebec, n.d.). The Energy Transition Law of 2015 prohibits companies from building planned obsolescence into their products and the first related lawsuit was launched in 2017 against HP for their printer cartridges. From 2015, French manufacturers were required to tell retailers how long they would make spare parts available for repair; and for products purchased after 2016, product warranties were extended to two years, with the burden of proof on the producer to demonstrate a fault does not exist.

In general, eco-design guidelines represent a soft, sector-based and business-led approach. Mandatory requirements are a harder approach. However, they will not have much impact unless they are monitored and backed up or made explicitly relevant e.g. through public purchasing criteria.

All of these should be included with careful consideration of the safety implications and manufacturer liabilities for user-repairs, an issue which achieved prominence at the 2018 G7 VRP Workshop in Montreal (European Commission & ECCC, 2018). Here, manufacturers expressed deep concern about the implications to their own liability of owners and consumers undertaking their own repairs. Further, where legitimate third parties had VRP’d their goods and faults had arisen (which might include design faults) the absolute responsibility for these has not been established yet and was noted as an international action point.

14.4.4 *Develop terminology, accreditation and labelling for remanufactured goods*

In the longer term, this includes the development of a definition, in keeping with international definitions, for each VRP to ensure consistent use and application of the terminology. We identified in the introduction that various terminologies and definitions are used by different sectors, but this extends across languages too. This is equivalent diversity in French to that in English which will clearly add an extra dimension of complexity in rationalizing in Canada. Fortunately, France, for one francophone nation, is highly active in both policy and research in VRPs and so could provide a terminological lead.

In the immediate term, the focus should be on remanufacturing as the most clearly definitive activity. For consistency, international compatibility and to avoid a plethora of standards and labels emerging, this is an activity that should be coordinated at the federal level. It dovetails strongly with the International action, Section 14.7.2, below, but draws more straightforwardly on the handful of national and international efforts to develop remanufacturing standards. It should be recognized, however, that standards are typically process-oriented, not product-oriented. It is therefore necessary to look out also to related schemes such as ecolabels to signal expectations of both process accreditation and performance expectations.

Major standards already in existence are the American National Standard for remanufacturing *RIC001.1-2016: Specifications for the Process of Remanufacturing* developed by the Remanufacturing Industries Council (RIC) in collaboration with a diverse consensus body made up of respected leaders from the industry; and *BSI8887-220:2010* developed by the British Standards Institute. Both define and provide a benchmark for the process of remanufacturing and establish specifications that characterize the remanufacturing process and differentiate remanufacturing from other practices.

Further, both standards should be considered as generic platforms which provide the basis for the development of product-specific standards (and from there, labels via accreditation). Also, both of these standards are being considered for 'internationalization', the US standard by agitation for elevation to ISO (via the US Remanufacturing Council); and the British Standard (via British Standards Institute) by cooperative development with Chinese authorities with the aim of normalizing UK-China-EU practices and hence reducing barriers to trade.

It is a matter of choice whether Canada develops its own system in this area, or perhaps piggybacks on an established system elsewhere. The most obviously relevant example is from the US, as described in Section 12.3.1, the subsection on US MERA and RIC certification programs and the talk of the 'Remanufactured in America' brand.

14.4.5 *Ensure research, development, skills & training resources match industry needs*

While many of the skills required by remanufacturers are the same as those of manufacturers, there are distinct competency differences. For example, in independent remanufacturers, deep product knowledge is valued. In all cases, diagnostic and problem-solving skills are required for product triage. Specific technical competences may be needed by sector, and on an evolving basis to cope with technology shifts, such as electric vehicles in automotive.

Recently, a peer-group government of similar state of VRP development to Canada instituted a study of remanufacturing skills and related gaps in the curriculum for vocational and in-work training. This did indeed confirm that they were commonalities between manufacturing and VRPs, but distinct competences existed for the latter and could be addressed by specific modules related to the '9 step' remanufacturing process outlined in remanufacturing standard BS 8887-220:2010 (BSI, 2010). An example of a summary skills gap is shown in Annex H. Since it includes sectors of interest to Canada, its content is likely to be relevant.

A related issue is that of the state of knowledge of VRPs and CE amongst business leaders. Undoubtedly, the profile of environment has risen of late, but it is less certain that the thrust of, for example, MBA courses, economics and business studies has truly embedded this thinking as other than an add-on. A strong steer for these to be core to the curriculum is suggested. There are several institutions globally that may provide a steer on the content and delivery of this knowledge.

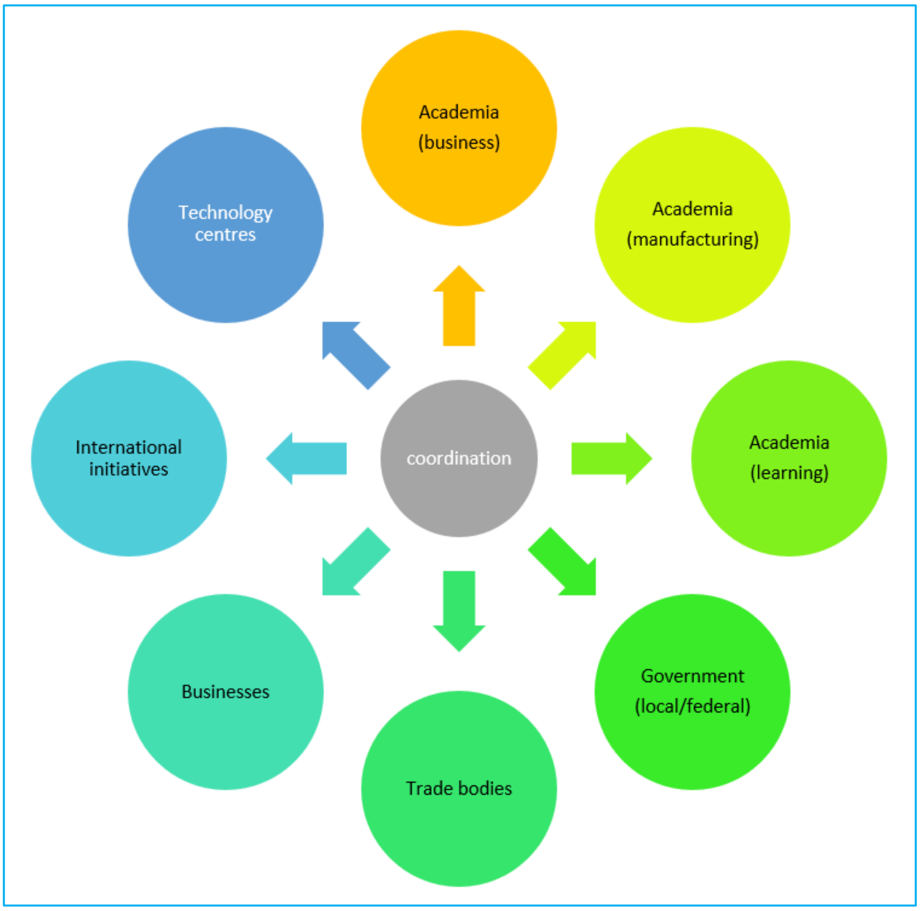
The issue of who might tackle research into various topics related to VRPs (some raised in this work) is relevant and a challenge shared with other jurisdictions. There is a fair degree of academic literature on manufacturing strategies and business models supportive of VRPs, but little has translated into concrete business assistance. Notable exceptions to this are Germany and the US which are characterized by the presence of strong centres of excellence in linking academia to business: In Germany, the Fraunhofer Institutes and in the US Rochester Institute of Technology (RIT)/Golisano Institute. Fraunhofer Institutes are a long-established flagship which have adapted smoothly to – especially – remanufacturing, but less so to other VRPs, unless there is a clear technical need. RIT has been a 20-year climb to establish a focus for interaction between not just research and business, but also the '3rd pillar' – policy and lobbying (with great success) – via its Remanufacturing Council trade body. RIT's specialism is remanufacturing but being the authors of the UN-IRP report, it is likely they will in time embrace a wider set of VRPs.

Elsewhere, there are centres of specialism – Linköping in Sweden, TU Delft in the Netherlands and Grenoble INP for system and product design, for example – but not the same degree of coordination. With a diverse manufacturing base and even more products within each sector, supporting research in this area risks becoming a haphazard collection of investigations, or a highly diffused effort which lacks critical mass. It is strongly recommended that Canada considers a centre for coordinating (but not commissioning) activity in order that:

- Initiatives fit within a broad landscape which covers major hotspots with complementary activities of sufficient force to make a difference, possibly using a challenge-led approach.
- There is a coherent meeting point for business, research and policy (via trade bodies and government).
- That there is a well-publicized clearing house for distributing knowledge gained more widely out to sectors and businesses, to governments for improving their messaging and approaches and to integrate and influence international collaborations.

This approach is currently in its gestation in the UK. The coordinating body could be private or public, academic or business focused as long as it has a good network of related governmental, business and academic interests. A 'network' of typical stakeholders in shown in Figure 49.

Figure 49: Coordinated research eco-system



The issue of technology development is also tackled in Section 14.7.3.

14.5 Market pull and confidence building

This is a short section but should receive high priority for the action's ability to lead by example and support VRPs in a very concrete way with potentially substantial contracts.

14.5.1 *Implement public procurement based on the life cycle impact of goods and services*

This action is for operation at all levels but will require federal coordination to develop the principles.

Public purchasing is a substantial component of public spending either directly by agencies of the administration or via subsidiaries such as hospitals, schools and the like and thus represents a leverage point of high potential for market development of VRPs. (Circular Innovation Council, 2020) identifies that:

> *"Public sector procurement in Canada is valued at $200 billion annually with 80 percent taking place at local government levels."*

Many jurisdictions advocate Green Public Purchasing, but few build VRPs, re-use and the like into their policies; some are sensitive that strict environmental criteria may be perceived as prejudicial or anti-competitive. However, there are counter-factual examples.

For example, preparing for the Olympics 2012, the Organizing Committee of the Olympic Games, took an innovative approach to the purchase of the temporary facilities. Via a committee of experts, it established purchasing criteria which mandated whole-life carbon impacts and a hierarchy of VRP tactics to be demonstrated by purchasers including leasing, re-use and redeployment. This was a major contributor to the 'greenest games ever'.

Implementing a national purchasing policy which operates at all levels which concentrates on whole life impacts and demonstrable EPR, would send very strong signals to the business community. Alongside this, publicity associated with successes could also inform and motivate the public in VRP benefits.

Prime initial targets are IT (including office equipment), furniture, other maintained infrastructure and vehicle/utility vehicle fleets.

14.6 Action under provincial and territorial control

This section considers actions which are predominantly under the control of provincial and territorial governments, implemented in those regions, or which involve community action within municipalities. This will be the point at which policies become a reality for VRP businesses, purchasers of services and consumers.

14.6.1 *Adapt infrastructure per P&T to enable VRP loops especially for home products*

It is hard to anticipate specifics of this action as it will be highly dependent on the provincial, territorial or municipal context. However, some generic actions might be in respect of what is now called waste management, whereby a more triaged approach is taken. Rather than consign all unwanted products as waste, have services which collect even in small batches – so-called mosquito fleets – in a controlled, safe and non-destructive way to return to a hub or directly to businesses possibly re-usable products.

If Canada is considering strengthening EPR schemes, it is worth considering how collective systems might assist in the collection of consumer goods such as furniture, IT and appliances in a safe and secure manner which preserves their value. For example, recovering used goods from households to hubs would assist in triage as well as to better audit and regulate the obligations on individual retailers or manufacturers.

14.6.2 *Support community-led initiatives to self-help, repair clinics etc.*

Repair hubs are an increasingly common feature in other jurisdictions and there is precedent in Canada: our survey reveals that they are a feature in Quebec and British Columbia, so there is potential learning on successes and failures. These initiatives can augment the increasing amount of repair material being put on-line to assist users, such as iFixit, as well as kits of tools and simple parts. Such ventures have an added benefit of increasing community cohesion. Similarly, product share hubs allow time-share of (especially) tools which would otherwise be unproductive for much of their lives. Again, Quebec and British Columbia demonstrate this with the 'Tool Library On-line'. On a day-to-day basis, BC's Turo C2C Car-share demonstrates that consumer-owned assets can be elevated to the level of a service without compromise.

14.6.3 *Target public messaging and knowledge to boost VRP confidence especially in repair*

One possible messaging source was identified under public procurement above, but clearly there is much work to do to raise awareness of and confidence in VRPs. To a large extent, this will depend on solutions being in place already to avoid advertising an 'empty' proposition. For example, other actions on stimulating repair hubs, accredited services, collection systems etc. are necessary precursors. However, much information could be portal-based, pointing at other resources: spares supply sites, repair sites, re-use and recovery portals, reclaim sites etc.

Equally important are messages about safety: not going beyond confidence and competence or infringing warranties. Here the repair café could provide a resource of confidence and advice.

14.6.4 *Adapt local business interventions to stimulate VRP measures*

Provinces and territories have several tools to assist businesses at their disposal albeit with limited resources. These can include grants, preferential access to facilities, business advisory services and the like. Some further thought is required by each locality as to what the best interventions are or indeed if new interventions are needed and whether the existing interventions should be discontinued if counterproductive. Further resources, assistance and guidance from the national level may be required.

14.7 International co-operative actions

This section considers actions which must be enacted by cooperation and negotiation with other countries. Because the impacts of for example, greenhouse gas emissions extend globally, common approaches and understandings are required. This is to ensure that Canada is not unreasonably disadvantaged by enacting forward-thinking policies with strong environmental benefits without reciprocating commitments by others.

14.7.1 *Ensure consistent approach to VRPs, core, imports and exports, and impact tariffs*

This issue has been well-tackled in CUSMA, which clearly forms a model agreement. However, this level of understanding is not always enacted in agreements. Further, some sectors in our survey still reported foreign jurisdictions (and even the US) were treating core as waste or remanufactured products as used. This will remain an area of vigilance to ensure fair compliance. It may be possible to institute a reporting system which could alert International Trade officers to potential violations or non-compliances.

Though this talks of tariffs, there is of course the issue of where tariffs turn into taxes, and in particular if certain jurisdictions take a view on rebalancing prices based on carbon impacts whose impacts have not been fairly priced in. This is a trickier problem, but the necessary precursor is for Canada to determine its internal mechanism for fairly weighting the impact of new goods versus VRP goods or even recycled content goods, a substantial research project.

In a 2018 workshop conducted by the International Resource Panel and the European Commission on the promotion of Remanufacturing, Refurbishment, Repair and Direct Re-use (European Commission & International Resource Panel, 2017), it was highlighted that policy makers must reduce the barriers for the sector by creating a ‘level playing field’, removing legislative barriers and facilitating greater international trade for product cores.

Some specific examples of how this may be achieved included providing clarity on the distinction between products that may undergo product retention processes and those that are ‘true waste’, mandatory Green Public Procurement schemes (e.g. Article 19 of Italy’s 2015 ‘Collegato Ambientale’ law (Aoki-Suzuki, Miyazawa, Kato, & Fushima, 2019)[9]) and national educational plans to raise awareness of the circular economy.

14.7.2 *Agree protocols for recognizing VRP goods and services*

This item relates to the ability to verify truly remanufactured products (and by extension other VRP’d goods). This is a slightly different issue from that of remanufacturing standards per se, but it is highly inter-related. This protocol is likely to be very process oriented. It has applicability not just in foreign trade, but domestically too, for example in purchasing.

[9] A synthesis report as a follow-up activity of the G7 Alliance on Resource Efficiency

More detail on this item – which entails some degree of research as well as potential collaboration with US agencies – can be found in the Future Research, Section 15.2, below.

14.7.3 *Set up international collaborative R&D ventures*

Remanufacturing in key sectors is a global industry. There is a critical mass of interest forming in China, US and Europe which is attracting substantial R&D and demonstrator finance. For smaller countries, building a critical mass of activity, though, is difficult. Here it is especially the case that Canada should not be left behind so should attempt to collaborate in such ventures to develop its internal capability and stay current on the world stage.

As an example, the UK (Innovate UK) and Canada currently have a joint call for collaborative R&D in agriculture, a model which could be developed for VRPs, possibly with a permanent focus. The EU Horizon program is also a target and with significantly more funding though (in our experience) much less nimble.

14.8 Suggested implementation timeline

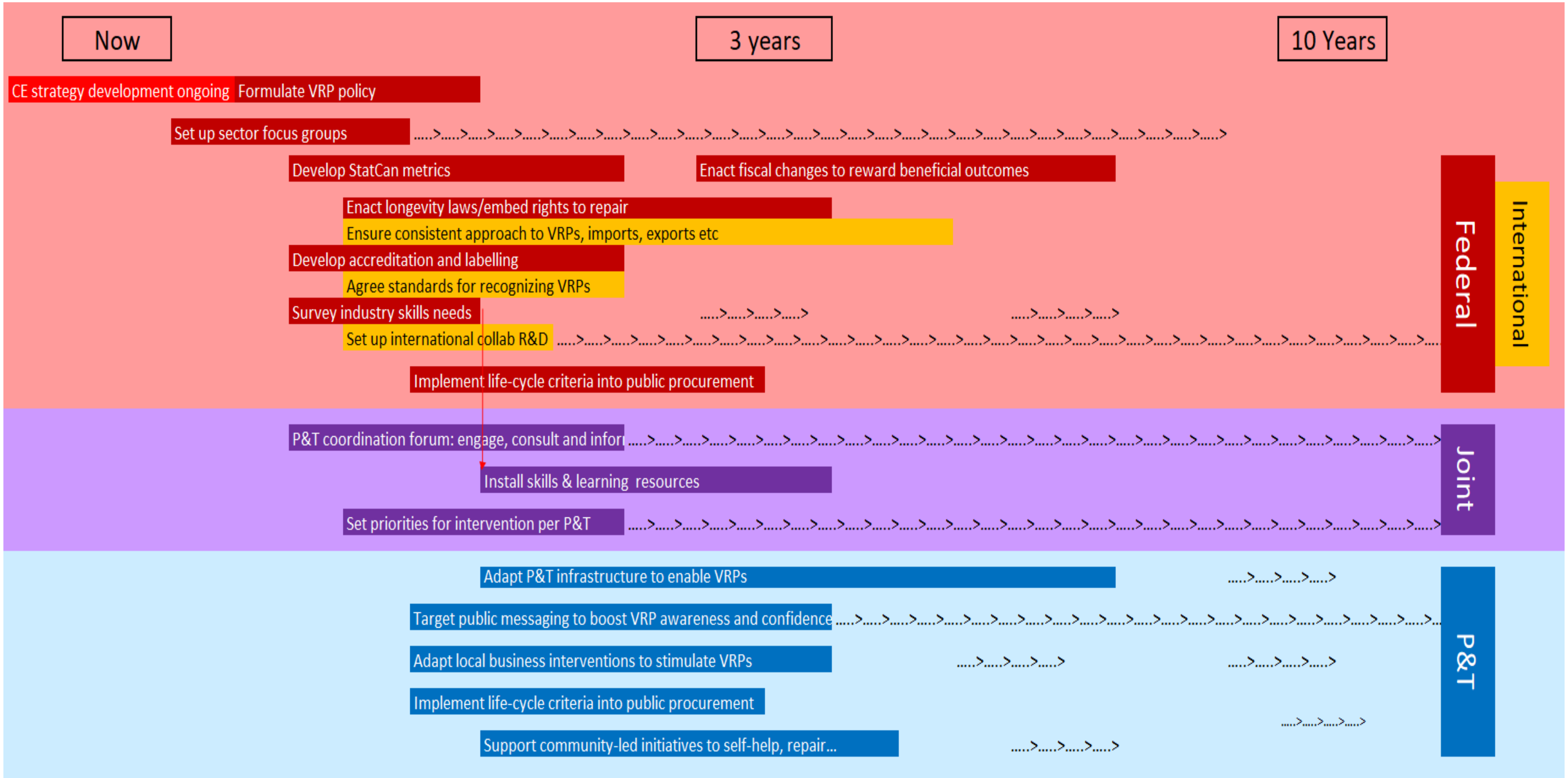
Figure 50 shows a broad timeline for implementation of the previously identified actions at the federal, provincial/territorial and municipal levels. This timeline takes into account the need for an overarching strategy to be developed first at the federal level, the need to include input from the sectors at the early stages and the follow-on tactics needed to monitor and encourage VRP activities at both the federal and provincial/territorial levels. The timescales are broadly classified as 'Now', 3-year horizon and 10-year horizon. The timing of later actions may have dependence on earlier ones, or at least when their effect has materialized and made conditions right for later actions.

For example, it is assumed that formulation of the VRP (remanufacturing) policy and strategy is an early starter, which is a necessary precursor to other coordinated actions which require diffusion into provinces and territories and buy-in from those jurisdictions.

However, engagement with sectors can and start before this as deeper intelligence on the needs of particular sectors is necessary to formulate action plans with a high chance of engaging with getting buy-in from the industrial targets.

Some actions are of extended duration, especially those related to international action because such actions are likely to be more contentious and subject to iteration to reach multi-lateral agreement. Other actions are expected to be ongoing or periodic as they require feedback on the evolving VRP landscape and adaptation of actions. An example of this would be the industry dialogue, skills surveys, public messaging and review of the effectiveness of actions at both federal and particularly provincial level.

Figure 50: Suggested implementation timeline



15 Future research

This study has encountered a number of areas worthy of further investigation, either because they have created gaps in the current research (such as flows of remanufactured goods, LCA data); because they are relevant to implementation of policies (such as purchasing behaviours); or because they add to the developing knowledge base in Circular Economy and related topics (such as the 'Plastics Strategy'). This section summarizes these areas which warrant further examination in future studies.

15.1 CE knowledge base

A useful addition to the knowledge base in this field would be a systematic, searchable assembly of credible LCA and other impact analyses across multiple sectors and product groups. These should compare new and VRP'd products of stated mass and equivalent duty cycles.

Why?

Studies such as these depend on evidence-based comparisons of the effect of different choices in the sourcing, manufacture, use, re-use and disposal of goods. Substantial effort is expended in gathering such data but is continually fraught with incompleteness, incompatibility and lack of clarity on the basis of comparison.

Commentary

A properly researched and peer-reviewed database – which should be kept live and growing – possibly linked to related international LCA initiatives, would reduce the cost of data sourcing activity. It would have high transferability to related CE work, all of which is likely to be dependent on fundamental quantitative analysis.

15.2 Internationalization of VRPs

Under CUSMA, goods may need to be labelled as remanufactured and need to meet as-new performance. However, it does not appear that there is currently a means of attesting how or what process of remanufacturing – if any – had been applied to such goods and this should be an area of future work.

Why?

The net result is the improved formalization of VRP processes leading to greater purchaser confidence and lower barriers to the movement of both core and finished product. The process of putting such a standard together will itself uncover regional variations and assist in harmonization or removal of barriers. In addition, an international trade must be well-policed to maintain its credibility and avoid abuse. Having a protocol is a tool for international trade and custom and excise personnel to validate (or ask for validation against).

Commentary

It is possible that the US MERA and RIC certification programs (discussed under CUSMA) could be leveraged, certainly for CUSMA-related trade. Their criteria might be used more broadly for certification or self-certification by foreign or domestic companies.

There are several international initiatives in the development of country-specific standards for remanufacturing: US, UK, EU and China. Several existing standards at ISO level reference remanufacturing but not in a comprehensive manner which embraces the diversity of agents involved[10,11].

15.3 Systems of tariffs and taxes

Repair offers very high benefits in avoiding emissions from a new purchase, particularly if this can be translated into consumer goods where repair is less prevalent. In general, consumer goods failures prompt new purchases rather than repair. This indicates the disparity between the residual perception of value by the owner (once repair costs are factored in) and the value in potential avoidance of new product environmental burdens. The differential is an action area which could be attacked by better consumer information and possibly tax reliefs related to carbon avoidance.

Why?

One reason that VRP'd goods are often disfavoured over new purchases is because of the high cost of repair or remanufacture. A substantial and significant fraction of this relates to the fact that externalities are not fully applied to new goods, specifically the pricing of GWP-producing inputs in the form of raw materials.

Commentary

A direct, equitable and systematic approach to this would be to impose carbon taxes on embedded carbon (related to their abatement cost, typically \$CAD 50–200/t.CO_{2e}) on all goods. This would require international agreement to avoid disadvantage to local producers, but which is in itself a policy option.

An alternative, cruder approach is to consider graduated EPR schemes, which act at the end of life rather than the beginning. Many jurisdictions already imposed tariffs on new purchases which are speculated to assist end-of-life management or impose mandatory recovery schemes. In practice, such schemes often target the simplest and cheapest actions of collection and disposal and tariffs fund the infrastructure to enable this. The problem here is that carbon- or other impact-beneficial processes are treated equally and so favour the most expedient solution. There is no incentive for suppliers of goods to behave differently.

Some jurisdictions, such as the EU, have imposed mandatory collection and recycling targets but, again, other options are demoted in practice because they are not mandated. Formulating the 'correct' target is politically sensitive. An alternative approach is to impose end-of-life tariffs at point of sale, but which are graduated according to the projected impact at end-of-life via re-use, remanufacture, recovery recycling or landfill. Such tariffs would be simpler to impose locally and more easily adjustable according to business response and evolving measurement of impact. Increase in re-use levels (through modified products, servitization, repairable items, lower mass items) would naturally result in less disposal and need for infrastructure as well as lower tariff burdens on suppliers.

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[10] ISO 10987-2:2017(en) Earth-moving machinery — Sustainability — Part 2: Remanufacturing dealing with remanufacturing specifically. This standard has a different definition of remanufacturing as it restricts activity to OEMs or an authorized party.
[11] Definitions at variance with the UN-IRP report are given in ISO 16714 and ISO 10987.

Questions would be raised regarding who bears the cost of these tariffs when third parties are involved. However, this could be treated similarly to a gross sales tax, where the re-use of an item passes a tariff credit back up the supply chain to the OEM. Such a system has been proposed to the European Commission after an investigation into the effect of the WEEE Directive on re-use of printer cartridges (Waugh, Symington, Parker, Kling, & Zotz, 2018).

N.B. This aspect will be substantially informed by the following research topic.

15.4 The Jevons paradox

A rigorous analysis requires an economic and environmental examination of the elasticity of competing uses of resources and their weighted environmental effects. This would be a fruitful and topical research area which is beyond the scope of this project, but which could inform an impact-based fiscal policy. Disparities in carbon pricing between say, transport and electricity (according to their relative pollution potential) may be obvious sources of such elasticity.

Why

Behavioural economics requires a good understanding of the factors affecting decisions by consumers and users in relation to transactions. This is not well elucidated in the domain of environmental impacts. An analysis of the components of impact and how they vary between products by, for example, different carbon pricing, will provide a better platform for fiscal policies which attempt to even out and eliminate perverse choices in trade-offs.

15.5 National metrics for the auditing of VRPs

This topic is not mentioned explicitly in the text, but arises from the action plan

Develop a system of metrics and accounting across all components of the CE which reliably indicates progress on impacts and contributors to it.

Why?

Quite simply, what cannot be measured cannot be controlled.

Commentary

Some prior work in this area has been conducted by Smith (Smith, 2020) for ECCC, namely *Measuring the Circular Economy in Canada: A Review of Current Definitions, Approaches and Data with Recommended Future Efforts.* This work is highly relevant and raises good questions about fitness for purpose of indicators. However, the work is thin on VRPs so further research is required to determine what information should be collected from businesses, via national returns or via survey which would give timely, relevant and correlated information about direction of travel, and contributions to the effort towards environmental impact reductions via VRPs and other CE measures.

15.6 Plastics research

This topic is not mentioned explicitly in the text but arises from the solicitation and lack of data found to date.

Make a product/sector specific study of how and to what extent VRPs retain plastics in use as well as the attitude to and practice of VRP agents in recycling.

Why?

One of the desired outcomes from this project for ECCC was the quantification of plastic material savings as a result of current VRP activities in Canada. In 2018, the Canadian Council of Ministers of the Environment (CCME) approved, in principle, the Canada-wide Strategy on Zero Plastic Waste which aims to reduce the harmful environmental impacts of waste plastics in Canada through prevention, collection, value-retention, value recovery and least preferred, energy recovery (CCME, 2019). As part of that commitment, the Government of Canada commissioned the "Economic study of the Canadian plastic industry, markets and waste" (Deloitte and Cheminfo, 2019) which estimated the volume of plastics saved through VRP activities in Canada to be 228 kt. There is a significant gap between those estimates and the figures of this study, a combination of conservatism on our part and, we suspect, generousness in Deloitte's work. This difference needs further understanding.

Commentary

Our findings suggest that VRPs are responsible for keeping at least 74 kt/yr of plastics in use, but substantial data gaps remain for some sectors which could significantly boost this figure. (In context, Canada currently recycles (not re-uses) around 280 kt/yr of plastics.) From the survey and interviews, previous studies on remanufacturing and a review of VRP LCAs, it is apparent that quantifying plastic material savings as a result of VRP activities has not been a priority. There are certain products, such as electronics and furniture, whose refurbishment lends itself well to plastic material savings. However, for products such as mechanical equipment and for processes such as remanufacturing and comprehensive refurbishment where products need to meet the 'like new' condition, the material savings focus appears to be on metals. No data regarding plastic material savings could be found for the four initial assessment sectors studied, one of which –medical devices –is likely to lend itself well to such savings; the plastic material savings estimated for the other sectors are likely low.

15.7 Hazardous waste and toxic substance regulations

This topic is not mentioned explicitly in the text but arises from the solicitation and lack of data found to date.

Investigate the impact of federal and provincial hazardous waste and toxic substance regulations and international treaties on VRPs.

Why?

ECCC is interested in determining the impact of domestic hazardous waste and toxic substance regulations and international treaties on domestic VRP activities. Some EoL products that can undergo VRP activity, such as electronics, batteries and medical devices, may contain chemicals or materials that are regulated as hazardous waste; are listed under the Prohibition of Toxic Substances Regulations domestically; are otherwise regulated under the Canadian Environmental Protection Act; or which fall under similarly intentioned foreign or international agreements. This could negatively impact the growth of VRP activities as well as the size of the potential market.

Commentary

From the survey and interviews conducted as part of this study, we are aware of at least one instance where the intra-provincial transport of spent EV batteries on their way to the US for refurbishment has been cited as a hurdle. Further research should be done to determine if there are other hurdles or barriers to the transport of EoL or EoU products classified as "hazardous waste" if they are being transported for the purposes of remanufacturing, refurbishing, repairing or re-use domestically or internationally.

An obvious area of impact is in electronics which historically contained lead-based solders. However, much in the electronics space is short cycle so is cleared from the market quickly in any case. Exemptions are often made for critical applications where for technical reasons, some hazardous content is tolerated, such as in aerospace.

16 Conclusions on actions and priorities

This study has shown that VRPs are a significant economic activity in Canada, which have a substantial contribution to avoiding CO_2 emissions when compared to recycling, for example. These benefits flow from both the embodied energy in the processed materials of which products are made and are preserved during VRP action; and from the overall reduced amount of processing effort needed to raise an end-of-life product back up to as-new condition. Accordingly, VRPs also reduced demand for raw materials, including plastics, though plastics are not as amenable to remanufacture as metals.

- In summary, VRPs are currently (2019) contributing around **$CAD 56 bn** in sales income to the economy although this is dominated by re-use and repair and to a lesser extent refurbishment, with remanufacturing and comprehensive refurbishment contributing about **$CAD 5-6 bn** to this total. Aerospace is the largest single contributor to remanufacturing and comprehensive refurbishment income, but this does not translate into equivalent GWP avoidance or materials benefits because of the high value of goods involved.
- VRPs are having noticeable environmental benefits in materials savings and consequently, GWP avoidance. In total we estimate they are currently (2019) reducing emissions by around **1.6 Mt/yr** in the six sectors about 40% of which is attributable to remanufacturing, comprehensive refurbishment and refurbishment, and over half to re-use and repair.
- Considering GWP avoidance levels, there are remanufacturing activity hotspots in **automotive and HDOR** in absolute terms with comprehensive refurbishment spread across most sectors. Re-use is having its biggest impact in **electronics and furniture**.
- As expected, materials follow this trend – 10% of the current (2019) ~470 kt/yr materials savings are due to remanufacturing and comprehensive refurbishment in the six sectors – with remanufacturing savings dominated by automotive and HDOR. Furniture dominates the re-use and refurbishment landscape. Electronics materials savings appear small, but they have high embedded carbon and so have highly leveraged effects. In fact, this sector forms the clearest target for high-impact intervention to increase VRPs.
- Plastics data is sparser and more uncertain. Tire retreading (remanufacturing) accounts for around a quarter of the estimated **74 kt/yr** current (2019) savings and home appliances over half, with an even spread across other VRPs. Again, **furniture** is a stand-out contributor because of its relatively high plastic content in a domestic or light industrial environment.

This analysis only covers the six refined sectors but could be projected across all sectors. Under that assumption, all-sector benefits **could be double** those described here.

Contributions to net-zero, Circular Economy and resource efficiency

Are the GWP reductions and material savings significant? When we benchmark them against other 'circular' activities such as recycling (of steel, plastics) we can see an impact. As materials they represent about **7% of steel recycling**, for example, and a significant fraction of plastics recycling. When we consider their contribution to Canada's 2030 '30% reduction' GWP target, we estimate that current VRP levels cover over **8% of that target**.

However, what is more exciting is the potential for growth. Extracting the remanufacturing and comprehensive refurbishment elements, we have benchmarked them to assess their 'intensity' - how they compare as a percentage of manufacturing in general. We have chosen these benchmarks because they are clear end-of-life/new-life transformations which displace new goods. Intensities vary by sector but average out around 2 to 4%. Industrial contributors to this report have been surprisingly bullish about growth potentials citing growth to **intensities of 20%** or more. If we impose this across 9 sectors of the study (which excludes medical), we observe total GWP benefits of around **10 Mt/yr across all VRPs**, but especially strongly in remanufacturing and comprehensive refurbishment. This represents a serious contribution to Canada's 2050 net-zero – estimated as 13% of that target – and deserves further attention.

VRP impacts are compared to a number of benchmarks in Figure 51 and Figure 52.

Figure 51: Summary of VRP's contribution to offsetting Canada's carbon impact

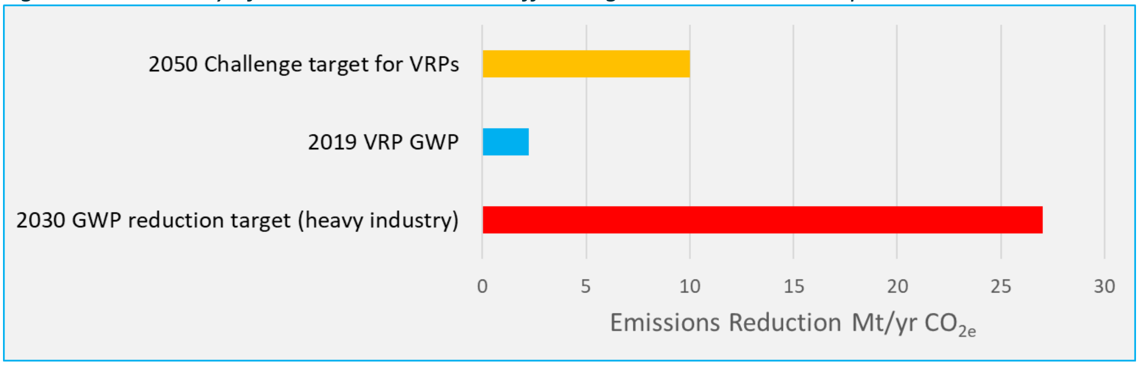
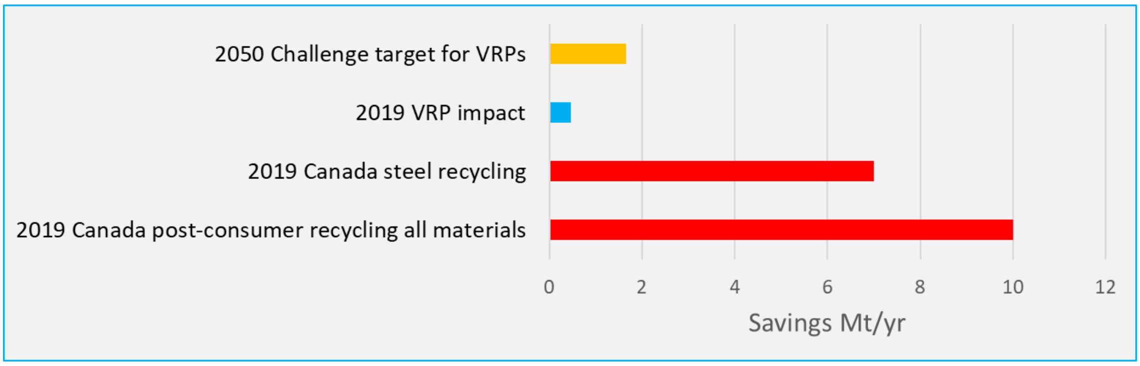


Figure 52: Summary of VRP's contribution to off-setting Canada's material recovery efforts



The immediate potentials of remanufacturing and other VRPs

In the timescale to 2030, we consider what we can do to boost VRPs under the current paradigm.

Our analysis of sector growth to 2030 has projected scenarios ranging from 'do nothing' through to a strong intervention. Under strong intervention, growth is significant even accounting for displacement of manufacturing activities and yields about **25% uplift** in all the socio-economic and environmental benefits described above. This is because a proportion of goods studied are made abroad, so domestic manufacturers are less impacted. This heightens the incentive for boosting VRPs, bringing with them repatriation of the manufacturing base, further **skilled jobs**, **environmental and financial benefits,** as described in Section 10.

Location of potentials

Where is it best to stimulate further uptake of VRPs? It is too simple to look at the table of current remanufacturing intensity levels and target those which are currently low. This does not consider which is the best VRP to apply or even how amenable they are to intervention.

- Firstly, it is easiest to say where not to spend promotional effort: **aerospace**. Remanufacturing is well embedded, and awareness and activity are high. This does not mean that assistance is not required: Our sector strategy acknowledges that aerospace is a high tech, value-adding component of the economy which should be sustained by feeding the skills base and staying internationally current with appropriate partnerships and collaborations to keep critical mass. Because it has leading practices, it can also be an exemplar for growing remanufacturing sectors and to support sunrise technology sectors such as renewables.

- **Automotive is a prime target** for assistance because of both its potential and existential challenges (such as needing to maintain critical mass against neighbours and embrace technology shifts due to electrification of transport). Currently remanufacturing services – at best – process components arising during warranty periods because there are strong recovery networks from franchises to Tier 1 suppliers with a strong financial motive imposed by brand owners. While well-embedded, considerable potential exists to reclaim the post-warranty 'grey' market. Technology (reclamation techniques, component tracking, tracing and provenance determination) and skills (Lean remanufacturing) are key components of this. Shifts to electric technology will require different set of skills and technology support and international collaboration may play a stronger role. **HDOR** we estimate has some capacity to grow, though this is not highlighted as a prime driver for strategic action in the sector actions section. However, because of the similarity to automotive, it can benefit from common actions in skills, for example.
- Probably the biggest VRP shifts can be achieved in **consumer-facing goods such as electronics**. These goods embody a lot of carbon in their creation and extraction of often critical raw materials, but they are discarded for recycling too easily with a huge loss of potential. This is frustrating because IT is generally very modular with elements of 'frozen' technology. To some extent, IT is seen as a fashion item which is expected to be upgraded irrespective of residual age or actual performance even if it is years from failure.

  There are several businesses exploiting this potential in, for example, laptop refurbishment into corporate markets, but there is high buyer risk aversion and fear that technology is not future proof. Leading edge companies are addressing this but need support also to expand into domestic consumer markets.

  This is a sector where the full range of VRPs can play a role: remanufacturing at the 'top end' for expensive performance goods, through repair and, better, enabled home repairs through advice, parts and repair cafés. Here, the public sector can play a role in all parts of the life cycle: Public purchasing can pull through volumes of devices or return them into legitimate operators for remanufacture; establishing and promoting resources for home and community-based repair; and ensuring end-of-use devices are securely and safely managed and directed back to remanufacturers by consumer information campaigns or dedicated collection and aggregation infrastructure.
- **Home appliances** are a worthy but more challenging target that requires a different approach. Ideally, appliances would be servitized: manufacturers would engage directly with consumers to lease a device which they would maintain, keep at high performance through monitoring and servicing and manage properly at end-of-use or end-of-life. To date there have been experiments in this area, but no large-scale uptake so sector dialogue with advocates is recommended to understand the issues.

  A more practical model is the Dyson model: staying in touch with and closely supporting through parts support and cost effective at-home rejuvenation services. These companies could be encouraged and promoted, not least through public purchasing. (This applies equally to office equipment such as photocopiers).

  Again, home repair for more accessible devices opens up the repair VRP route as is the case with IT. Promotion of repair resources, parts, manuals etc. is within local government's capability. At the federal level, though, we know that there are concerns from manufacturers over their residual liabilities and this may need industry dialogue to ensure a fair balance of responsibilities in the eyes of the law.

Overcoming barriers to expansion of VRPs and remanufacturing in particular

This section considers what coordinated action the public sector can take to stimulate VRPs but especially remanufacturing and comprehensive refurbishment.

The challenge targets outlined above are beyond what can be reasonably achieved by 2030 and should more likely be set at 2050. They require wider changes in society that can only happen as priorities evolve in the public's and policy makers' minds. In normal times, changing mindsets to accept VRP'd goods and to adapt business models and the political environment to fully reward these changes takes substantial time, likely beyond the 2030 horizon.

That being said, these are not normal times and 2020 has shown that changes in behaviour, what is acceptable and where future priorities – including environmental challenges – lie can happen very quickly. Conditions may therefore be better than might have been expected that attitudes to keeping products in use are improving. All the barriers discovered and actions proposed here are still relevant and are necessary to allow businesses to adapt to and take advantage of these changing conditions.

In summary, we've collated a range of barriers facing the expansion of remanufacturing and other VRPs in Canada. These can be broadly summarized as follows:

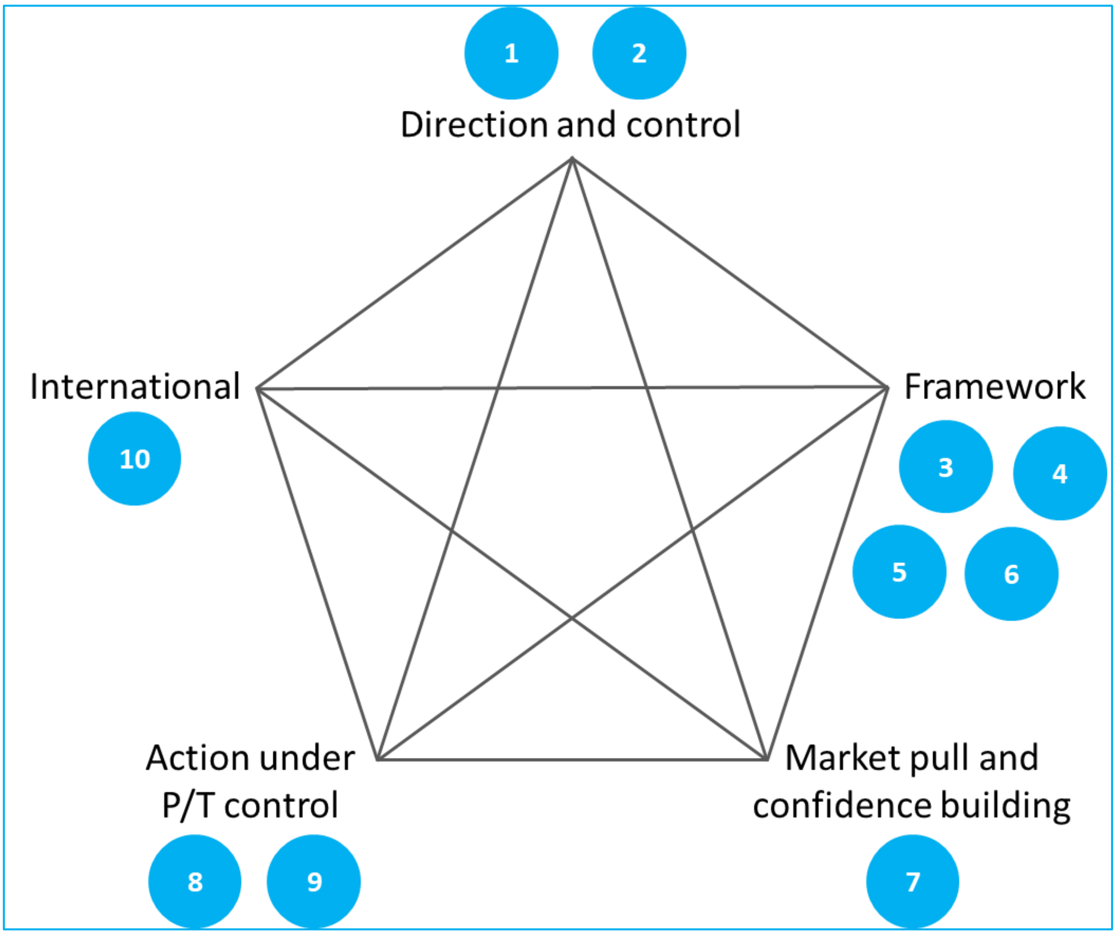
- **Regulatory and access barriers:** barriers affecting flows of finished remanufactured products from producers to customers in domestic and/or international markets (forward-logistics) present operational challenges to VRP practitioners.
- **Market structure barriers:** barriers affecting VRP practitioners' access to customers via intermediaries, such as retailers, who may have little/no interest in boosting VRP activity at the expense of new sales.
- **Collection infrastructure barriers:** barriers affecting flows of EoU products and components from the customer/user back into the secondary markets and/or to the OEM to be used as inputs to remanufacturing (reverse-logistics) can constrain VRP activity.
- **Customer market barriers:** barriers limiting customer awareness and understanding, demand and trust in VRP activities and outputs may hinder the industry's growth.
- **Technological barriers:** barriers affecting the ability to and cost of developing and maintaining domestic VRP capabilities.
- **Administrative barriers:** barriers affecting the visibility, understanding and measuring of VRP activities at a governmental level, whereby the industry is not well regulated and supported by appropriate policy.

The presence and impact of these barriers currently limits the potential of Canada's VRP activities, however this study has identified and prioritized action areas that could be taken to support a transition towards a higher VRP activity-level scenario.

Priority action areas

We have identified a shortlist of 10 priority action areas for the Government of Canada to positively influence market forces and encourage increased VRP activity. These action areas cover the five target areas for intervention identified in Section 14: action areas include those intended to provide a clear **direction and control** for how priorities and targets for VRPs are set. Other action areas support the development of a **framework** within which VRP activity in Canada is defined, monitored and supported through regulation, while action areas targeting **market pull and confidence building** aim to support increased demand for VRP outputs. Additional action areas distinguish between those that involve **action under provincial and territorial control** and those requiring **international** engagement and alignment. These action areas are mapped out in Figure 53.

Figure 53: Priority action area map



Here is a brief description of our 10 priority action areas (not in priority order):

1. **Coordinate knowledge transfer, CE approach and roadmap at P&T level**; *there is a strong case for a pan-Canadian 'Directive' approach as exemplified by the EU and China and receptiveness to the idea from provinces and territories.*
2. **Establish sector focus groups** for information gathering and action coordination in the six sectors analyzed in this study; *learning from other countries suggest interventions must be targeted at sector, sub-sector and even product-level issues to gain the necessary traction for change.*
3. **Develop and implement CE & VRP Statistics Canada metrics** to measure impact progress; *audit and control is difficult without metrics in place which can adequately differentiate VRPs from other services and general manufacturing.*
4. **Explore implementation of fiscal changes which reward desired environmental outcomes** such as reduction of GST for re-use products and tariff-based EPR schemes; *link to the spectrum of end-of-life options i.e. disfavour landfill, incineration for energy recovery recycling, and instead promote re-use.*
5. **Explore development of laws that remove barriers to longevity and embed rights to repair**, particularly in the electronics and home appliances sectors; *industry dialogue on contingent liabilities will be paramount.*
6. **Develop and align VRP terminology**, including consideration of adopting a remanufacturing standard; *tie into international efforts already underway.*
7. **Make a high-profile commitment to VRPs in public purchasing**; *use 'whole-life criteria' to boost VRP attractiveness.*
8. **Support community-led VRP initiatives for re-use and repair**; *there are good exemplar initiatives in Canada and around the world to draw on.*
9. **Target public messaging and knowledge to boost VRP confidence especially in repair**; *this work highlights the easy environmental wins of repair, so linking this selling point to trusted operators would be highly beneficial and especially if Action 4 is implemented.*
10. **Agree protocols for recognizing VRP goods and services**; *the burden of proof of compliance with CUSMA, for example, falls on the importer/exporter so this will offer protection to legitimate VRPers as well as inform customs officers and trade officials.*

These priority action areas would represent the start of a long-term strategy to recognize, regulate and support VRP activities in Canada. While not all VRPs are appropriate for all sectors and products, this study has shown that increased VRP activity (particularly remanufacturing) within Canada has the potential to make a valuable contribution to the socially, economically and environmentally sustainable country Canada seeks to become.

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Annex A *Economic modelling technicalities*

The proportional allocation of demand denotes the source of demand categorically where:

- New demand is related to the increase in demand for products resulting in new demand for VRPs (e.g. sectoral growth).
- Substitution demand is related to the increase in demand for VRPs as a substitute for new manufactured products (e.g. market share growth).

The substitution ratio is equal to the output value of 1 manufactured good relative to 1 VRP produced good. Literature suggests the most typical ratio is 70%. Therefore, $CAD 1 in manufacturing output was substituted for $CAD 0.70 of VRP produced goods. Other ratios may be employed for specific sectors when literature suggests a more appropriate ratio.

New manufactured goods supplied to Canada can be manufactured abroad. It was assumed that the substitution demand of new manufactured goods for VRP produced goods will be proportional, which means the demand reduction will be adjusted by the proportion of the sector's demand met by domestic production. For example, if there is a $CAD 1 reduction in manufacturing output, and 50% of the value of goods in that sector is imported, only a $CAD 0.5 shock will be applied to Canadian manufacturing.

Once a demand shock has been established, the demand is distributed between growth and substitution effects. Growth effects relate to the overall performance of the sector and the expectation that, without disruption, VRP growth will be proportional to overall sector growth. Growth effects are assessed based on the multipliers for the relevant sectors. Substitution effects relate to the increased prevalence of VRP activities where new manufactured goods are substituted for VRP produced goods. Substitution effects demonstrate the socio-economic impacts of divergence from the current trajectory of the sector, likely spurred by market disrupters such as policy action. Substitution effects consider the net effect of:

- An increase in domestic VRP activity as more consumers purchase VRP produced goods.
- A decrease in domestic manufacturing as demand for goods is filled by VRPs.

We caution that this assessment is on a per-dollar basis rather than a per-good basis. Given that a remanufactured product is typically sold for 70% of new (Netto, Bloemhof, & Corbett, n.d.), the substitution of one manufactured good for one remanufactured good would generate only 70% of the revenue output. This may vary by sector, but in the absence of available data for a specific sector, 1:0.7 will be used – a typical value across many products. Therefore, an expansion of VRP activities is expected to generate lower revenue output relative to a similar expansion of new manufacturing. N.B. This does not imply that they are of lower profitability.

Our assessment assumes that the VRP activities gained through this substitution will occur in Canada. While this substitution does negatively impact new manufacturing, in all sectors analyzed, a large proportion of goods purchased in Canada are produced in international markets, therefore this negative impact on the substitution effects will be discounted accordingly. For example, based on the Supply and Use Tables for relevant good types, 81%[12] of consumer electronics are imported into Canada. This means that the negative demand shock to new manufacturing in Canada will be 19% of the substitution output change. Therefore, the net impact of this substitution will be equal to the net gain from domestic VRP activities less the losses in the domestic manufacturing sector.

[12] The specifics of this calculation are detailed in the consumer electronics section. The example, as described, is for explanatory purposes related to model's assumptions.

Comparing the multipliers calculated for VRP activity (defined as repair and maintenance multipliers)[13] for each sector against Statistics Canada (2016) multipliers for manufacturing, we can reasonably assume that the labour intensity for VRP activities is higher than traditional manufacturing. This is in keeping with other studies on remanufacturing. Therefore, an expansion of domestic VRP activity can be expected to generate more jobs than a similar expansion to new manufacturing and may offset some of the job losses associated with the substitution effects.

As a result, for VRP activities (j = VRP) repair and maintenance multipliers were used and for new manufacturing (j = M), manufacturing multipliers were used for the relevant sector. This approximates the differences in expected economic impact due to a change in production method as repair is a type of VRP activity. The total impact for each scenario is the sum of the growth driven socio-economic effects with the net substitution effects for VRP activities. This yields the net socio-economic impact of increased VRP activity for each scenario.

For all scenarios considered, increases are relative to the baseline. The baseline is defined as the current size of the specific VRP sector (2019). Based on the nature of Input-Output multipliers and data limitations, these projections should not be treated as absolute but provide indicative projections of how enhancing VRP activity may generate socio-economic outcomes. Expansion may also yield economies of scale and other microeconomic efficiencies at a firm-level, which alter multipliers. These types of changes cannot be captured in an Input-Output model as they are static in nature reflecting current economic relationships.

[13] Initial analysis used manufacturing multipliers as it was expected remanufacturing and many other VRP activities would be part of the cumulative manufacturing captured within each sector's multipliers. However, when considering new VRP activities, and their differential returns relative to manufacturing, repair and maintenance multipliers were used to illustrate the transition to labour intensity through using multipliers for a VRP activity.

Annex B *Overview of residual life factor method*

Remanufacturing and refurbishment

For the VRP which is perhaps most complicated to perform, remanufacturing – and refurbishment considered within the same category – is the most clear-cut case. The definition is absolute in stating that goods reach the end of their life, undergo remanufacture and enter a new life of equal length to a new good. They may undergo several iterations of remanufacture, each time accruing benefits over new manufacture: the longer they remain in service, the lower the overall impact per year of use. The only parameter for debate is the real life of items – it does not affect the relative benefit of remanufacture over new, only the absolute impact per year of use.

Repair

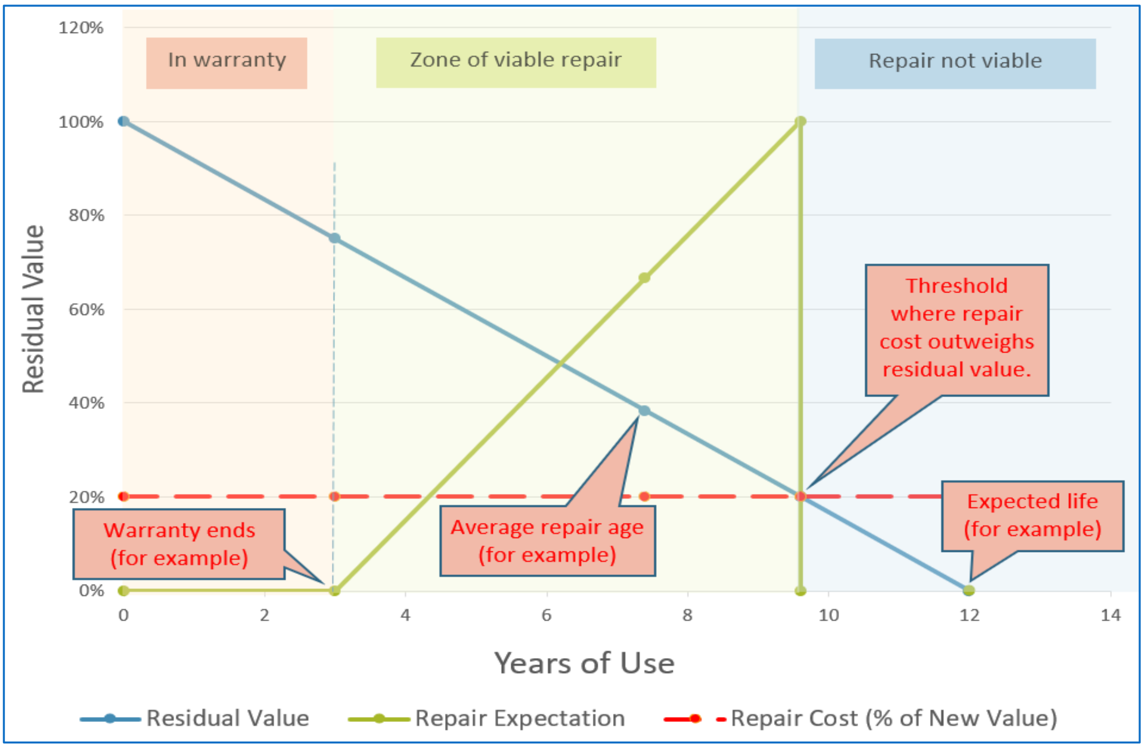
As a headline, repair offers an excellent return on environmental impacts compared to replacing with new. However, the financial aspects play a major consideration in the minds of consumers at least and offer a significant barrier to continued use. High repair costs weigh heavily when considering residual life.

In considering the benefits of repair, we have made several simplifying assumptions:

- We can define an expected life for household goods and electronics, typically in the range 3 to 15 years; the value of goods depreciates (linearly) over this life period.
- That this expected life is an absolute, not one which is observed at point of disposal aggregating fully used and prematurely failed goods.
- That, even if a repair is conducted, it still only endures for its original lifespan. (Any VRP which extended life would be classified as refurbishment or better.)
- That all goods have some sort of warranty period within which they will be replaced or repaired under manufacturer guarantee and so can be discounted within repair statistics; repair is taken to be an explicit activity in out-of-warranty period. This is reasonable because in-warranty repair is built into the original price of the item and should therefore not appear as a separate cost or revenue line.
- There is a typical, or at least minimum cost of repair; consumers or purchasers are assumed to be rational and informed, so they note that when the cost of repair exceeds the residual value of their good, they reject repair.
- The likelihood of repair increases (linearly) from 0% at the end of warranty up to the viability threshold; this is a simplification which favours repair as, in reality, many products showing a much greater frequency of failures towards the end of their design life. We assume a weighted average between these two to determine the likely failure age and hence how much life is left. It is this **residual life** that is saved by conducting repair. Note that in the environmental impact tables of the sector chapters which follow, this **residual life factor** is presented as an estimate of the fraction of a whole use life which is attributable to the particular VRP.
- N.B. This curve is not an absolute likelihood of requirement for repair or indeed of seeking repair; it is simply a cumulative frequency distribution of when a failure might be expected (i.e. more likely towards end of life), thus triggering repair.

For those sectors where repair is observed as a VRP, we have applied this modelling to get a more realistic view of residual life and hence what the offset may be from a new good. Figure 54 presents a sample output for the case of home appliances, specifically a washing machine.

Figure 54: Graphical representation of repair residual life modelling, exemplified by a washing machine



Re-use

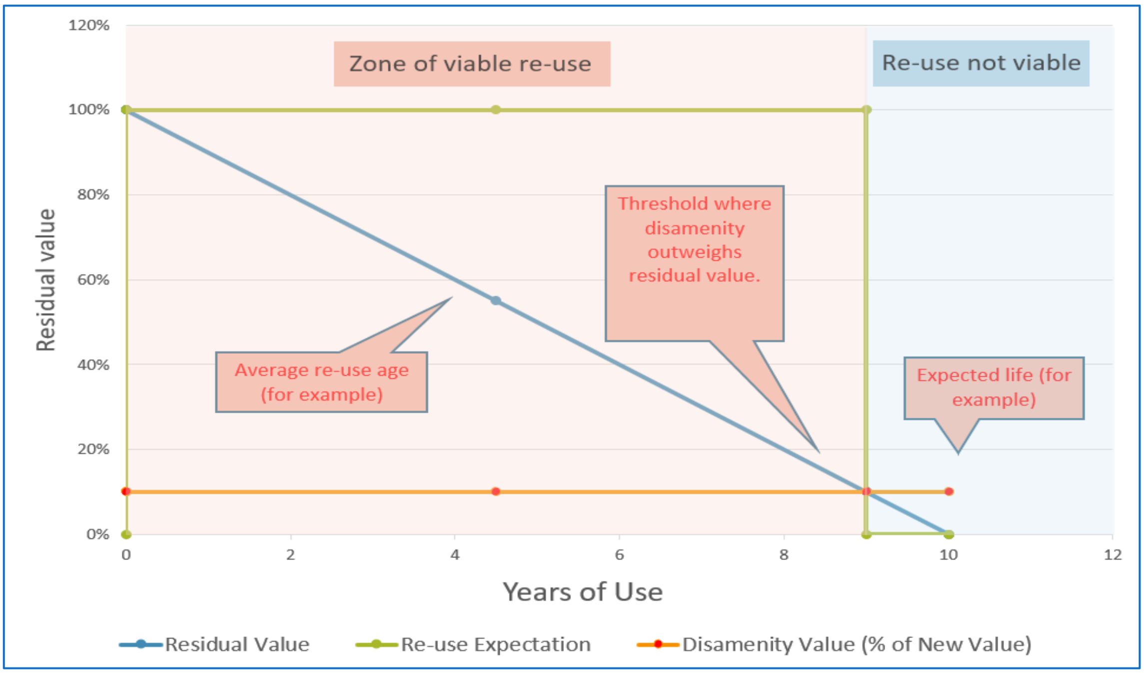
Re-use presents a more complicated problem. From the IRP's perspective, re-use is an option applicable before an item reaches the end of its life, but if put back into service, it still has the same total expected lifetime. In most of the impact studies that we have found, re-use has a small, almost negligible impact as a VRP but appears to claim the whole benefit of an avoided new object. Impact-wise, it seems obvious that things should be re-used rather than disposed of and replaced, but these headline benefits do not properly account for the residual life left in the object being less than a full life. For one, the 'transaction cost' on the disposer's side may outweigh the real cost of finding a new home, or indeed any intangible benefits such as a rise from donation or altruism. It may be also that this consideration is what is uppermost in potential re-users' minds: having information on how long a good has been in service and what a full service life should be in order to judge what price might be paid. (Note that this price is likely to fall to zero before 'no remaining life' due to the implied effort (or dis-utility in economic terms) of continually re-purchasing short-lived items.)

Trying to account for this raises quite fundamental questions regarding product life: What is product life and is it ever really 'designed' in by the OEM? If not, are we judging the product life by what we see at disposal – the amalgamation of 'true' end of life (after one or more users) and premature disposal? Little work has been done on this and what has is very product specific. In practice, our only guide is the observed life (or age distribution) at point of disposal, which has been crudely estimated for a range of common goods.

With this in mind, what really concerns us is at what fraction of their use life does disposal of potentially re-usable goods take place. To estimate the potential for further re-use, we also need to know the proportion of goods which are capable of re-use, but which are prematurely disposed of. For most classes of good, this information is sparsely available or not definitive in quantifying use life's. Within this study, the only accurate estimate of re-use exists for the automotive sector. This activity is dominated by the resale of pre-owned vehicles, with a lower contribution from parts reclaimed from salvage at end of vehicle life (which will be ignored at this level of accuracy).

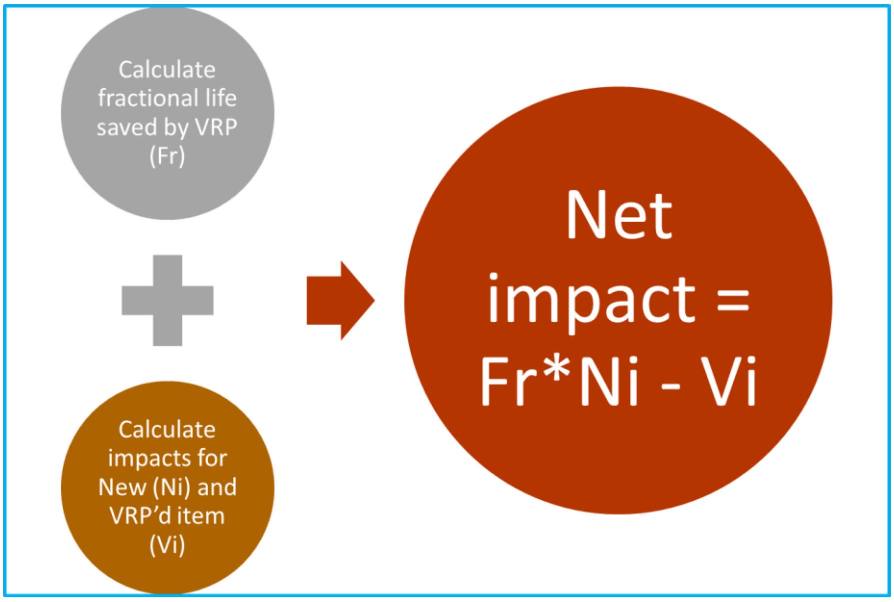
In effect, a similar model for residual life pertains as was developed for repair. In a commercial transaction, there will still be considerations of residual value and the age where dis-utility becomes dominant, and hence an upper bound exists on age for re-use. (Note that in donated goods, this upper bound is absent.) On the other hand, there may be no lower bound on re-use, which may take place within the warranty period. (This feature would no doubt be reflected in the transaction price.) Otherwise, we consider that re-use happens uniformly between these bounds. Figure 55 shows such a model for automotive.

Figure 55: Graphical representation of re-use residual life modelling for transacted goods, exemplified by automotive



This fractional residual life (Fr) is combined with the impact of new item manufacture (economic, environmental) and the headline impact of the VRP activity to yield a net VRP benefit, as illustrated in Figure 56.

Figure 56: Approach to calculating the VRP benefits



Annex C *Automotive sector relationships*

In this sector, there is a range of actors involved in remanufacturing activities, distinguishing between in and out of warranty activities and activities independent from or connected to the OEM. These actors and relationships are summarized in the table below.

Table 47: Actors and relationships in automotive remanufacturing

Remanufacturing actor	Actor description	Actor relationships/markets			
		OEM	**Tier 1**	**Independent**	**Local rebuilders**
OEMs	Vehicle manufacturers who mostly remanufacture major components they have designed and/or manufactured, e.g. engines, gearboxes	Internal remanufacturing program	May issue remanufacturing contracts for in-warranty repairs		N/A
Tier 1	(Original) component manufacturers who also undertake remanufacturing	May undertake remanufacturing under contract for in-warranty repairs	Internal remanufacturing program for out of warranty repairs	May contract out remanufacturing to independents	May franchise out service workshops, who may also undertake local rebuilding
Independent	Remanufacturers who are not involved in the manufacture of new components	May undertake remanufacturing under contract for in-warranty repairs	May remanufacture under contract for Tier 1	Internal remanufacturing program for out of warranty repairs	N/A
Local rebuilders	Local actors who undertake "rebuilding" i.e. a less rigorous process than remanufacturing	N/A	May be service workshops franchised by Tier 1	N/A	Internal rebuilding activity for out of warranty repairs

Annex D *Extended analysis of the home appliance sector*

Early analysis of data suggested that VRP agents acquire cores through their existing supply chain – primarily through appliance retailers who pick up end of life/end of use appliances when delivering new appliances to customers. This relates specifically to home appliances.

As background, Deloitte (Deloitte and Cheminfo, 2019) estimated that end of life/end of use appliances generated in Canada per annum contained 130 kt of plastics. Using an average plastic composition of 23%, this implies that the mass of EoL/EoU appliances generated per annum is approximately **565kt**. This is similar to the findings of (Kumar & Holuszko, 2016) who estimated that the end of life or end of use appliances generated in Canada in 2014 was approximately **560 kt**. However, this is likely an overestimation as it includes additional types of waste such as large printing and copying machines. (These numbers are so similar it is likely Deloitte based their estimates on Kumar's data.)

The Major Appliance Recycling Roundtable (MARR) Annual Report for 2018 (MARR, 2019) reported appliance disposal in BC. A previous report on MARR's activity (PwC, 2017) quoted an average device mass of **88 kg**, which is high but implies that disposals are dominated by washing machines, freezers, driers, ranges and the like. (This has not been verified as part of this project.) However, extrapolating the BC data across Canada, we estimated that 4.86 million end of life/end of use appliances (approximately **430 kt**) were generated in Canada in 2018. This figure is in line with the Kumar figures, allowing for non-home appliance devices.

Using MARR data, we judge that, of those appliances arising for waste (4.86 million):

- 0.97 million are diverted through direct re-use, donations or long-term storage
- 3.7 million are diverted from landfill through recycling or refurbishment; and
- 0.19 million cores are disposed directly in landfills.

Our survey data indicates that, of the 3.7 million, a minimum of 60,000 cores are refurbished in Canada per annum, specifically home appliances. Using the MARR data, this implies a refurbished mass of **5.3 kt/yr**. Assuming a notional value of $CAD 400 per device at point of sale, this suggests a refurbishment income of **$CAD 24 million/yr**.

This is far from the $CAD 0.92 billion reported for repair services in the national statistics (see Home Appliances section). We infer, therefore, that there must be a substantial (overwhelming) element of repair, and a strong contribution from devices in the non-domestic setting. It is also likely the case that many of these other devices find their way to disposal via routes other than the conventional domestic route; and – more importantly – that they are subject to refurbishment or even remanufacturing. This is the case, for example, with Xerox print-stations and similar from other large players.

Is it possible to break down the split between domestic and business VRP activity? To do this, we need to estimate the domestic repair activity. Assume the following:

- There are 10 million households in Canada
- There are 3 major appliances per household
- There is a 10% chance of a major failure requiring repair per year per appliance
- The price of a repair is $CAD 200

This implies a repair value of $CAD 600 million/yr.

Take the balance to be industrial VRP services e.g. printers, industrial and institutional laundries, etc. These are more likely to be biased towards refurbishment (perhaps even servitized) VRPs than repair. Taking this into account, we construct this matrix:

		Refurbishment	Repair	VRP total $CAD million
Domestic	Sales Income $/yr	$24,000,000	$600,000,000	
	Price $	$400.00	$200.00	
	No. of Units/yr	60,000	3,000,000	
	Mass t/yr	5,280	264,000	
Industrial	Sales Income $/yr	$96,000,000	$200,000,000	
	Price $	$800.00	$400.00	
	No. of Units/yr	120,000	500,000	
	Mass t/yr	10,560	44,000	
Total	Sales Income $/yr	**$120 million**	**$800 million**	**$0.92 billion/yr**
	No. of Units/yr	**180,000**	**3,500,000**	**3.68 million/yr**
	Mass t/yr	**15,840**	**308,000**	**314 kt/yr**

This has been taken forward for impact analysis.

Annex E *Canada-United States-Mexico (CUSMA) trade agreement*

Section 1 of the agreement text (Initial Provisions and General Definitions) includes the following definitions:

> ***remanufactured good*** *means a good classified in HS Chapters 84 through 90 or under heading 94.02 except goods classified under HS headings 84.18, 85.09, 85.10, and 85.16, 87.03 or subheadings 8414.51, 8450.11, 8450.12, 8508.11, and 8517.11, that is entirely or partially composed of recovered materials and:*
>
> *(a) has a similar life expectancy and performs the same as or similar to such a good when new; and*
>
> *(b) has a factory warranty similar to that applicable to such a good when new.*
>
> ***recovered material*** *means a material in the form of one or more individual parts that results from:*
>
> *(a) the disassembly of a used good into individual parts; and*
>
> *(b) the cleaning, inspecting, testing or other processing of those parts as necessary for improvement to sound working condition.*

The three key aspects highlighted in the CUSMA remanufacturing definition are:

1. A similar life expectancy.
2. Performance similar to or the same as a new good.
3. A factory warranty similar to that for a new good.

These aspects are broadly consistent with the remanufacturing definition in Section 1.1.2 of this report, with the requirement for a “factory warranty” implying the industrialized nature of remanufacturing. There is room for interpretation around what constitutes “similar” in relation to life expectancy, performance and warranty, but the CUSMA definition is unlikely to misclassify genuine remanufactured products.

The CUSMA definition of “recovered material” can be considered to be equivalent to the definition of “core”.

The definition of remanufacturing in CUSMA provides a list of HS codes for defining what goods may be classified as remanufactured and what goods are excluded. These codes are listed in the Table 48. Codes highlighted in green are permitted to be classified as remanufactured, codes highlighted in red are not permitted to be classified as remanufactured.

Table 48: HS Codes for permitted and excluded remanufactured products under CUSMA

Code	Description	Code	Description
84	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof	85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers; television image and sound recorders and reproducers, parts and accessories of such articles
86	Railway, tramway locomotives, rolling stock and parts thereof; railway or tramway track fixtures and fittings and parts thereof; mechanical (including electro-mechanical) traffic signaling equipment of all kinds	87	Vehicles; other than railway or tramway rolling stock, and parts and accessories thereof
88	Aircraft, spacecraft and parts thereof	89	Ships, boats and floating structures
90	Optical, photographic, cinematographic, measuring, checking, medical or surgical instruments and apparatus; parts and accessories	94.02	Furniture; medical, surgical, dental or veterinary (e.g. operating tables, hospital beds, dentists' chairs) barbers' chairs; parts
84.18	Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machines of heading no. 8415	85.09	Electro-mechanical domestic appliances; with self-contained electric motor, other than vacuum cleaners of heading 85.08.
85.10	Shavers, hair clippers and hair removing appliances, with self-contained electric motor	85.16	Electric water, space, soil heaters; electro-thermic hair-dressing apparatus; hand dryers, irons; electro-thermic appliances for domestic purposes; electro heating resistors, not of heading no. 8545
87.03	Motor cars and other motor vehicles; principally designed for the transport of persons (other than those of heading no. 8702), including station wagons and racing cars	8414.51	Air or vacuum pumps, air or other gas compressors and fans; ventilating or recycling hoods incorporating a fan whether or not fitted with filters: Fans; table, floor, wall, window, ceiling or roof fans, with a self-contained electric motor of an output not exceeding 125W
8450.11	Household or laundry-type washing machines; including machines which both wash and dry: Washing machines; household or laundry-type, fully automatic, (of a dry linen capacity not exceeding 10kg)	8450.12	Household or laundry-type washing machines; including machines which both wash and dry: Washing machines; household or laundry-type, with built-in centrifugal drier, (not fully automatic), of a dry linen capacity not exceeding 10kg
8508.11	Vacuum cleaners: Vacuum cleaners, with self-contained electric motor, of a power not exceeding 1,500 W and having a dust bag or other receptacle capacity not exceeding 20L	8517.11	Telephone sets, including telephones for cellular networks or for other wireless networks; other apparatus for the transmission or reception of voice, images or other data (including wired/wireless networks), excluding items of 8443, 8525, 8527, or 8528: Line telephone sets with cordless handsets

	PERMITTED		EXCLUDED

Table 49 summarizes the implications of the permitted/excluded HS codes for the product sectors considered in this study.

Table 49: Implications of HS Code treatment on sectors of interest

Sector	CUSMA text implications
Aerospace	All products permitted for remanufacturing classification.
Automotive	Whole vehicles (87.03) cannot be classified as remanufactured goods. This does not have any significant ramifications as automotive remanufacturing occurs on a parts basis. Reconditioned vehicles (e.g. restored classic cars) could not be classified as remanufactured goods, but that is in-line with industrial interpretations of remanufacturing practice.
Electronics	Products under HS code 8517.11 are not permitted to be classified as remanufactured. (This likely reflects the relatively poor definition of remanufacturing practice or performance in the sector.) These are telephone sets, including cell phones. All other electronic items can be classified as remanufactured, with the exception of vacuum cleaners classified under 8508.11
Home appliances	The majority of home appliances are not permitted for remanufacturing classification. (This likely reflects the relatively poor definition of remanufacturing practice or performance in the sector.) This has limited implications due to the lack of remanufacturing activity currently taking place in this sector, where refurbishment, repair and re-use are more widely encountered VRPs. This exclusion may have implications going forward, should there be an uptake in remanufacturing activities, for example to support a lease-based model operating internationally.
Heavy-duty and off-road	All products permitted for remanufacturing classification. (This likely reflects the inherent high value of parts and machines; the relatively advanced definition of remanufacturing practice or performance in the sector; and possibly the concerns of vested interests of major manufacturers)
Furniture	No products permitted for remanufacturing classification, except medical, surgical, dental, barbers' or veterinary furniture items (and their parts) where the products contain rotating, reclining, elevating elements, or mechanical fittings. Examples of office furniture remanufacturers operating in Canada were found and this exclusion would prevent their classification of goods as remanufactured for the purposes of trade with the US and Mexico. Our understanding is that businesses could still trade the goods without classification as remanufactured, however, a party could impose a prohibition/restriction on the import of used furniture, in which case, remanufactured furniture would not be exempt from this. However, no evidence of Canadian furniture remanufacturers selling their products outside of Canada have been found to date.
Marine	All products permitted for remanufacturing classification.
Medical devices	All products permitted for remanufacturing classification except goods classified under 8414.51 (i.e. certain pumps, compressors and fans). This exception leaves substantial scope for other remanufactured goods in this sector.
Industrial equipment	All products permitted for remanufacturing classification except goods classified under 8414.51 (i.e. certain pumps, compressors and fans) or 84.18 (i.e. certain refrigerating, freezing and heat pump devices). These exceptions leave substantial scope for other remanufactured goods in this sector.
Rail	All products permitted for remanufacturing classification.

Additional elements of the CUSMA text relevant for remanufacturing and other VRP activities are:

- The Committee on Technical Barriers to Trade – any barriers to trade of remanufactured goods or core related to regulations, standards, and conformity assessment that are encountered could be raised via this committee.
- The Commission for Environmental Cooperation work program includes reference to "Reducing pollution and supporting strong, low emissions, resilient economies through... (I) the sound management of chemicals and waste, including transboundary movements of hazardous waste, and the life cycle management of, and trade in, reusable, recoverable, and recyclable materials;". Remanufacturing and other VRP activities would fall within this definition. The Commission could therefore be considered a pertinent stakeholder for dissemination of findings related to VRPs.

Annex F *Economic multipliers for jobs & growth*

Economic returns are expected to be on a sub-sector basis. The total multipliers included in sector profiles provide estimates of the economic impact of spending in each sub-sector considered within the study. While these multipliers do not disaggregate to specifically cover VRP activities, they can be used as an estimator of economic impact. Multipliers for specific industries were included in previous sections, and a summary of total multipliers is provided in Table 50.

Table 50: Summary of Total Multipliers for VRP activities in Canada (2019)

Sector	Output	GDP at market prices	Labour income	Taxes on production	Jobs
Aerospace	1.667	0.753	0.432	0.023	5.578
Automotive	1.979	1.190	0.739	0.047	15.775
HDOR	2.045	0.928	0.557	0.03	8.344
Electronics	1.621 - 1.860	0.735 - 0.894	0.414 - 0.513	0.024 - 0.030	6.294 - 10.298
Domestic Appliances	1.884	0.781	0.462	0.028	8.003
Furniture	2.019 - 2.112	0.924 - 1.032	0.52 5- 0.675	0.033 - 0.038	9.288 - 13.202
Marine	1.979	0.989	0.585	0.031	9.534
Medical devices	1.879	0.983	0.576	0.031	9.663
Industrial equipment	1.935 - 1.990	0.941 - 1.022	0.589 - 0.649	0.033 - 0.034	8.977 - 9.447
Rail	2.174	0.876	0.584	0.032	7.922

Note(s): Detailed descriptions of multipliers, sectors included, and other industry-specific information is included in the table specific to each industry, below. However, it can be noted manufacturing multipliers in each sector are typically used as the proxy for VRP activities.

As there are no specific multipliers available for VRP activities, qualitative considerations of differences between input requirements for VRP activities and traditional manufacturing activities prevail. Statistics Canada multipliers (2016) for repair and maintenance industries suggest labour income and job opportunities are typically higher than for manufacturing sectors identified.

Direct labour income in repair and maintenance activities is typically 150% of direct labour income in manufacturing sectors. Excluding automotive, which used repair and maintenance multipliers, direct labour income multipliers for sectors considered was between 0.209 and 0.365. This is much lower than the multipliers in Table 50 which are approximately 0.46. Direct jobs per million dollars of output in repair and maintenance sectors was between 8 and 11 jobs while in manufacturing estimates, direct jobs per million dollars of output ranged from 2 to 8 jobs though most sectors had fewer than 5 jobs.

All economic data derived from (Statistics Canada, 2020).

Notes common to all tables

a. Financials expressed as per dollar of direct output (for multipliers)
b. Jobs expressed as per million dollars of output (for multipliers)
c. The induced multiplier measures the value of production driven by household expenditures associated with labour income (for example, wages) generated from the direct and indirect effects. Induced effects tend to exaggerate the impacts of final expenditures within a one-year production cycle.
d. The simple multiplier measures the total value of production required from all industries across all stages of production to produce one unit of output for final use.
e. The total multiplier measures the sum of the direct, indirect and induced multipliers.
f. Tables may contain rounding differences in totals.

Table 51: National Input-Output Multipliers & Economic Impacts – Automotive and Non-Automotive Repair, 2016

Multiplier Type	Output	GDP at Market Prices	Labour Income	Taxes on production	Jobs
Automotive Repair and Maintenance					
Direct	1	0.598	0.459	0.011	10.398
Indirect	0.487	0.267	0.147	0.014	2.606
Induced	0.492	0.325	0.133	0.022	2.772
Simple	1.487	0.865	0.606	0.025	13.003
Total	**1.979**	**1.190**	**0.739**	**0.047**	**15.775**
Repair and Maintenance (except automotive)					
Direct	1	0.608	0.463	0.008	8.858
Indirect	0.497	0.270	0.149	0.014	2.660
Induced	0.495	0.327	0.134	0.022	2.787
Simple	1.497	0.878	0.613	0.022	11.518
Total	**1.992**	**1.205**	**0.747**	**0.044**	**14.305**

Table 52: National Input-Output Multipliers & Economic Impacts – Aerospace Product and Parts Manufacturing

Multiplier Type	Output	GDP at Market Prices	Labour Income	Taxes on production	Jobs
Multipliers (2016)					
Direct	1	0.382	0.24	0.005	2.338
Indirect	0.408	0.2	0.122	0.006	1.782
Induced	0.259	0.171	0.07	0.012	1.457
Simple	*1.408*	*0.582*	*0.363*	*0.011*	*4.12*
Total	**1.667**	**0.753**	**0.432**	**0.023**	**5.578**
Magnitudes (Current 2019)					
Direct	8,016,000,000	3,062,100,000	1,923,800,000	40,080,000	18,700
Indirect	3,270,500,000	1,603,200,000	978,000,000	48,096,000	14,300
Induced	2,076,100,000	1,370,700,000	561,100,000	96,192,000	11,700
Simple	*11,286,500,000*	*4,665,300,000*	*2,901,800,000*	*88,176,000*	*33,000*
Total	**$CAD 13,362,600,000**	**$CAD 6,036,000,000**	**$CAD 3,462,900,000**	**$CAD 184,368,000**	**44,700**
Future 2030 Scenarios					
As-Is (gross new)					
Direct	1,633,900,000	993,400,000	756,500,000	13,100,000	14,500
Indirect	812,100,000	441,200,000	243,500,000	22,900,000	4,300
Induced	808,800,000	534,300,000	218,900,000	35,900,000	4,600
Simple	*2,446,000,000*	*1,434,600,000*	*1,000,000*	*35,900,000*	*18,800*
Total	**3,254,800,000**	**1,968,900,000**	**1,218,900,000**	**71,900,000**	**23,400**
Rebound (net new)					
Direct	1,315,100,000	799,600,000	608,900,000	10,500,000	11,600
Indirect	653,600,000	355,100,000	196,000,000	18,400,000	3,500
Induced	651,000,000	430,000,000	176,200,000	28,900,000	3,700
Simple	*1,968,800,000*	*1,154,700,000*	*804,900,000*	*28,90,000*	*15,100*
Total	**2,619,800,000**	**1,584,800,000**	**981,100,000**	**57,900,000**	**18,800**
Delayed Rebound (net new)					
Direct	966,700,000	587,800,000	447,600,000	7,700,000	8,600
Indirect	480,500,000	261,000,000	144,000,000	13,500,000	2,600
Induced	478,500,000	316,100,000	129,500,000	21,300,000	2,700
Simple	*1,447,200,000*	*848,800,000*	*591,600,000*	*21,300,000*	*11,100*
Total	**1,925,700,000**	**1,164,900,000**	**721,200,000**	**42,500,000**	**13,800**
Recession (net new)					
Direct	-735,000,000	-446,900,000	-340,300,000	-5,900,000	-6,500
Indirect	-365,300,000	-198,400,000	-109,500,000	-10,300,000	-2,000
Induced	-363,800,000	-240,300,000	-98,500,000	-16,200,000	-2,000
Simple	*-1,100,300,000*	*-645,300,000*	*-449,800,000*	*-16,200,000*	*-8,500*
Total	**-1,464,100,000**	**-885,700,000**	**-548,300,000**	**-32,300,000**	**-10,500**

Table 53: National Input-Output Multipliers & Economic Impacts – Automotive Repair and Maintenance Activities

Multiplier Type	Output	GDP at Market Prices	Labour Income	Taxes on production	Jobs
Multipliers (2016)					
Direct	1	0.598	0.459	0.011	10.398
Indirect	0.487	0.267	0.147	0.014	2.606
Induced	0.492	0.325	0.133	0.022	2.772
Simple	*1.487*	*0.865*	*0.606*	*0.025*	*13.003*
Total	**1.979**	**1.190**	**0.739**	**0.047**	**15.775**
Magnitudes Current 2019					
Direct	32,815,000,000	19,623,400,000	15,062,100,000	61,000,000	341,200
Indirect	15,981,000,000	8,761,600,000	4,823,800,000	459,400,000	85,500
Induced	16,145,000,000	10,664,900,000	4,364,400,000	721,900,000	91,000
Simple	*48,796,000,000*	*28,385,000,000*	*19,885,900,000*	*520,400,000*	*426,700*
Total	**$CAD 64,941,000,000**	**$CAD 39,049,900,000**	**$CAD 24,250,300,000**	**$CAD 1,242,300,000**	**517,690**
Future 2030 Scenarios					
As-Is (gross new)					
Direct	3,006,000,000	1,797,600,000	1,380,000,000	33,100,000	31,300
Indirect	1,463,900,000	802,600,000	441,900,000	42,100,000	7,800
Induced	1,479,000,000	977,000,000	399,800,000	66,100,000	8,300
Simple	*4,470,000,000*	*2,600,200,000*	*1,821,700,000*	*75,200,000*	*39,100*
Total	**5,949,000,000**	**3,577,200,000**	**2,221,500,000**	**141,300,000**	**47,400**
Natural Growth (net new)					
Direct	71,600,000	88,700,000	73,900,000	1,900,000	1,900
Indirect	-45,900,000	300,000	-4,200,000	1,700,000	30
Induced	69,500,000	45,900,000	18,800,000	3,200,000	400
Simple	*25,800,000*	*89,000,000*	*69,700,000*	*3,600,000*	*2,000*
Total	**95,200,000**	**134,900,000**	**88,900,000**	**6,800,000**	**2,400**
Moderate Action (net new)					
Direct	358,200,000	443,500,000	369,500,000	9,300,000	9,700
Indirect	-229,400,000	1,600,000	-20,800,000	8,600,000	140
Induced	347,300,000	229,300,000	94,200,000	15,900,000	2,000
Simple	*128,800,000*	*445,100,000*	*348,700,000*	*17,900,000*	*9,800*
Total	**476,100,000**	**674,300,000**	**442,900,000**	**33,900,000**	**11,800**
Strong Action (net new)					
Direct	716,400,000	886,900,000	739,000,000	18,600,000	19,400
Indirect	-458,900,000	3,200,000	-41,600,000	17,200,000	300
Induced	694,600,000	458,500,000	188,400,000	31,900,000	3,900
Simple	*257,600,000*	*890,200,000*	*697,400,000*	*35,800,000*	*19,600*
Total	**952,100,000**	**1,348,700,000**	**885,900,000**	**67,700,000**	**23,600**

Note: Automotive repair and maintenance multipliers were used as the multipliers for VRP activities in the automotive sector.

Table 54: National Input-Output Multipliers & Economic Impacts – Agriculture, Construction and Mining Machinery Manufacturing

Multiplier Type	Output	GDP at Market Prices	Labour Income	Taxes on production	Jobs
Multipliers (2016)					
Direct	1	0.358	0.257	0.004	3.344
Indirect	0.674	0.324	0.2	0.01	2.908
Induced	0.371	0.245	0.1	0.017	2.092
Simple	*1.674*	*0.683*	*0.457*	*0.014*	*6.252*
Total	**2.045**	**0.928**	**0.557**	**0.03**	**8.344**
Magnitudes (Current 2019)					
Direct	846,000,000	302,900,000	217,400,000	3,400,000	2,800
Indirect	570,200,000	274,100,000	169,200,000	8,400,000	2,500
Induced	313,900,000	207,300,000	84,600,000	14,400,000	1,800
Simple	*1,416,200,000*	*577,000,000*	*386,600,000*	*11,800,000*	*5,300*
Total	**$CAD 1,730,100,000**	**$CAD 784,200,000**	**$CAD 471,200,000**	**$CAD 26,200,000**	**7,100**
Future 2030 Scenarios					
As-Is (gross new)					
Direct	225,300,000	137,000,000	104,300,000	1,800,000	2,000
Indirect	112,000,000	60,800,000	33,600,000	3,200,000	600
Induced	111,500,000	73,700,000	30,200,000	5,000,00	600
Simple	*337,300,000*	*197,800,000*	*137,900,000*	*5,000,000*	*2,600*
Total	**448,900,000**	**271,500,000**	**168,100,000**	**10,000,000**	**3,200**
Natural Growth (net new)					
Direct	23,000,000	3,000,000	2,300,000	40,000	50
Indirect	700,000	600,000	200,000	60,000	10
Induced	2,000,000	1,300,000	600,000	90,000	10
Simple	*3,700,000*	*3,500,000*	*2,500,000*	*100,000*	*60*
Total	**5,700,000**	**4,900,000**	**3,100,000**	**190,000**	**70**
Moderate Action (net new)					
Direct	15,000,000	14,700,000	11,600,000	200,000	260
Indirect	3,500,000	2,800,000	1,100,000	300,000	30
Induced	10,200,000	6,700,000	2,800,000	400,000	60
Simple	*18,500,000*	*17,600,000*	*12,700,000*	*500,000*	*290*
Total	**28,700,000**	**24,300,000**	**15,400,000**	**1,000,000**	**350**
Strong Action (net new)					
Direct	30,000,000	29,500,000	23,200,000	400,000	510
Indirect	6,900,000	5,700,000	2,200,000	600,000	70
Induced	20,400,000	13,500,000	5,500,000	900,000	120
Simple	*36,900,000*	*35,200,000*	*25,300,000*	*1,000,000*	*580*
Total	**57,400,000**	**48,700,000**	**30,900,000**	**1,900,000**	**700**

Table 55: National Input-Output Multipliers & Economic Impacts – Electronics

Multiplier Type	Output	GDP at Market Prices	Labour Income [a]	Taxes on production [a]	Jobs [b]
Multipliers (2016)					
Direct	1	0.324-0.451	0.210-0.302	0.004-0.007	2.763-6.931
Indirect	0.302-0.516	0.164-0.258	0.101-0.157	0.005-0.009	1.572-2.556
Induced	0.274-0.345	0.181-0.228	0.074-0.093	0.012-0.015	1.542-1.942
Simple	*1.302-1.516*	*0.554-0.666*	*0.340-0.422*	*0.011-0.015*	*4.609-8.503*
Total	**1.621-1.860**	**0.735-0.894**	**0.414-0.513**	**0.024-0.030**	**6.294-10.298**
Magnitudes (Current 2019)					
Direct	1,391,800,000	450,900,000-627,700,000	292,200,000 - 420,300,000	5,6,000 - 9,700,000	3,800 - 9,700
Indirect	420,300,000 - 718,200,000	228,300,000 - 359,100,000	140,600,000 - 218,500,000	7,000,000 - 12,500,000	2,200 - 3,600
Induced	381,300,000 - 480,200,000	251,900,000 - 317,300,000	103,000,000 - 129,400,000	16,700,000 - 20,877,000	2,100 - 2,700
Simple	*1,812,100,000 - 2,109,900,000*	*679,200,000 - 986,800,000*	*432,800,000 - 638,800,000*	*12,500,000 - 22,300,000*	*6,000 - 13,200*
Total	**$CAD 2,193,40,000 - 2,590,1,000**	**$CAD 931,100,000-1,304,100,000**	**$CAD 535,833,000 - 768,260,000**	**$CAD 29,200,000 - 43,100,000**	**8,200 - 15,900**
Future 2030 Scenarios					
As-Is (gross new)					
Direct	285,400,000	173,500,000	132,100,000	2,300,000	2,500
Indirect	141,800,000	77,000,000	42,500,000	4,000,000	800
Induced	141,300,000	93,300,000	38,200,000	6,300,000	800
Simple	*427,200,000*	*250,600,000*	*174,600,000*	*6,300,000*	*3,300*
Total	**568,400,000**	**343,900,000**	**212,900,000**	**12,600,000**	**4,100**
Natural Growth (net new)					
Direct	8,900,000	5,900,000	4,600,000	70,000	100
Indirect	4,400,000	2,400,000	1,300,000	140,000	small
Induced	4,800,000	3,200,000	1,300,000	220,000	small
Simple	*13,200,000*	*8,300,000*	*5,900,000*	*210,000*	*100*
Total	**18,100,000**	**11,600,000**	**7,200,000**	**430,000**	**<200**
Moderate Action (net new)					
Direct	44,400,000	29,500,000	23,100,000	370,000	400
Indirect	21,800,000	12,200,000	6,500,000	700,000	120
Induced	24,400,000	16,100,000	6,600,000	1,100,000	140
Simple	*66,200,000*	*41,700,000*	*29,600,000*	*1,100,000*	*<600*
Total	**90,600,000**	**57,800,000**	**36,200,000**	**2,200,000**	**700**
Strong Action (net new)					
Direct	88,900,000	59,000,000	46,300,000	740,000	850
Indirect	43,600,000	24,400,000	130,000,000	1,400,000	250
Induced	48,800,000	32,200,000	13,200,000	2,200,000	300
Simple	*132,500,000*	*83,400,000*	*59,300,000*	*2,100,000*	*1,100*
Total	**181,200,000**	**115,700,000**	**72,500,000**	**4,300,000**	**1,400**

Note: The range of multipliers includes computer and peripheral equipment manufacturing, communications equipment manufacturing, other electronic product manufacturing, semiconductor and other electronic component manufacturing, electric lighting equipment manufacturing, electrical equipment manufacturing and other electrical equipment and component manufacturing.

Table 56: National Input-Output Multipliers & Economic Impacts – Household Appliance Manufacturing

Multiplier Type	Output	GDP at Market Prices	Labour Income	Taxes on production	Jobs
Multipliers (2016)					
Direct	1	0.298	0.209	0.005	3.62
Indirect	0.585	0.285	0.173	0.009	2.702
Induced	0.298	0.197	0.081	0.013	1.682
Simple	*1.585*	*0.584*	*0.382*	*0.014*	*6.321*
Total	**1.884**	**0.781**	**0.462**	**0.028**	**8.003**
Magnitudes Current 2019					
Direct	920,000,000	274,160,000	192,280,000	4,600,000	3,300
Indirect	538,200,000	262,200,000	159,160,000	8,280,000	2,500
Induced	274,160,000	181,240,000	74,520,000	11,960,000	1,500
Simple	*1,458,200,000*	*536,600,000*	*351,440,000*	*12,880,000*	*5,800*
Total	**$CAD 1,732,360,000**	**$CAD 717,600,000**	**$CAD 425,960,000**	**$CAD 24,840,000**	**7,400**
Future 2030 Scenarios					
As-Is (gross new)					
Direct	188,600,000	114,700,000	87,300,000	1,500,000	1,700
Indirect	93,800,000	50,900,000	28,100,000	2,600,000	500
Induced	93,400,000	61,700,000	25,300,000	4,100,000	500
Simple	*282,400,000*	*165,600,000*	*115,400,000*	*4,100,000*	*2,200*
Total	**375,800,000**	**227,300,000**	**140,700,000**	**8,300,000**	**2,700**
Natural Growth (net new)					
Direct	3,300,000	2,400,000	1,800,000	30,000	<50
Indirect	1,600,000	900,000	500,000	50,000	small
Induced	1,900,000	1,200,000	500,000	80,000	small
Simple	*4,900,000*	*3,200,000*	*2,300,000*	*80,000*	*40*
Total	**6,800,000**	**4,500,000**	**2,800,000**	**200,000**	**50**
Moderate Action (net new)					
Direct	16,600,000	11,800,000	9,100,000	150,000	180
Indirect	7,800,000	4,400,000	2,300,000	260,000	<50
Induced	9,300,000	6,200,000	2,500,000	420,000	50
Simple	*24,400,000*	*16,200,000*	*11,500,000*	*410,000*	*220*
Total	**33,700,000**	**22,400,000**	**14,000,000**	**800,000**	**270**
Strong Action (net new)					
Direct	33,300,000	23,700,000	18,200,000	300,000	350
Indirect	15,600,000	8,800,000	4,700,000	520,000	90
Induced	18,600,000	12,300,000	5,000,000	830,000	110
Simple	*48,800,000*	*32,500,000*	*22,900,000*	*800,000*	*440*
Total	**67,500,000**	**44,800,000**	**27,900,000**	**1,700,000**	**550**

Table 57: National Input-Output Multipliers & Economic Impacts – Furniture Manufacturing, 2016

Multiplier Type	Output	GDP at Market Prices	Labour Income	Taxes on production	Jobs
Multipliers (2016)					
Direct	1	0.336-0.418	0.214-0.360	0.005-0.007	3.583-7.473
Indirect	0.63-0.758	0.300-0.356	0.180- 0.0217	0.012	2.902-3.732
Induced	0.35-0.436	0.231-0.288	0.095-0.118	0.016-0.019	1.973-2.455
Simple	*1.63-1.758*	*0.693-0.744*	*0.430-0.557*	*0.017-0.019*	*7.315-10.747*
Total	**2.019-2.112**	**0.924-1.032**	**0.525-0.675**	**0.033-0.038**	**9.288-13.202**
Magnitudes Current 2019					
Direct	385,133,000	129,405,000 - 160,986,000	82,419,000 - 138,648,000	1,926,000 - 2,696,000	1,400 - 2,900
Indirect	242,634,000 - 291,931,000	115,540,000 - 137,107,000	69,324,000 - 83,574,000	4,622,000	1,100 - 1,400
Induced	134,797,000 - 167,918,000	88,966,000 - 110,918,000	36,588,000 - 45,446,000	6,162,000 - 7,318,000	800 - 900
Simple	*627,767,000 677,065,000*	*244,945,000 - 298,093,000*	*151,743,000 – 222,222,000*	*6,547,000 - 7,318,000*	*2,500 - 4,300*
Total	**$CAD 762,564,000 - 844,983,000**	**$CAD 333,911,000 - 409,012,000**	**$CAD 188,330,000 – 267,668,000**	**$CAD 12,709,000- 14,635,000**	**3,300 - 5,300**
Future 2030 Scenarios					
As-Is (gross new)					
Direct	79,000,000	48,000,000	36,600,000	600,000	700
Indirect	39,200,000	21,300,000	11,800,000	1,100,000	200
Induced	39,100,000	25,800,000	10,600,000	1,700,000	200
Simple	*118,200,000*	*69,300,000*	*48,300,000*	*1,700,000*	*900*
Total	**157,300,000**	**95,200,000**	**58,900,000**	**3,500,000**	**1,100**
Natural Growth (net new)					
Direct	500,000	700,000	500,000	10,000	negligible
Indirect	-300,000	-100,000	-100,000	10,000	negligible
Induced	400,000	300,000	100,000	20,000	negligible
Simple	*200,000*	*700,000*	*400,000*	*20,000*	negligible
Total	**600,000**	**900,000**	**500,000**	**40,000**	**negligible**
Moderate Action (net new)					
Direct	2,600,000	3,700,000	2,400,000	30,000	<50
Indirect	-1,700,000	-300,000	-400,000	60,000	negligible
Induced	1,900,000	1,300,000	500,000	90,000	negligible
Simple	*900,000*	*3,400,000*	*2,000,000*	*90,000*	*<50*
Total	**2,800,000**	**4,700,000**	**2,500,000**	**200,000**	**<50**
Strong Action (net new)					
Direct	5,100,000	7,400,000	4,700,000	60,000	<100
Indirect	-3,400,000	-600,000	-800,000	120,000	negligible
Induced	3,900,000	2,600,000	1,000,000	180,000	negligible
Simple	*1,700,000*	*6,800,000*	*3,900,000*	*180,000*	*<100*
Total	**5,600,000**	**9,400,000**	**5,000,000**	**400,000**	**<100**

Note: Considers the range of multipliers Household and institutional furniture and kitchen cabinet manufacturing [BS337100], office furniture (including fixtures) manufacturing [BS337200] and other furniture-related product manufacturing [BS337900].

Annex G *Summary of VRP findings for Provinces and Territories*

The following table records a mixture of both voluntary survey information received from provinces and territories and web searches of their websites.

Province/ Territory	Understanding of VRP Activity in Jurisdiction?	Policies, strategies or legislation in place to encourage VRPs/CE?	Public/private initiatives in place to support VRPs?	Barriers to VRPs/circular economy known?	Enablers to VRPs/circular economy identified?	Planned policies, strategies or legislation that may impact VRPs?
NL	Unknown	• Electronics EPR. Otherwise, primarily focused on waste diversion	Unknown	Unknown	Unknown	Not apparent
PE	Unknown	• EPR for electronics	Unknown	Unknown	Unknown	Unknown
NS	• Repair/re-use is the largest employment sector in NS	• Trade agreements that incorporate environmental footprints	Unknown	• Low-cost products from other countries are a barrier to VRPs	• Creation of industry associations. • EPR policies and removing sales taxes from VRP products, a symbol to communicate the benefits of VRP products	Unknown
NB	Unknown	• Tire stewardship program	• Government website on suggestions for citizen re-use and reduction	Unknown	EPR	Unknown
QC	• Repair cafes • On-line sharing platforms (*Québec Circulaire* (quebeccirculaire.org)) • Significant academic research on CE. • Specific initiatives have been summarized by others including EDDEC Institute. For example, Mapping of Circular Economy Initiatives in Montreal.	• Residual Materials Management Policy 4R-D principle gives priority to reduction and re-use. • Regulation Respecting the Recovery and Reclamation of Products by Enterprises requires EPR programs to consider re-use before recycling for electronics, batteries, household appliances. • EPR for tires, electronics and other products (http://www.environnement.gouv.qc.ca/matieres/reglement/recup-valor-entrepr/faq.htm). • Quebec Circular initiative developed by EDDEC Institute *Le Plan d'actions pour la croissance et les technologies propres 2018-2023*. In there, they announced the creation of a roadmap for CE.	• Government collaboration with social enterprises that focus on material re-use.	Not apparent	Not apparent	Not apparent

Province/ Territory	Understanding of VRP Activity in Jurisdiction?	Policies, strategies or legislation in place to encourage VRPs/CE?	Public/private initiatives in place to support VRPs?	Barriers to VRPs/circular economy known?	Enablers to VRPs/circular economy identified?	Planned policies, strategies or legislation that may impact VRPs?
		• Development of an Interdepartmental Working Group on CE. • Montreal's Residual Materials Management Plan (PDGMR) with the aim of transitioning to zero waste.				
ON	• Focus primarily on EPR/ diversion, some refurbishment/re-use of electronics, repair cafes, tool library, on-line sharing platforms	• EPR and Resource Recovery and Circular Economy Act, 2016 (RRCEA) - targets for retreading of tires, incentive for refurb/re-use of EEE. • Strategy for a Waste-Free Ontario: Building the Circular Economy • Toronto's CE and Innovation Unit https://www.toronto.ca/services-payments/recycling-organics-garbage/long-term-waste-strategy/working-toward-a-circular-economy/	Unknown	Unknown	Right to Repair	• Supporting the Federal zero Plastic waste strategy
MB	Unknown	• EPR for 12 products including electronic equipment, batteries and tires under the Waste Reduction and Prevention Act https://www.gov.mb.ca/sd/wastewise/pros.html • 4-R Depots in Winnipeg: https://winnipeg.ca/waterandwaste/recycle/4rdepots/default.stm	Unknown	Unknown	Unknown	Unknown
SK	Unknown	• EPR for electronics and tires. Primarily focused on waste diversion and value recovery (not retention)	Unknown	• Small, dispersed population a barrier to VRP economy of scale	Unknown	• Supporting the Federal zero Plastic waste strategy
AB	Re-use centres in Edmonton	• Road Map for Clean Technologies: https://open.alberta.ca/dataset/d576f7d2-54b6-4503-9018-021343e2047a/resource/fe054cad-4b8a-4a5b-bff1-dc8d8399135d/download/edt-clean-technology-road-map.pdfapparent	Unknown	Unknown	Unknown	Not apparent

Province/ Territory	Understanding of VRP Activity in Jurisdiction?	Policies, strategies or legislation in place to encourage VRPs/CE?	Public/private initiatives in place to support VRPs?	Barriers to VRPs/circular economy known?	Enablers to VRPs/circular economy identified?	Planned policies, strategies or legislation that may impact VRPs?
BC	• Repair Cafes • Turo C2C car sharing • Tool Library • On-line sharing platforms • Building deconstruction and re-use initiatives	• Zero waste initiatives in several municipalities. • EPR for tires, batteries and electronics. • In 2017, BC government commissioned a jurisdiction scan of CE global best practices to accelerate a transition to a CE.	• Repair Cafes • Turo C2C car sharing • Tool Library • Sharing platforms • Vancouver Economic Commission (VEC) Upcycle Design Project to enable Building deconstruction and re-use initiatives • VEC is also incubating local CE initiatives	• Barriers to deconstruction of buildings for material re-use include lack of warehousing spaces. • Lack of consumer knowledge. • Lack of market demand for reclaimed materials.	• Right to repair • Incubating CE initiatives	Not apparent
YT	Unknown	• Actions in Our Clean Future draft strategy include moving to EPR and conducting an LCA to determine best management practices for dealing with waste	• Zero Waste Yukon is engaging the public on CE. • Communications campaign “Do the Heavy Lifting” to raise awareness on reduction/re-use	• Economies of scale, large distances for transport	• Right to Repair legislation	• Circular Economy Strategy (2020) • Supporting federal Zero Plastic Waste strategy • Discussions on EPR
NT	• Artisanal scale VRP activity	• CE guiding principles included in Waste Resource Management Strategy and Implementation Plan	None	• Presumably same as manufacturing (i.e. economies of scale)	• Vancouver’s building deconstruction bylaw • EU’s Right to Repair legislation	Nothing specific
NU	Unknown	Not apparent	Unknown			

NL: Newfoundland and Labrador; PE: Prince Edward Island; NS: Nova Scotia; NB: New Brunswick; QC: Quebec; ON: Ontario; MB: Manitoba; SK: Saskatchewan; AB: Alberta; BC: British Columbia; YT: Yukon; NT: Northwest Territories; NU: Nunavut

Annex H *Example of a remanufacturing skills gap analysis*

Remanufacturing stage	Required competence	Automotive	Electronics	Medical devices
1. Collection of documentation	Sourcing required documentation	Green	Green	✓
2. Collection core	Material selection	Grey ✕	Grey ✕	Grey ✕
	Purchasing, identifying and grading appropriate core	Orange	Green	✓
	Salvage engineering	Red	Grey ✕	Grey ✕
	Reverse logistics	Green	Grey ✕	Grey ✕
	De-installation	Grey ✕	Grey ✕	✓
3. Inspection (initial and/or detailed)	Cleaning	Orange	Green	✓
	Visual and/or mechanical	Orange	Green	✓
	Product analysis/diagnostics	Orange	Green	Grey ✕
	Quality control	Orange	Green	Grey ✕
	Safety	Red	Green	✓
4. Disassembly	Cleaning, technical and reverse engineering skills	Red	Green	✓
	Design skills	Grey ✕	Grey ✕	Grey ✕
	IT skills	Grey ✕	Green	Grey ✕
	Safety	Orange	Green	Grey ✕
5. Remediation of parts	Cleaning techniques	Green	Green	✓
	Repair skills – mechanical and technical	Orange	Grey ✕	✓
	Electronics skills	Grey ✕	Green	Grey ✕
	Disinfection	Grey ✕	Grey ✕	✓
6. Replacement	Inspection, removal and replacement	Orange	Orange	Grey ✕
	Technical	Orange	Orange	Grey ✕
7. Reassembly	Soldering/welding	Grey ✕	Orange	Grey ✕
	Reassembly of parts and products	Red	Orange	✓
	Practical skills – mechanical and technical	Red	Orange	Grey ✕
8. Testing	Safety testing	Orange	Green	✓
	Component and product testing	Orange	Green	✓
	Quality control	Orange	Green	✓
9. Warranty	Business models	Orange	Orange	✓
	Market needs and forecasting	Orange	Orange	Grey ✕

Legend:

Green– Skills are adequately addressed
Orange – Skills are insufficiently addressed
Red – Skills are not addressed at all

Grey ✕ – Skills not needed
✓- Skills needed