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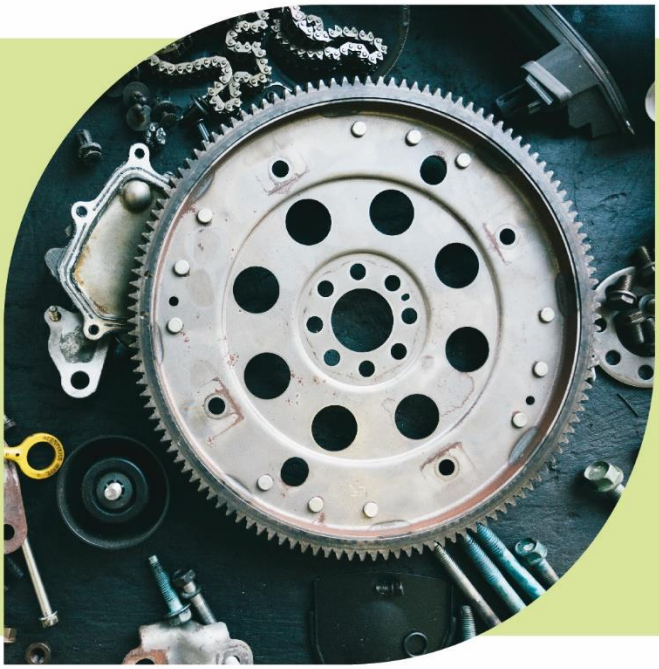

Executive summary of the socio-economic and environmental study of the canadian remanufacturing sector and other value-retention processes in the context of a circular economy

Canada

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Glossary

CE	Circular Economy
GDP	Gross domestic product
GWP	Global Warming Potential (quantified as tonnes CO_2 equivalent)
HDOR	Heavy-duty and off-road (equipment)
ICT	Information and communications technologies (as a subset of the Electronics sector)
MRO	Maintenance, repair and overhaul
R+R	Remanufacturing & Comprehensive Refurbishment combined
US(A)	The United States (of America)
VRPs	Value-retention processes
$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

Value-Retention Processes	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. (1)
Remanufacturing	Remanufacturing is a full-service life value-retention process 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. These products must be sold with the guarantee, or warranty, that they are in the aforementioned 'as good as' or 'better than' new condition. (1)
Comprehensive Refurbishment	Refurbishment that takes place within industrial or factory settings, usually consisting of data wiping (for electronics) and upgrade, repair for functionality and then aesthetic touch-ups. The rigorous nature of this process results in a product whose service life will often be almost equal to that of the full new product service life. (1)
Refurbishment	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 it modifies the product unit as such that the usable product life can extend past the designed lifespan but does not result in a full new service life like remanufacturing. (1)
Repair	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.
Direct Re-use	The collection, inspection and testing, cleaning and redistribution of a product back into the market (1). 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.
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. (2)
Waste	Any substance or object which the holder discards or intends or is required to discard. (2)

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

Language

This report is available in French and English and uses harmonized terms for Value-Retention Processes in both.

Contents

Introduction

Transitioning to a circular economy (CE) has been identified as a way to reduce the environmental impacts associated with current production and consumption processes while improving socio-economic outcomes. One tactic for bringing about the circular economy, both in Canada and worldwide, is through the use of value-retention processes (VRPs).

There are only a handful of studies from around the world that have gathered data in this topic. They cover broadly the same sector areas, but they focus entirely on one VRP, remanufacturing. That makes comparisons on the level of activity more complicated: this study is the world's first attempt to assess what is happening in a country across **all** VRPs. There is no other benchmark.

Recognizing VRPs' potential for enabling a transition to a more circular economy, and to positively contribute to the federal agenda on zero plastic waste, Canada intends to develop a national strategy to encourage remanufacturing of products and other VRPs. The outcomes of this study will feed into that process and will inform policy options and recommendations for action. The ultimate objective of the strategy is to enable the growth of the Canadian remanufacturing sectors and other VRPs, but to do this requires a better understanding of the state of Canada's overall VRP industry. Currently, the scope and size of the VRPs industry in Canada is not well understood and there is little socio-economic information for this industry that is available on a national scale. With the broad aim of establishing this 'baseline', the objectives of this study were to:

- define and describe the current state of the remanufacturing sector and other VRPs in Canada
- evaluate their environmental and socio-economic cost and benefits
- identify barriers and opportunities
- provide case studies on remanufacturing in specific industry sectors in Canada
- identify sectors in Canada that would benefit the most from remanufacturing and those where remanufacturing would not be the best placed approach, and
- suggest potential policy instruments and incentives that could be implemented in Canada to further develop the remanufacturing sector.

Value-retention processes

Simply put, VRPs are activities which keep products in use for longer, either through direct reuse, repair, refurbishment, comprehensive refurbishment or remanufacturing. The level of formal processes and the socio-economic and environmental benefits of VRPs are on a spectrum (see Figure 1). At one end of the spectrum are re-use and repair – familiar processes to almost everyone - which prolong the in-use life of a product. At the other end of the spectrum, few people will have heard of remanufacturing and comprehensive refurbishment, tactics designed to put worn out products back to as-new or better condition and which, for many products, can provide better socio-economic and environmental outcomes over less rigorous processes.

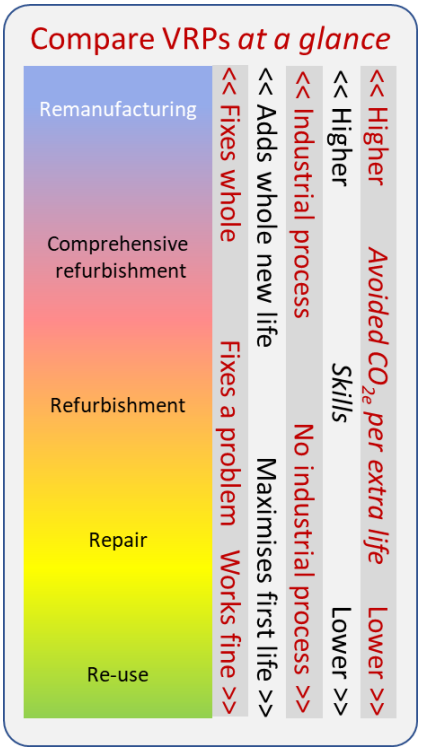
Different sectors have taken various approaches to these 'as-new' processes and often use different terminology – one of the problems identified in getting concerted action to promote them. This is compounded by the treatment of terms in different languages, which will be a challenge for Canada. Definitions used for VRPs in this report are based on those used in the 2018 International Resource Panel report on VRPs (1) and have been included in the "Definitions" section at the beginning of this report.

It is important to stress that not all VRPs are appropriate for all sectors and products. For example, commercial furniture is amenable to remanufacturing while domestic furniture may not have the right characteristics to support remanufacturing. In this case, it's better to:

- encourage re-use between citizens to maximize useful life
- ensure domestic furniture is designed for easy recycling, and
- make sure that there are robust collection, segregation and recycling processes in place.

All in all, this highlights the need to evaluate each case on its merits and use sound evidence to examine the consequences of different VRP options.

Figure 1: A comparison of VRP processes & outcomes

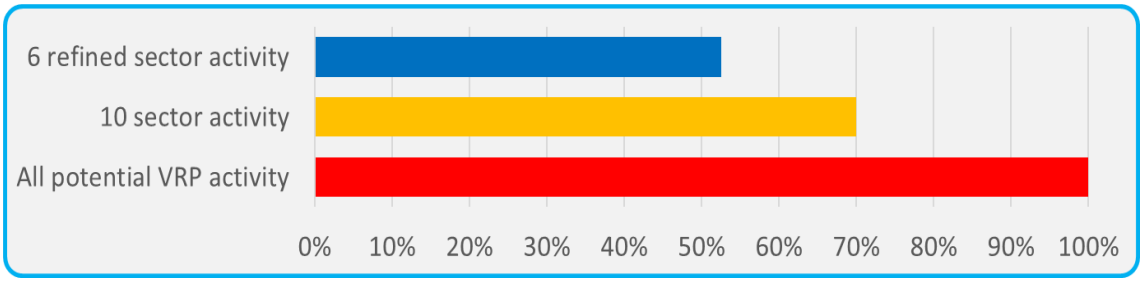


Sectors included in the study

The initial phase of the study identified and researched 10 sectors, listed below. Based on this initial research, 6 priority sectors were identified for more in-depth study. In this report, where necessary in tables, these are referred to as the **'refined'** and **'initial'** sets.

We estimate that the full 10 sectors cover around 70% of the potential revenue available from feasible VRP services. The 6 sectors in the 'refined' set make up approximately 75% of the total revenue for the full 10 sectors, illustrated in Figure 2.

Figure 2: Estimated coverage of VRP activity by sectors in this study



The 6 refined sectors, listed below, account for over 50% of the potential VRP revenue.

1. **Aerospace:** this sector includes commercial and military aircraft and their components. Maintenance, repair and overhaul (MRO) activities, a key part of the Canadian aerospace sector, are considered to include remanufacturing and repair.
2. **Automotive:** this sector refers to passenger and light commercial vehicles. The full range of VRP activities are typically found in the automotive sector, with remanufacturing activities primarily focused on higher value, complex components.
3. **Electronics:** this sector refers to information and communication technologies (ICT), consumer electronics and office imaging equipment. Amongst consumer electronics, there is a limited amount of repair. Higher value electronics have 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.
5. **Heavy-duty/off-road equipment (HDOR):** this sector includes heavy-duty commercial vehicles, agricultural vehicles and off-road equipment. As per automotive, we observe a wide range of VRPs in this sector including world-leading remanufacturers employing advanced service-based models of business.
6. **Furniture:** this sector includes furniture for both commercial and domestic uses. Non-traditional remanufacturing practices and re-use models are of significance here.

The following, smaller sectors, were not investigated to the same extent as the first 6 sectors. These sectors were selected based on their sales statistics and for having the right characteristics to support VRP activity.

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 investment and are capital intensive to build and purchase.

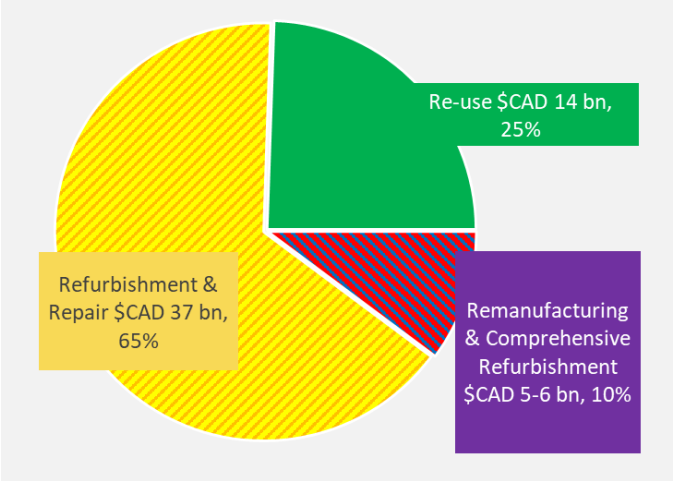
9. **Industrial equipment:** this sector includes the remanufacturing, refurbishment and repair of equipment including machinery for manufacturing and process industries, machine tools, pumps and compressors, engines and turbines (excluding aircraft, automotive and HDOR engines).
10. **Rail:** this sector 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.

The estimated remaining 30% of potentially viable activity is broadly spread across the swathe of manufacturing. This includes a host of niche and not-so-niche products. It is not possible to detail this vast range of individual products across so many sectors, but some of the sectors which fell into this category are listed in the main report.

The report goes into the findings in detail from here, but if you want quick 'take-away' summaries for sector findings, impacts, potentials, challenges and actions, there are one-pagers covering all 10 sectors (4 in lighter detail) at the end of the document.

The importance of VRPs to the Canadian economy

Figure 3: Split of sales income by VRP, 2019



The research suggests VRPs in Canada are currently (2019) worth about **$CAD 56 billion** to the economy, judged by their sales incomes. This is split by type of VRP in Figure 3 and Table 1 summarizes the VRP activity levels in each sector.

VRPs currently support around 380,000 jobs in Canada.

Table 1: Summary of VRP sales incomes by sector ($CAD billion per year), 2019

	Remanufacturing	Comprehensive Refurbishment	Refurbishment	Repair	Direct Re-use	TOTAL
Refined sector analysis						
Aerospace[a]	0.5	3.5	-/-	4	Unknown	**8**
Automotive	~1.8 (includes tires)		17.3		13.7	**32.8**
HDOR[b]	0.63		0.11	0.11	Unknown	**0.85**
Electronics	0.14 (including toner/print cartridges)		0.62		0.62	**1.4**
Home Appliances	Not Applicable		0.12	0.8	Unknown	**0.92**
Furniture	Limited		0.39		Unknown	**0.39**
Initial sector analysis						
Marine	[0.06, included in repair]		4.5		Unknown	**4.5**
Medical Devices	Unknown in detail; around 0.03 remanufacturing					**0.03**
Industrial Equipment	7.4 (min)				Unknown	**7.4**
Rail	[~0.07, included in refurbishment]		1.0		Unknown	**1.0**
TOTAL	**~$CAD 56 billion**					

**Note:* *a. Annual VRP activity for aerospace is based on 2020 data.*
b. Heavy-Duty and Off-Road equipment.
c. Findings for the sectors in red are from the initial sector analysis. Those in black, the refined view.

For context, the Gross Domestic Product (GDP) for manufacturing as a whole in Canada in 2019 was $CAD 199 billion according to Canadian Government statistics (3) – a little over 10% of the entire economy. GDP is not the same as sales income but provides a rough measure of the size. On this basis, VRP activities represent a significant element of the Canadian economy, although mostly focused on the industrial customers rather than domestic consumers.

VRPs are significant contributors to environmental impact reduction

Table 2 summarizes the estimates of environmental benefits of current (2019) VRP activities in Canada. Information on our methodology can be found in the main report.

ⓘ *We used a combination of life-cycle analysis data, material composition, reported recovery rates and analogies across similar product ranges to estimate the environmental impacts of VRPs for the different sectors.*

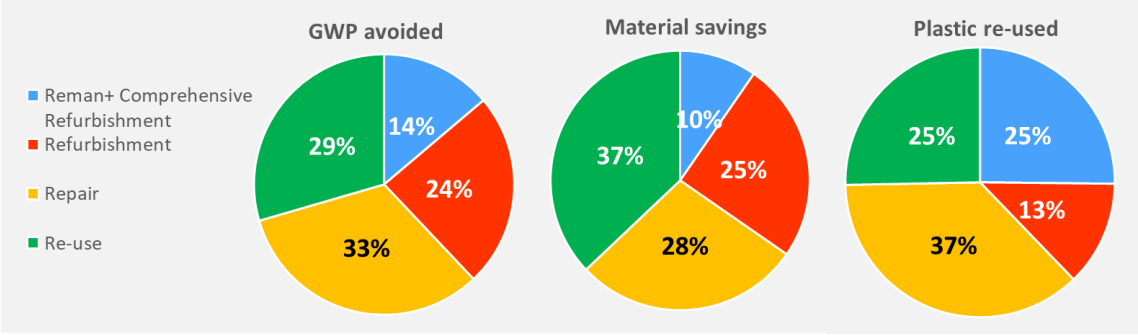
Table 2: Summary of VRP environmental impacts by sector in 2019 Remanufacturing, Refurbishment, Repair and Re-use activity levels

Sector	CO_{2e} emissions avoided[c] [kt CO_{2e}/yr]	Material savings [kt/yr] of which →	Plastics re-used [kt/yr]
Refined sector analysis			
Aerospace	183	33	No sector data
Automotive[a]	269	30	4.4
HDOR[a]	75	8	1.2
Electronics	339	24	7.2
Home Appliances	366	150	34
Furniture	368	199	11
6 sector sub-total	***1,600***	***444***	***57***
Supplementary analysis of tires sub-sector			
Automotive tires	1.7	1.7	1.3 (min)
HDOR tires	19 (min)	19 (min)	15 (min)
Initial sector analysis			
Marine	[~100][b]	[~15][b]	No sector data
Medical Devices[e]	Unquantified	Unquantified	No sector data
Industrial Equipment	[~150][b]	[~20][b]	No sector data
Rail	[~30][b]	[~3][b]	No sector data
Total (excludes initial sectors)	**1,620 minimum**	**470 minimum**	**74 minimum**

**Note:* *a. Excludes hypothetical Automotive 600 kt & HDOR 60 kt material saving from 2nd hand re-use.*
b. Scaled by Sales Income to automotive. Not included in totals.
c. GWP – Global Warming Potential (expressed as tonnes-equivalent of CO_2).
d. Findings reported in red relate to the sectors only examined for the initial assessment.
e. There is insufficient data to quantify medical benefits.

Figure 4 uses the source data of Table 2 to show how each VRP contributes to the three impacts.

Figure 4: Contribution of each VRP to the GWP, materials and plastics impacts, 2019



The research suggests that current (2019) VRPs are saving at least **1.6 million tonnes per year** (Mt/yr) of CO_{2e} emissions from entering the atmosphere. Similarly, the need for virgin materials is reduced by at least **470 thousand tonnes** per year (kt/yr), of which at least **74 kt/yr are plastics**. Remembering that these sectors capture 70% of all potential VRP activity, and that estimates of some environmental benefits are not available for a portion of the sectors listed in Table 2, there is a fair case for believing all sector VRP activity is up to double the figures calculated.

To put these environmental benefits in context, the CO_{2e} emissions savings equate to 2.3% of Canada's 2017 industrial emissions (4) and the material savings is equal to 4.7% of all materials recycled in Canada per annum. Notably, these materials savings are **more beneficial than recycling** since they are materials in products that are re-used, in effect as-is, with very little energy input.

The tonnages of plastics re-used via VRPs 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. In relative terms, though, plastics are generally low in manufacturers' concerns because of their relative cost, which in large part reflects their low CO_{2e} impact at point of manufacture. Nevertheless, the best opportunities to recover more plastics almost certainly lie in the electronics and home appliances sectors because of the construction of these devices.

Scenario modelling for the 6 refined sectors

Table 3: Sector strategic framework

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.

Part of this examination has been to uncover the motives for engaging in VRPs and to understand the challenges faced within each sector. With that understanding, a sector strategic framework (Table 3) was developed which outlines a set of 'strategic thrusts' for the growth of VRPs in each sector. Additionally, suggested approaches for each of the 6 sectors were elaborated upon (Table 4).

These actions and policies are directed almost exclusively at areas which federal and other levels of government can influence and are not necessarily directed at industry players themselves. They are outline policies, which may need substantial development beyond the scope of this study and possibly across sectors.

A condensed synthesis of the findings is captured in Table 4 which gives a one- or two-word summary of key responses (in parentheses) to the challenges. 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 4: Summary of suggested 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	✓				

Canada could address some or all of these to enable the growth of remanufacturing and other VRPs. The more tackled, the better the prospects.

Potential future benefits of VRPs

The study also projected the socio-economic and environmental outcomes in 2030 associated with three growth scenarios (**Natural Growth, Moderate Action and Strong Action**) using applied economic input-output factors and available proxies to provide high-level estimates of growth related to jobs, GDP and the like. These analyses are illustrative of what might be achieved with more or less supporting action but are heavily caveated due to the ongoing COVID-19 pandemic, which has put a discontinuity into many businesses and made projections even more challenging. The effects of the pandemic and possible recovery trajectories have played heavily into these assessments of growth and are described in detail in the main report.

> ⓘ *The three scenarios are projected to 2030 and compared to an "As-Is" scenario. The As-Is scenario is a business-as-usual case that records what would happen if VRPs simply kept the same market share between 2019 and 2030. In effect, it just shows what the effect of price inflation would be. All the other scenarios consider that VRPs increase their market share so – to some extent – are displacing new manufacturing. The extent of this displacement – technically called substitution – depends on how much new manufacturing is in Canada compared to what is made abroad and imported.*

The scenario analysis for the aerospace sector 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. Therefore, the aerospace VRP scenarios are aligned with scenarios for the global aerospace industry response to COVID-19. These scenarios consider **rebound**, **delayed rebound** and **recession-based** trajectories.

Table 5 summarizes the estimated direct benefits of the expansion of VRP activity in Canada in 2030, including the 'As-Is' scenario. We would expect additional benefits due to the indirect and induced economic activity stimulated by the direct activities.

Table 5: Summary of direct socio-economic impacts of VRP expansion based on various growth scenarios (excludes indirect and induced revenues and jobs)

Sector	2019 Current VRP Market		2030 Projection Ranges	
	Direct Revenue $CAD billion	Direct Jobs	Direct Revenue $CAD billion	Direct Jobs
Aerospace	8.02	19,000	7.29–9.65	12,000–33,000
Automotive	32.8	341,000	35.8–36.5	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**

Notes: The numbers in this table are reflective of summations from tables in the main report. For methods, please refer to the sector specific tables. Only direct revenues are considered. Projected revenues and jobs ranges reflect the lowest possible number of direct jobs and the highest number of direct jobs related to the given range of scenarios from 'As-Is' to 'Strong Growth' or 'Rebound' for aerospace.

Table 6 provides a summary of the potential environmental impacts that might be realized through the range of growth scenarios.

Table 6: Summary of the environmental impacts of current VRP levels and VRP expansion based on various growth scenarios

Sector	CO_{2e} emissions 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[a,b]	269	286 – 306	30	32 – 34	4.4	4.7 – 5.0
HDOR[b]	75	95 – 104	8.4	11 – 12	1.2	1.5 – 1.7
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,c]	**~1,600**	**~1,770 – 1,940**	**~444**	**~493 – 535**	**58**	**63 – 66**

Notes: a. Excludes notional benefits of re-use (~GWP 600 kt/yr) and associated materials savings etc.
b. Excludes tire retreading.
c. Totals may vary due to rounding of components.

The important point to note about expansion is that in truth there is plenty of headroom to grow VRPs. Optimism arises from the fact that VRP practitioners tend to be relatively bullish about the ultimate levels of VRPs despite current concerns over the effect of COVID-19; and because VRPs are currently at low levels compared to manufacturing. This topic is explored in more detail in a later section when the idea of a 'challenge target' is considered.

Achieving VRP expansion

The VRP sector currently faces a range of barriers that 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.
- **Price barriers**: barriers related to subsidized raw material extraction as well as competition with low-cost imports.
- **Collection infrastructure barriers:** barriers affecting flows of end-of-use products and components from the customer/user back into the secondary markets and/or to the original equipment manufacturer 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.

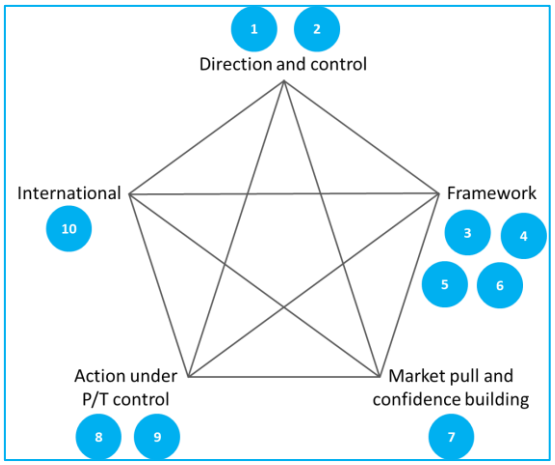
The presence and impact of these barriers currently limit the potential of Canada's VRP activities, however this study has identified and prioritized action areas that could be taken to support a transition towards a higher VRP activity-level scenario. Given the jurisdictional structure of Canada, and for the sake of coherency and gaining traction, the case appears strong for a central commonly agreed 'Directive' approach at the federal level with supporting actions and policies from the provinces and territories. In support of this, a key finding of this study is that there is a high level of receptiveness amongst the provinces and territories to a stronger steer from the federal level – together with adequate funding to enable potentially radical infrastructure changes.

The main report identifies 16 headline action areas. However, a shortlist of 10 priority action areas for the Government of Canada to positively influence market forces and encourage increased VRP activity is summarized below. These action areas cover the five target areas for intervention including:

- providing clear **direction and control** for how priorities and targets for VRPs are set;
- supporting the development of a **framework** within which VRP activity in Canada is defined, monitored and supported through regulation;
- increasing **market pull and confidence building** with the aim of supporting increased demand for VRP outputs;
- **action under provincial and territorial control;** and
- action requiring **international** engagement and alignment.

The priority action areas are mapped out under the above target areas in Figure 5.

Figure 5: Priority action area map



Here is a brief description of the 10 priority action areas (not listed in a particular order of priority):

1. **Coordinate knowledge transfer, CE approach and VRP roadmap at provincial and territorial level**; *there is a strong case for a pan-Canadian 'Directive' approach as exemplified by the European Union and China, and receptiveness to the idea from provinces and territories. This accompanies a broader knowledge transfer and coordination piece which describes the role of VRPs within the circular economy.*

2. **Establish sector focus groups** for information gathering and action coordination in the six sectors analyzed in this study; *learning from other countries suggests 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 that 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 extended producer responsibility schemes; *link to the spectrum of end-of-life options i.e. disfavour landfill, energy-from-waste, recycling, and promote re-use.*

5. **Explore development of laws which 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 under way.*

7. **Make a high-profile commitment to VRPs in public purchasing**; *use 'whole-life criteria' to boost VRP attractiveness by informing the public of the benefits of VRPs and improve confidence in uptake through demonstrable use by the public sector.*

8. **Support community-led VRP initiatives for reuse 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, especially if Action 4 is implemented.*

10. **Agree on protocols for recognizing VRP goods and services**; *the burden of proof of compliance with the Canada-US-Mexico Agreement (on trade), for example, falls on the importer/exporter so this will offer protection to legitimate VRP practitioners 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.

Priority sectors to boost remanufacturing and other VRPs

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: the sector strategy acknowledges that aerospace is a high tech, value-adding component of the economy; it 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 the US and Mexico 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 remanufacturing is well embedded as a practice, 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. Additionally, international collaboration may play a stronger role.

HDOR is estimated to have some capacity to grow, though this is not highlighted as a prime driver for strategic action in the sector actions section (in the main report). However, because of the similarity to automotive, it can benefit from common actions in skills, for example, and by use of public purchasing in fleet contracts for public vehicles.

Probably the biggest VRP shifts can be achieved in consumer-facing goods. The outstanding sector in this analysis is information and communication technologies **(ICT)**, a subset of the **Electronics** sector. These goods embody a lot of carbon in their manufacture and through the extraction of often critical raw materials, but they are discarded for recycling too easily with a huge loss of potential. This is unfortunate because ICT is generally very modular with elements of 'frozen' technology. To some extent, ICT 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 buyers are risk averse as they fear that technology is not future proof. Leading edge companies are addressing this, but they need support 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, even better, home-repair enabled 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; by 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 ICT. 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.

A challenge target for VRPs

Up to this point, this report has been laying out the current understanding of VRP levels and impacts, considering where opportunities lie and what action Canada could take to boost them. This plan has been set against a modest – but still challenging – set of scenarios out to 2030. This is a sort of 'bottom-up' approach, building on where Canada is now, and it is not a radical departure from what is familiar and expected. But what if there is a change of perspective, a top-down 'helicopter' view that considers a vision that is more radical, more challenging but more impactful?

As part of the study, we asked industry contributors to consider a VRP future where all barriers to expansion had been removed. Some industry participants to this study have expressed much higher potentials for remanufacture and comprehensive refurbishment (R+R) than the sector scenarios have considered, often more than 20% of manufacturing. This is an exciting prospect given that R+R, in particular is, currently, a low proportion of total manufacturing sales income – an estimated 2 to 4% overall.

Is this a realistic prospect? Aerospace appears to already have achieved at least 20% so, yes. Therefore, **a very challenging target for R+R could be set at 20% compared to manufacturing**. Adding a note of realism, starting from the 2019 position, this will not be possible to achieve by 2030, the horizon for this study, but should rather be part of the 2050 ambition.

The main report examines what this target means for each sector in more detail, but the overall impact is that **CO_{2e} savings across all VRPs could reach 10 Mt/yr by 2050** if all sectors achieved 20% of manufacturing levels. The bulk of this increased saving is in R+R.

Table 7: Remanufacturing + Comprehensive Refurbishment as a fraction of manufacturing in 9 sectors in 2019

Sector	% of manufacturing
Aerospace	at least 20%
Automotive	1.50%
HDOR	10%
Electronics	1%
Home Appliances	~1%
Furniture	2%
Industrial Equipment	2%
Rail	4%
Marine	2%

Achieving such a target would meet around 13% of Canada's commitment to reducing industry emissions to net-zero in the same timescale. This, of course, also means materials and plastics savings go up.

To repeat, 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.

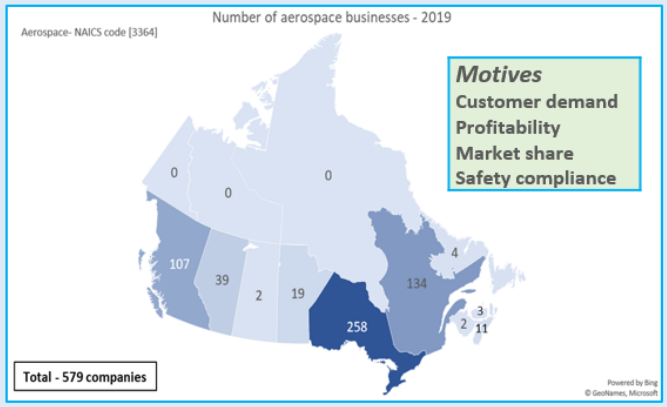
That being said, these are not normal times and 2020 has demonstrated that changes in behaviour, what is acceptable and where future priorities – including environmental challenges – lie can happen very quickly. Conditions may therefore be better than might have been expected, as attitudes to keeping products in use are improving. However, all the barriers discovered and actions proposed within this report are still relevant. These proposed actions are necessary to allow businesses to adapt to and take advantage of these changing conditions and realize the great potential of VRPs in terms of revenue, jobs and fighting climate change.

One-Page summaries of sectors

- Aerospace
- Automotive
- Heavy-Duty & Off-Road (HDOR)
- Electronics
- Home Appliances
- Furniture
- 4 ‘initial sector’ summary

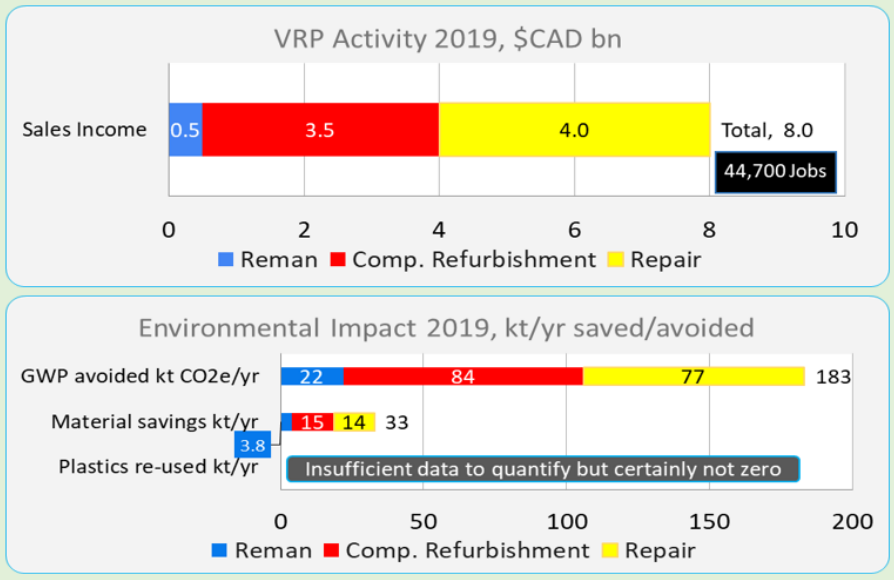
Aerospace *on a page*

Competitive Landscape

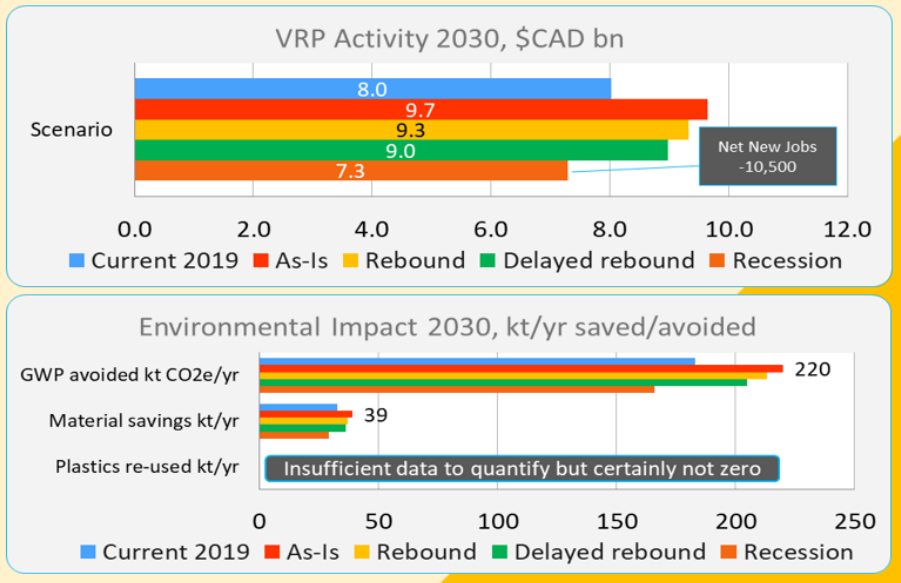


	Barrier / Opportunity	Supporting actions
	COVID-19 pandemic has presented a severe shock. Possible severe long-term effects.	**Continue and extend the range of fiscal measures** already put in place as part of the COVID-19 response to prevent loss of critical skills in short to medium term.
	International legislation cited as restricting operations.	**Monitor policy** to ensure MRO activities are not hampered through any new regulations.
	Customers don't recognize the value of some VRP services.	Use **sector focus group** to explore further; **develop an accreditation service** for customer reassurance if necessary. Accreditation and purchaser confidence is a cross-sectoral problem.
	Low availability of skilled personnel with the required degree of product knowledge.	**Support training and investment in MRO activity** to keep up with new low-carbon technologies, such as hydrogen. A sector-focused R&D hub or personnel exchanges between companies via collaborative projects could assist.
	Diffuse capabilities into less developed sectors.	Advanced aerospace engineering techniques and practices could boost less developed sectors. **Encourage cross-learning** as above and **via collaborative research projects** at home and abroad.

Current Performance

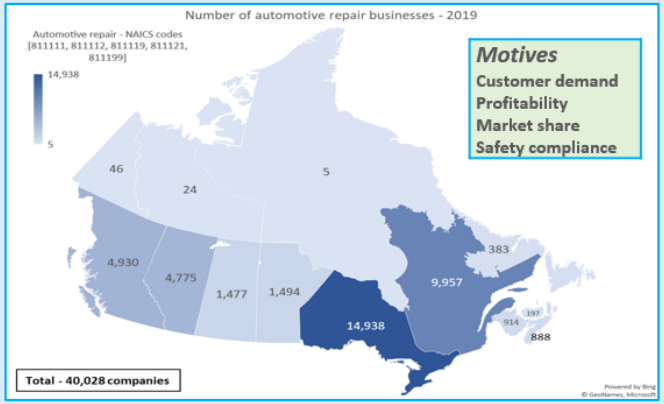


Future Outlook



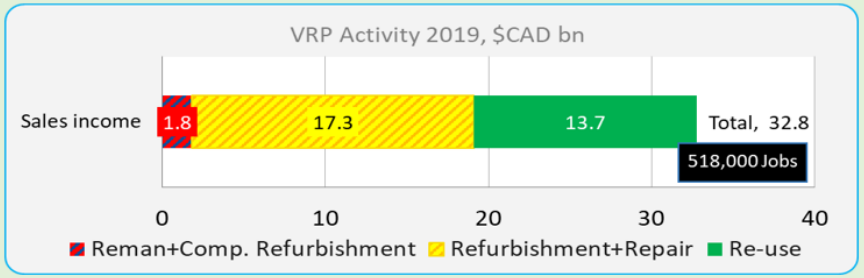
Automotive *on a page*

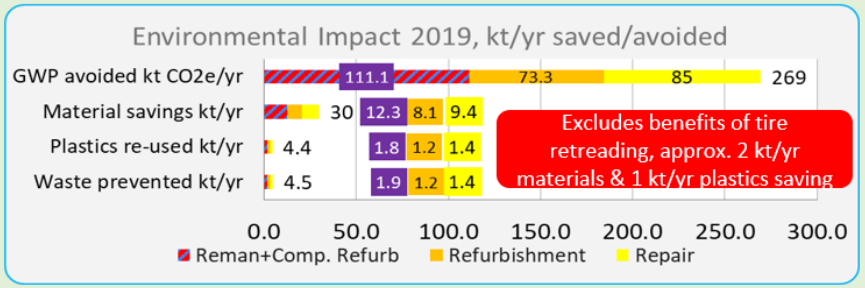
Competitive Landscape



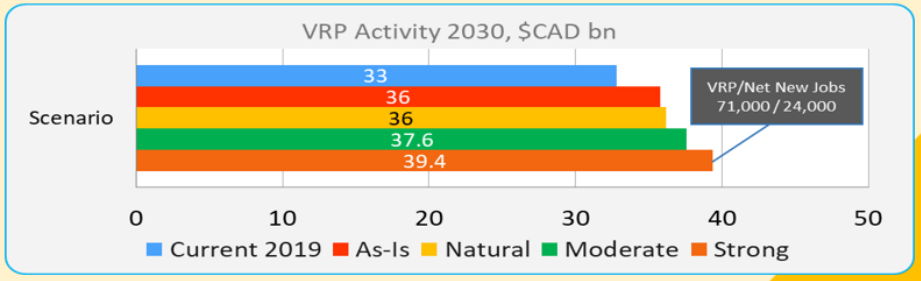
	Barrier / Opportunity	Supporting actions
	Limited engagement in VRPs	Aftermarket activities could be expanded by pull mechanisms such as **preferential public procurement** of remanufactured components for fleet vehicles, as in the U.S.
	Labour intensive nature of VRP activities.	Fiscal measures may help offset labour costs but applying **lean manufacturing principles** (e.g. **deploying automation) could reduce the cost base**. Support could be through **business grants or loans**, or development of **collaborative industry-academia programs.**
	Limits to skills and infrastructure.	Assist in **building clusters of competence for** new manufacturing and remanufacturing. Target e.g. **skills and infrastructure** for efficiency and quality and to service new Electric Vehicle (EV) battery manufacturing and remanufacturing.
	Rapidly evolving powertrain technology.	Foster skills for new vehicle technologies through **research funding. Impact-based targets and best practice guidance** could assist in harmonizing end of life requirements in supporting VRP activities.
	Diffuse capabilities into less developed sectors.	**Leverage automotive competence** to assist other sectors. **Encourage transfer of knowledge & best VRP practice** for example through a sector hub, co-projects, or personnel exchanges.

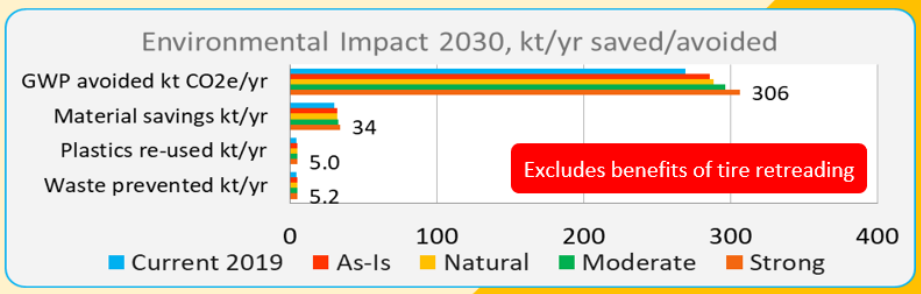
Current Performance





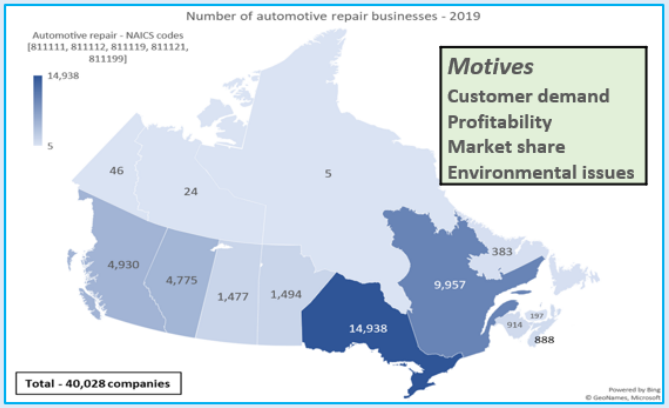
Future Outlook





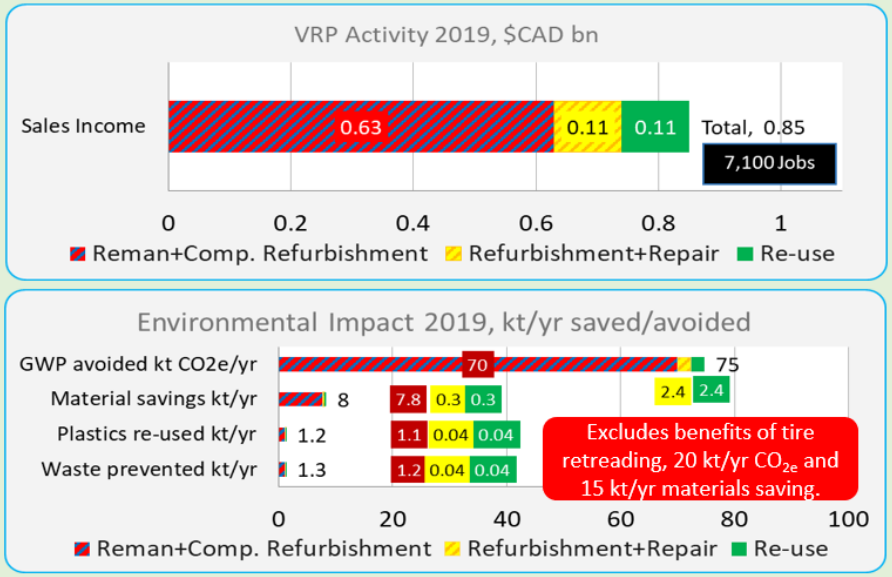
HDOR *on a page*

Competitive Landscape

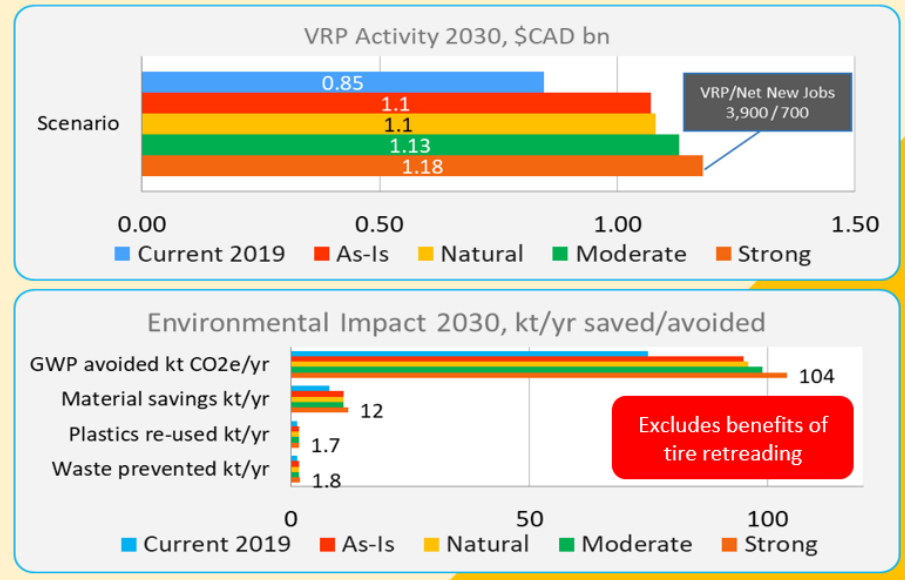


	Barrier / Opportunity	Supporting actions
	Low availability of skilled personnel with the required degree of product knowledge.	**Support training and investment** in HDOR VRP activity to safeguard the effectiveness of the sector. A sector-focused R&D hub or personnel exchanges between companies via collaborative projects could assist.
	Poor core access and quality.	**Promote** VRP activities for HDOR to mining sector **as good environmental practice**. Stimulate market through **public procurement** or contracted fleet vehicles.
	High labour cost.	VRP operations are labour-intensive and so more vulnerable to low cost imports. Fiscal measures can reduce the cost of labour as well as supporting initiatives to apply **lean manufacturing** principles to VRP activities. Lean could include the **deployment of automation**. Support could be through **business grants or loans**, or **collaborative industry-academia programs.**
	Additive manufacturing.	Foster uptake of advanced (e.g. additive) manufacturing technologies through **low interest rate loans or grants**. **Support and coordinate** collaborative ventures as above.

Current Performance

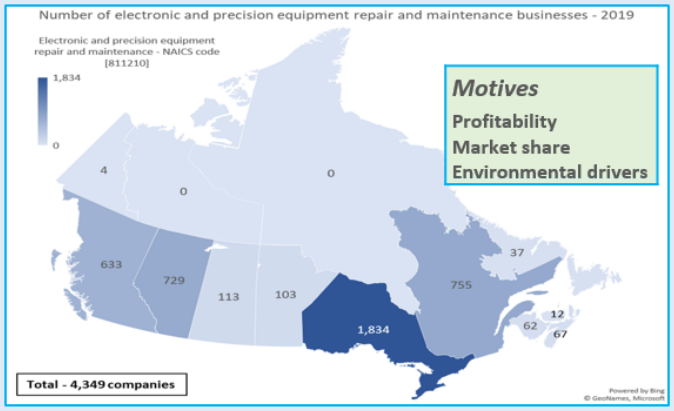


Future Outlook



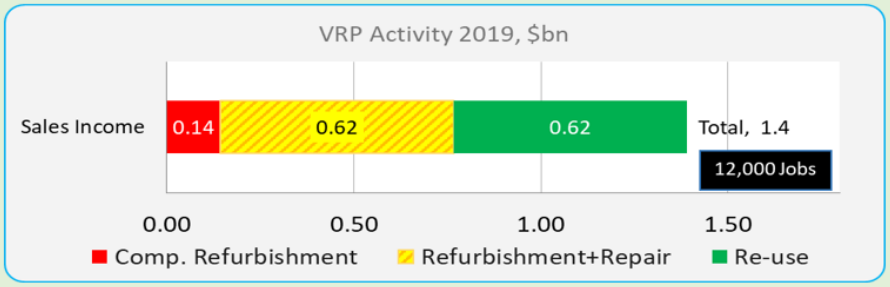
Electronics *on a page*

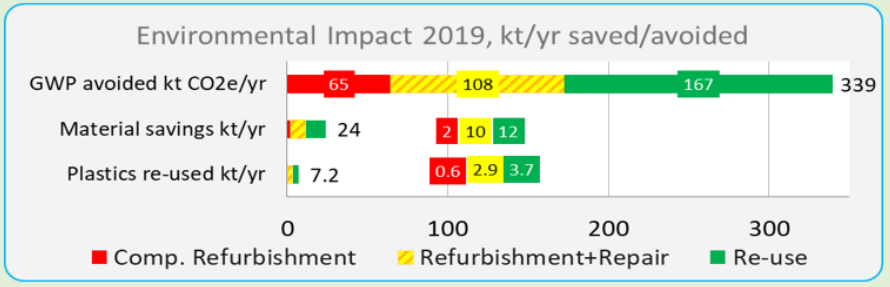
Competitive Landscape



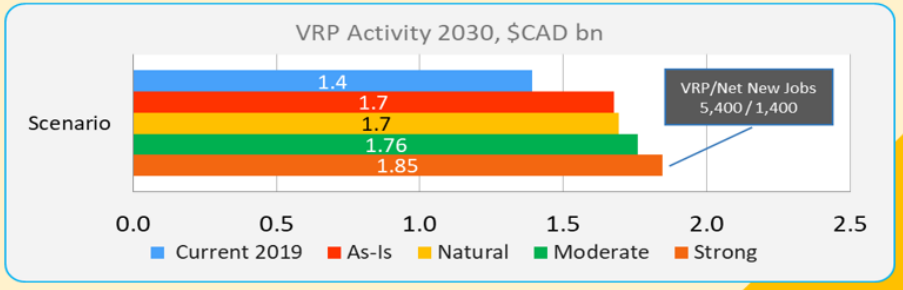
	Barrier / Opportunity	Supporting actions
	Lack of market pull.	**Develop and harmonize EPR schemes** to motivate valorizing used electronics, making a positive offering to customers. Implement refurbishment **standards and/or labelling schemes** to boost consumer confidence.
	Low availability of skilled personnel with the required degree of product knowledge.	**Support training and investment in electronics VRP activity** to safeguard the effectiveness. A sector-focused **R&D hub** or personnel exchanges between companies via **collaborative projects** could assist.
	High logistics costs.	Develop a **harmonized collection infrastructure** for EoL electronics to boost feasibility of VRP activities. Encourage public to **return hoarded EoL** devices through **information campaigns and publicity drives.**
	Promotion of whole life benefits.	**Analyse life cycle impacts** of electronics VRP activities and **publicise** when they have clear impact of longer-lived electronic devices. This may also help motivate the uptake of **Right to Repair** style regulations.

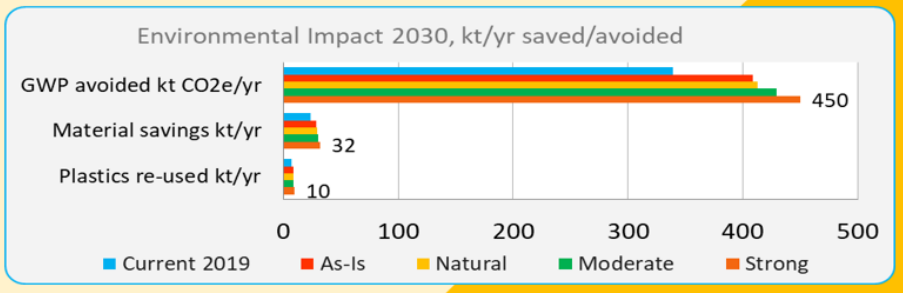
Current Performance





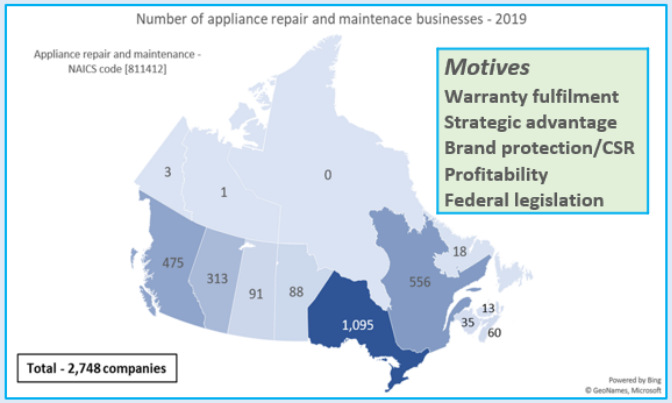
Future Outlook





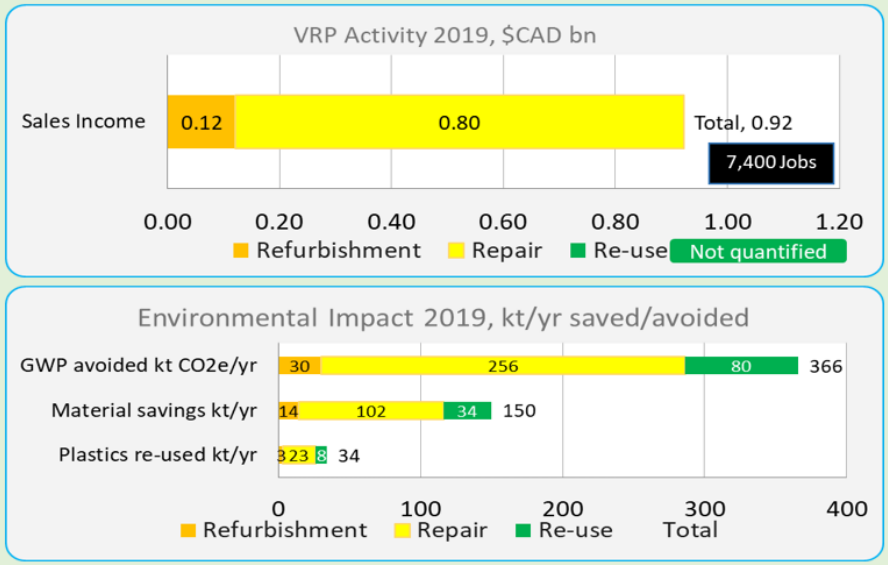
Home Appliances *on a page*

Competitive Landscape

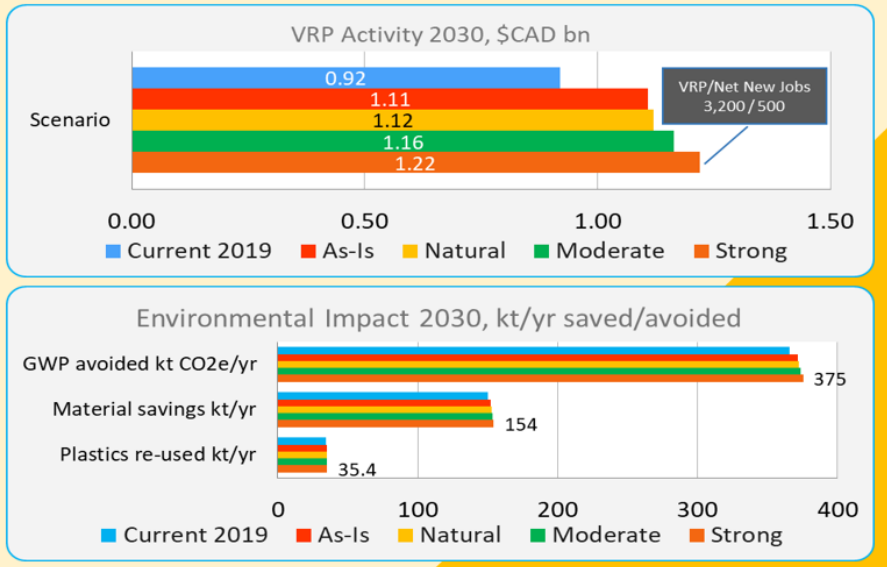


	Barrier / Opportunity	Supporting actions
	Lack of market pull.	**Fund local social enterprises** to provide employment and training opportunities to socially excluded communities. **Develop and harmonize EPR schemes** to motivate valorizing used appliances, making a positive offering to customers. Implement refurbishment **standards and/or labelling schemes** to boost consumer confidence.
	Breakthrough of sharing and other servitization business models.	**Better understand barriers to leasing and servitized models of business.** Support transformation by **policy that promotes and normalizes communal facilities** as demonstrated in Sweden.
	Promotion of whole life benefits.	**Analyse life cycle impacts** of appliance VRP activities and **publicise** when they have clear impact of longer-lived electronic devices. This may also help motivate the uptake of **Right to Repair** style regulations.

Current Performance

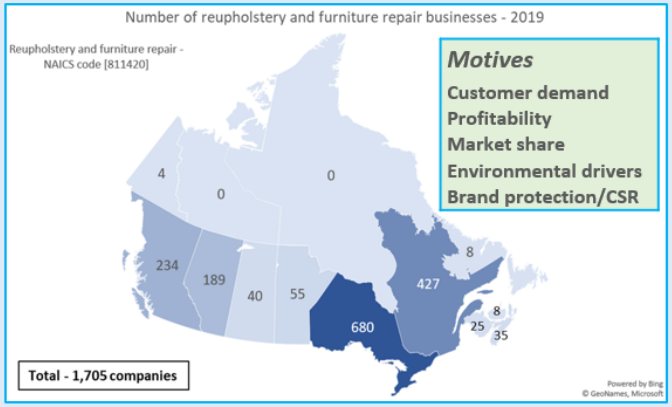


Future Outlook



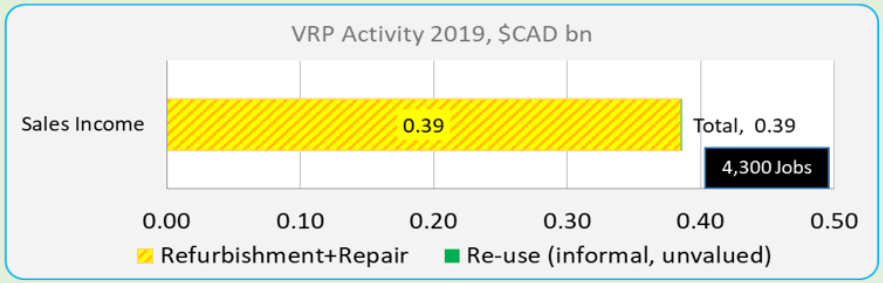
Furniture *on a page*

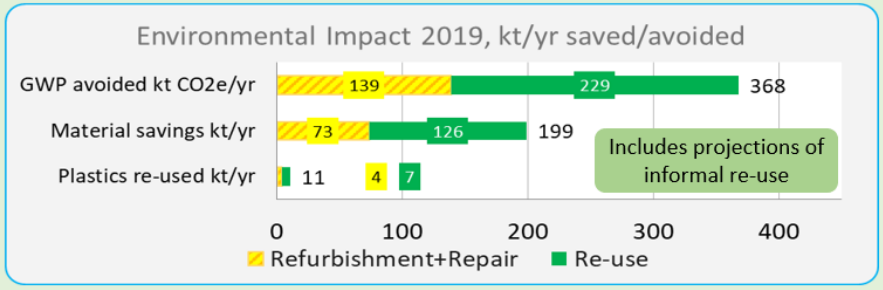
Competitive Landscape



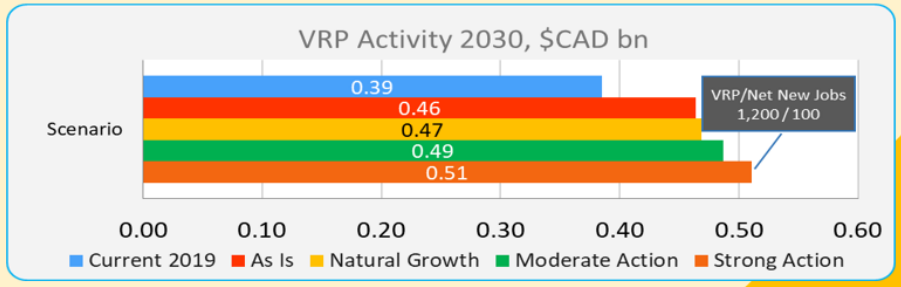
	Barrier / Opportunity	Supporting actions
	Customer recognition.	Promote a **full lifetime service** requirement including maintenance for office furniture. **End-of-life take back schemes** could make the re-use of reclaimed parts in new designs easier. **Accreditation** would help to build consumer trust. **Requires proper EoL management** to ensure materials segregation and diversion from landfill.
	Lack of market pull.	**Public purchasing policies and procurement** should specify VRP'd furniture. **Fund local social enterprises** to provide employment and training opportunities to socially excluded communities. **Harmonize EPR schemes** so VRPs are driven to valorize EoL furniture and make it attractive.
	High logistics costs.	**Establish centralized waste management organizations** to reclaim and sort furniture in a good state. **Take-back schemes**, whether they are voluntary or enforced, would help increase volumes to support economies of scale.
	Issue with product design.	Promote **design for disassembly** and **modular design** strategies through a **design awareness campaign**. Encourage or mandate the long-term supply of spare parts to assist VRPs.

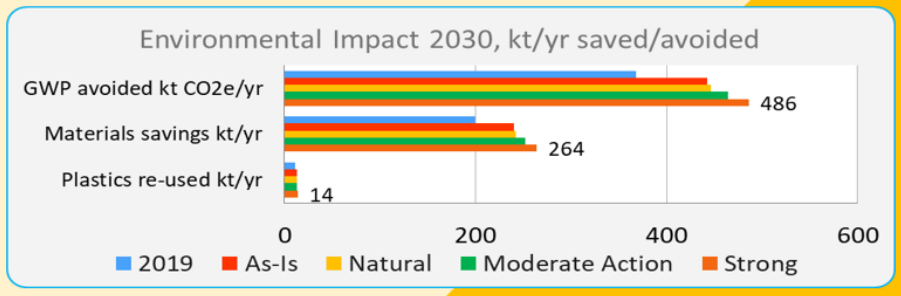
Current Performance



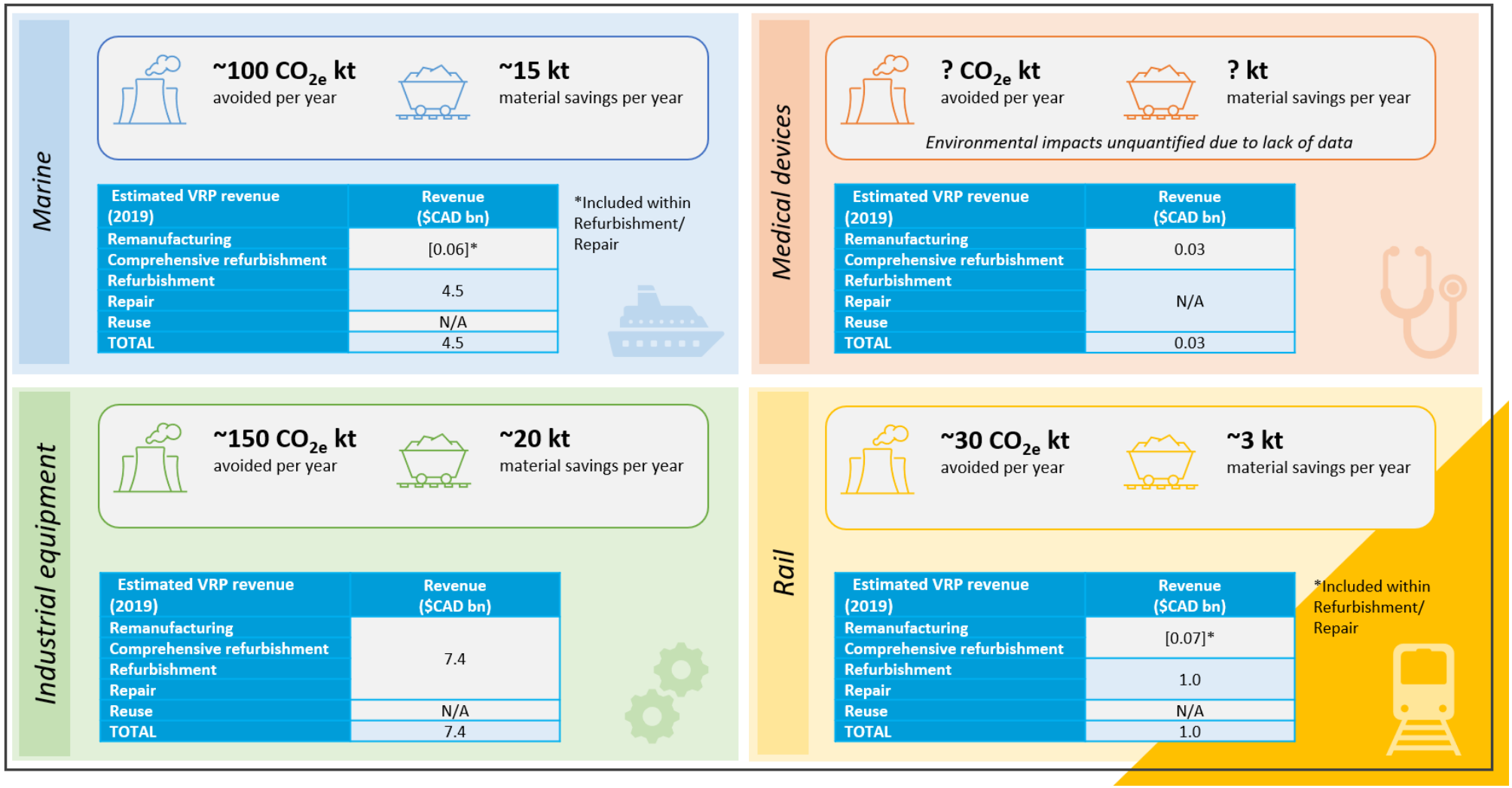


Future Outlook





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



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