PEMBINA institute

Costs, benefits and uptake of trailer fuel-saving devices

An examination of Canada's on-road freight sector

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photo: Roberta Franchuk, Pembina institute

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The Pembina Institute is a national non-partisan think tank that advocates for strong, effective policies to support Canada's clean energy transition. We employ multi-faceted and highly collaborative approaches to change. Producing credible, evidence-based research and analysis, we consult directly with organizations to design and implement clean energy solutions, and convene diverse sets of stakeholders to identify and move toward common solutions.

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Company names have been included where permission was obtained to do so.

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Executive summary

Over the past 10 years, regulations and the emergence of fuel-efficient technologies have played an important role in reducing the greenhouse gas (GHG) emissions of new gasoline and diesel on-road heavy-duty trucks (such as highway tractors, buses and dump trucks) in the United States and Canada. The Government of Canada introduced its first Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations in 2013, and the second phase of these regulations, published in 2018, are expected to lead to GHG emission reductions of approximately 73 Mt CO_2e for model year 2020 to 2029 vehicles.[1] Actions like this, which seek to improve fuel efficiency, along with efforts to reduce freight trips and drive towards low- and zero-emission vehicles, are pertinent as ever to decarbonize the transportation sector.

To improve fuel efficiency, trucking fleets across Canada are outfitting their trailers with fuel-saving devices, such as aerodynamic add-ons or low rolling resistance tires. These devices help improve fuel efficiency by reducing drag and rolling resistance, or by reducing the amount of weight that a tractor needs to pull. But how widely are such devices adopted in the Canadian trucking industry? And what is needed to encourage greater adoption in the future?

This study sets out to uncover the current rates of adoption of trailer fuel-saving devices in Canada, their various costs and benefits, and determine trends in adoption across different segments of Canada's on-road freight sector (e.g. large vs small fleets, for-hire vs private fleets, etc.). Based on a series of stakeholder consultations with key actors from Canada's trucking sector, including online surveys completed by 63 participants, two working group discussions, and three case studies, the following key themes emerged:

[1] Government of Canada, "Regulations Amending the Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations and Other Regulations Made Under the Canadian Environmental Protection Act, 1999: SOR/2018-98," *Canada Gazette, Part II, Volume 152, Number 11*, May 16, 2018. http://gazette.gc.ca/rp-pr/p2/2018/2018-05-30/html/sor-dors98-eng.html

- **Adoption of most fuel-saving devices is low among Canadian heavy-duty vehicle (HDV) fleets.** Nearly three-quarters of survey respondents have not installed underbody fairings, rear fairings, wide base single tires or gap reducers on any of their trailers. Although low rolling resistance dual tires and side skirts are shown to be effective interventions, 25 per cent of respondents have not used them. Approximately half of survey respondents have not installed tire pressure monitoring or automatic inflation systems.
- **A few key devices continue to dominate the trailer fuel-saving device market in Canada.** When fleet operators do choose to integrate devices into their operations, low rolling resistance dual tires and side skirts continue to be two of the most widely adopted trailer fuel-saving devices among trucking fleets in Canada. While not often included in previous studies on trailer fuel-saving devices, lightweight components were also identified as one of the most popular technologies.
- **Long-haul fleets exhibit higher rates of adoption of trailer fuel-saving devices than regional-haul fleets.** With long-haul fleets typically covering greater distances at highway speeds and consuming more fuel in comparison to regional-haul fleets, the benefit of these devices, such as a reduction in fuel costs, is greater.
- **Fleets with trailer fuel-saving devices commonly report fuel savings of 1-2%.** Only a small percentage of fleets surveyed reported fuel savings above 5% for any of the trailer fuel-saving devices. Fleet operators noted in the working group meetings, however, that assigning fuel savings can be challenging, as it can be difficult to isolate individual impacts when multiple devices are used.
- **The payback period of fuel-saving devices for trailers is highly variable.** The diversity of Canada's trucking sector means that there are significant variations in operations and inevitably a range in payback periods. For example, a fleet that travels longer distances may see a relatively fast return on investment due to greater amounts of fuel consumed over a short period of time.
- **Complementary financial and non-financial supports are required to promote greater adoption of fuel-saving devices for trailers in Canada.** To complement GHG emission standards, fleet operators continue to express the need for government funding support to reduce the payback period of certain devices, improved accessibility of credible and applicable information and real-world testing of the efficacy of fuel saving devices under Canadian conditions.

1. Introduction

Heavy-duty trucks play a vital role in Canada's economy by uniting consumers with essential goods. They are, however, also a growing source of greenhouse gas (GHG) emissions. Freight trucks alone represent 36% of Canada's transportation related GHG emissions, and emissions from these vehicles have more than doubled since 1990.[2]

Notable transformations are already occurring in the transportation sector to help Canada meet its greenhouse gas (GHG) emission target of net-zero by 2050. For regional- and long-haul heavy-duty on-road freight, fuel efficiency improvements have been critical. Many heavy-duty fleets are outfitting their vehicles with fuel-saving devices, such as aerodynamic add-ons, that improve the GHG emission output of their vehicles and result in fuel cost savings. Improving the efficiency of gasoline or diesel vehicles on the road today and for many years to come has and will continue to serve a fundamental role in achieving climate objectives.

When it comes to reducing GHG emissions from on-road heavy-duty vehicles, GHG emission standards have shown to be a powerful driving force. In 2013, the Government of Canada published the Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations.[3] These regulations set performance based GHG emission standards for new on-road heavy-duty vehicles (such as highway tractors, buses and dump trucks) and their engines made in 2014 and later years. These regulations were aligned with the United States' Environmental Protection Agency's Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines

In 2018, the Government of Canada published the second phase of these standards (also closely aligned with those introduced in the United States), which establish more stringent GHG emission standards that begin with model year 2021 on-road heavy-duty

[2] Natural Resources Canada, "Table 8: GHG Emissions by Transportation Mode," *Comprehensive Energy Use Database*. http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=tran&juris=ca&rn=8&page=0

[3] Government of Canada, *Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations* SOR/2013-24. https://laws-lois.justice.gc.ca/PDF/SOR-2013-24.pdf

vehicles and engines, and also introduce standards for trailers. These regulations are expected to lead to GHG emission reductions of approximately 73 Mt CO_2e.[4]

In 2016, however, the United States EPA announced it would begin a rulemaking process to amend the trailer provisions included in the Phase 2 standards in response to an appeal made by the Truck Trailer Manufacturers Association (TTMA).[5] The United States Court of Appeals stayed the implementation of the trailer standards, and as such, they are not currently being implemented.[6] The court case remains unresolved. As a result of the ongoing regulatory uncertainty in the United States, Canada has put forward an interim order to delay the implementation of their corresponding trailer standards and allow time for additional research into how these standards might impact key stakeholders in Canada, such as trucking fleets, trailer manufacturers, trailer dealerships and manufacturers of fuel-saving devices.[7] This interim order is in effect until May 18, 2021.

As the Government of Canada considers its path forward for trailer standards, this study serves to uncover current rates of adoption of trailer fuel-saving devices, their various costs and benefits, and if these trends are consistent across different segments of Canada's on-road freight sector (e.g. large vs small fleets, for-hire vs private fleets, etc.). A series of stakeholder consultations served to inform this research. First, two surveys were circulated – one to trucking fleets and another to trailer manufacturers – and a total of 63 responses were received. Next, two working group meetings were held with members of the Canadian Trucking Alliance and various provincial trucking associations to solicit commentary on key trends observed in the survey results. Lastly, interviews were conducted with three trucking fleets to develop case studies that illustrate their unique experience with trailer fuel-saving devices over time. To facilitate

[4] Government of Canada, "Regulations Amending the Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations and Other Regulations Made Under the Canadian Environmental Protection Act, 1999: SOR/2018-98," *Canada Gazette, Part II, Volume 152, Number 11*, May 16, 2018. http://gazette.gc.ca/rp-pr/p2/2018/2018-05-30/html/sor-dors98-eng.html

[5] E. Scott Pruitt, United States Environmental Protection Agency, letter to the Truck Trailer Manufacturers Association, August 17, 2017. https://www.epa.gov/sites/production/files/2017-08/documents/hd-ghg-phase2-ttma-ltr-2017-08-17.pdf

[6] *Truck Trailer Manufacturers Association Inc. v. Environmental Protection Agency, et al.*, 2020 USCA 16-1430. Available at https://www.docketbird.com/court-documents/Truck-Trailer-Manufacturers-v-EPA-et-al/PER-CURIAM-ORDER-1864013-filed-that-to-the-extent-they-apply-to-truck-trailers-the-compliance-dates-for-NHTSA-fuel-economy-regulations-be-stayed-pending-further-order-of-the-court-Petitioner-has-satisfied-the-stringent-requirements-for-a-stay-pending/cadc-2016-01430-01208268170

[7] Government of Canada, "Canada Gazette, Part I, Volume 154, Number 23: GOVERNMENT NOTICES," June 6, 2020. http://canadagazette.gc.ca/rp-pr/p1/2020/2020-06-06/html/notice-avis-eng.html

open discussion and information sharing, Chatham House Rules were applied, and, as such, this report omits participant and company names to ensure anonymity, unless permission was otherwise granted.

2. What are fuel-saving devices for trailers?

There are a number of devices that exist to improve the fuel efficiency of trailers. This research focuses on those identified in the Phase 2 of the Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations posted to the Canada Gazette II,[8] which include aerodynamic add-ons, low rolling resistance tires, tire pressure monitoring and automatic inflation systems, and lightweight components. These devices help improve the fuel efficiency of a trailer by reducing drag and rolling resistance, or by reducing the amount of weight that a tractor needs to pull. A brief description of each device is presented below.

Side skirts: Devices that extend the sides of trailer walls closer to the ground and serve to direct air away from the underside of the trailer. Side skirts can be made out of metal, composite, or in some cases, both.[9]

Underbody fairings: Devices that attach to the underbody of a trailer and which direct air away from the underside of the trailer. These devices may provide better clearance under the trailer than side skirts.[10]

[8] Government of Canada, "Regulations Amending the Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations and Other Regulations Made Under the Canadian Environmental Protection Act, 1999: SOR/2018-98," *Canada Gazette, Part II, Volume 152, Number 11*, May 16, 2018. http://gazette.gc.ca/rp-pr/p2/2018/2018-05-30/html/sor-dors98-eng.html

[9] Rick Mihelic, Dave Schaller, Mike Roeth, Frank Bio and Denise Rondini. *Confidence report: Trailer aerodynamics* (NACFE, 2020), 53. https://nacfe.org/downloads/confidence-report-trailer-aerodynamics/

[10] *Confidence report: Trailer aerodynamics*, 54.

Rear fairings: Devices that can be attached to the rear end of the trailer and which serve to reduce drag created by the wake of the trailer. One of the most common types of rear fairings are boat tails (or trailer tails), which are two collapsible panels that extend from the rear end of the trailer.

Gap reducers: Devices that serve to fill the gap between the tractor and the trailer in order to reduce air circulating in the void.

Low rolling resistance tires: Tires designed to reduce the amount of energy needed to overcome rolling resistance. They typically have thinner treads and are stiffer than their conventional counterparts.[11] They come in either a dual (i.e. two tires next to each other) or wide base single (i.e. a single tire with a wide base) configuration.

Lightweight components: A component that has been designed to be especially light in weight. Lightweight components can lead to fuel savings in two ways. For fleets that frequently reach their maximum payload, lightweight components can increase a trailer's payload capacity and reduce the total number of trips required to transport goods. For fleets that rarely, if ever, reach their maximum payload, lightweight components can reduce the amount of weight that needs to be pulled by a tractor, thereby leading to a reduction in fuel consumption.

Tire pressure monitoring systems: Devices that monitor the pressure of individual tires and which display a signal when pressure is above or below the pre-set target pressure.

Automatic tire inflation systems: Devices that monitor the pressure of individual tires and which automatically inflate them when pressure is below the pre-set target.

Telematics systems: Devices installed in the cab of a tractor or on a trailer that track various metrics associated with a vehicle's operations, including fuel consumption,

[11] Yunsu Park, Jim Rogers, Jim Park, Mike Roeth, Frank Bio and Denise Rondini, *Confidence report: Low rolling resistance tires* (NACFE, 2020), 23. https://nacfe.org/downloads/confidence-report-low-rolling-resistance-tires/

which can then help fleet operators identify potential fuel-efficiency improvements. Unlike the aforementioned technologies, telematics systems were not identified as a key technology to meet the Phase 2 standards posted in the Canada Gazette II.

3. Literature review

Several recent studies have explored the uptake of fuel-saving devices for trailers within the North American on-road freight sector. Table 1 provides an overview of some of the most recent studies that have explored current rates of adoption through surveys or interviews with key stakeholders.

Table 1. Overview of studies examining the uptake of trailer fuel-saving devices

Source	Region of study	Overview of study methods	Number of responses	Stakeholder groups engaged	Description of study participants
ChemInfo (2020)[12]*	Canada	Surveyed Canadian trucking fleets to better understand uptake of and barriers to the adoption of fuel-saving devices.	10	Trucking fleets	6 for-hire carriers 3 owner-operators 1 private fleet 1,450 class 5-8 trucks and 3,009 trailers Predominantly from Western Canada Evenly split between long-haul, regional and urban segments
ICCT and Pollution Probe (2015)[13]	Canada	Interviewed experts from Canada's on-road freight sector to develop a better understanding of Canada's market for fuel-saving devices for trailers.	18	Trucking fleets Trailer manufacturers Trailer dealerships Fuel-saving device manufacturers	9 trucking fleets (medium and large for-hire and private fleets that operate 30-1,500 tractors and 150-3,500 trailers) 3 trailer manufacturers 1 trailer dealership 10 fuel-saving device

[12] ChemInfo Services Inc., *Survey of the Industry to Collect Data on Heavy-Duty Vehicles and Retrofits* (2020).

[13] Ben Sharpe, Derek May, Bob Oliver and Husam Mansour, "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the Canadian On-Road Freight Sector," *The International Council on Clean Transportation and Pollution Probe* (2015). https://theicct.org/sites/default/files/publications/ICCT_Canada-trailers_20150209.pdf

					manufacturers
ICCT and NACFE (2014)[14]	North America	Interviewed experts from North America's on-road freight sector to develop a better understanding of the evolving market for fuel-saving devices for trailers.	22	Trucking fleets Trailer manufacturers Trailer dealerships Fuel-saving device manufacturers	11 trucking fleets (medium and large for-hire and private fleets that operate 250-10,000 tractors and 500-30,000 trailers) 3 trailer manufacturers 8 fuel-saving device manufacturers
NACFE (2019)[15]	North America	A compilation of data from NACFE's annual fleet fuel study, in which the fuel efficiency initiatives of trucking fleets are documented.	20	Trucking fleets	20 trucking fleets (operate 71,844+ tractors and 236,292+ trailers)

*Note: Due to the small number of fleets surveyed in the ChemInfo study, results from this study will be interpreted with caution.

Overall, studies have shown that there is a wide range in the level of adoption of fuel-saving devices in the North American trucking sector. While some devices are reportedly installed on the vast majority of trailers in North America, others have experienced very limited uptake. The estimated rates of trailer technology uptake from each of the aforementioned studies are summarized in Table 2. There are some discrepancies in the estimated rates of adoption across each of the studies, which may be the result of varying geographic contexts, the timing of the study, and different groups of stakeholders interviewed. Additionally, while the ChemInfo study reports on the percentage of fleets that have adopted the technology, the studies by ICCT and

[14] Ben Sharpe and Mike Roeth, "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the North American On-Road Freight Sector," *The International Council on Clean Transportation and North American Council for Freight Efficiency* (2014). https://theicct.org/sites/default/files/publications/ICCT_trailer-tech-costs_20140218.pdf

[15] North American Council for Freight Efficiency, *NACFE Data and Benchmark Tool* (2019). https://nacfe.org/downloads/nacfe-data-and-benchmark-tool/

Pollution Probe (2015), as well as ICCT and NACFE (2014) report on the percentage of new box trailers equipped with each technology.

Table 2. Estimated rates of trailer technology adoption in North American HDV fleets

	Trailer Technology Rates of Adoption by Study/Source			
Technology	ChemInfo (2020)[a]	ICCT and Pollution Probe (2015)[b]	ICCT and NACFE (2014)[b]	NACFE (2019)[c]
Aerodynamic devices	26%	-	-	-
- Side skirts	-	40-50%	40%	90%
- Underbody fairings	-	Very few	3%	0%
- Rear fairings (e.g. boat tails)	-	Very few	3%	25%
- Gap reducer (e.g. nose cones)	-	Very few	Very few	13%
Low rolling resistance dual tires	11%	80%+	-	84%
Single wide base tires	1%	5-10%	-	10%
Tire pressure monitoring systems	1%	5-15%	10%	13%
Automatic tire inflation systems	1%	20-30%	33%	85%
Aluminum wheels	11%	-	-	32%

[a] Percentage of surveyed trucking fleets that had adopted the technology.
[b] Estimated percentage of new box trailers equipped with the technology.
[c] Uptake rates for 2018, the most recent year reported.

Despite some discrepancies, there are a few key trends that can be inferred from these studies. From the studies that broke down aerodynamic devices by type, side skirts appear to be the preferred technology. This may be due to the fact that side skirts are a passive technology (i.e. do not require driver intervention) and have a shorter payback period than other aerodynamic devices (approximately 9 months for side skirts versus

12 months for underbody fairings, 13 months for boat tails and 15 months for gap reducers, on average).[16] Additionally, some of the other aerodynamic devices face their own unique barriers to adoption. For instance, rear fairings (e.g. boat tails) may require manual deployment that some drivers are reluctant to do in unfavourable conditions (e.g. during active winter weather),[17] and fleets have reported drivers forgetting to close them before backing up into loading docks.[18] Prior to 2014, there were also regulatory constraints against the adoption of rear fairings as a result of previous provincial and territorial limitations on trailer length, which have since been amended.[19] Underbody fairings have not seen very much adoption, due to the fact that fleet operators do not expect these devices to be as effective as side skirts in their fuel efficiency gains,[20] or perhaps simply because they've been on the market for a shorter period of time.[21] Lastly, the popularity of trailer gap reducers, such as nose cones, has been reduced in recent years due to the increasing popularity of aerodynamic tractors with cab extenders.[22] Due to the range of barriers facing other aerodynamic devices, side skirts have been the preferred technology to date.

Among the two low rolling resistance tire technologies, studies show that there is a preference for low rolling resistance dual tires over single wide base tires among trucking fleets in North America. Two notable barriers to the adoption of single wide base tires include the regulatory limit on axle weights when fleets operate wide base single tires in certain provinces and territories, as well as the risk of being stranded in the event of a tire popping.[23]

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[16] Ben Sharpe, Derek May, Bob Oliver and Husam Mansour, "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the Canadian On-Road Freight Sector," *The International Council on Clean Transportation and Pollution Probe* (2015), 23. https://theicct.org/sites/default/files/publications/ICCT_Canada-trailers_20150209.pdf

[17] Ibid, 16.

[18] North American Council for Freight Efficiency, *Confidence Report: Trailer Aerodynamics* (2020), 61. https://nacfe.org/downloads/confidence-report-trailer-aerodynamics/

[19] Task Force on Vehicle weights and Dimensions Policy, *Heavy Truck Weight and Dimension Limits for interprovincial Operations in Canada* (2019), 5. https://comt.ca/english/programs/trucking/MOU%202019.pdf

[20] "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the Canadian On-Road Freight Sector," 14.

[21] "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the North American On-Road Freight Sector," 9.

[22] *Confidence Report: Trailer Aerodynamics*, 66.

[23] *Confidence Report: Trailer Aerodynamics*, 19.

In terms of tire pressure systems, automatic tire inflation systems appear to be preferred over tire pressure monitoring systems. Certain fleets have expressed a preference for automatic tire inflation systems seeing as they are a more passive technology.[24]

Overall, the perceived and actual barriers to devices are well-documented in literature. A 2013 NACFE study identified primary barriers as being a lack of credible information, uncertain payback periods, capital cost constraints, concerns around reliability and a lack of technology availability.[25]

[24] "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the Canadian On-Road Freight Sector," 20.

[25] Mike Roeth, Dave Kircher, Joel Smith and Rob Swim, "Barriers to the Increased Adoption of Fuel Efficiency Technologies in the North American On-Road Freight Sector," *North American Council for Freight Efficiency* (2013). https://theicct.org/sites/default/files/publications/ICCT-NACFE-CSS_Barriers_Report_Final_20130722.pdf

4. Research methodology

4.1 Survey

The Pembina Institute designed a survey for fleets and trailer manufacturers doing business in Canada to solicit information on the current rates of uptake of fuel-saving devices for trailers, as well as costs and benefits of technologies. The survey was available in English and French, and distributed to select participants through industry associations and networks, including:

- The Canadian Trucking Alliance
- Several provincial trucking associations
- The Private Motor Truck Council of Canada
- The Canadian Transportation Equipment Association
- The Peel Goods Movement Task Force
- Natural Resources Canada's SmartWay program

The survey was distributed electronically via email and respondents were given the choice to complete the survey online using Survey Monkey or by filling out a Microsoft Word document. Two surveys were circulated – one for fleets and one for trailer manufacturers (see Appendix A).

Survey respondents were asked a series of questions that helped identify which fleet segments they belonged to (or served, in the case of manufacturers) based on the following characteristics:

Location of headquarters:	Atlantic, Quebec, Ontario, Prairies, British Columbia or Territories
Regions of operation:	Atlantic, Quebec, Ontario, Prairies, British Columbia or Territories
Type of fleet:	For-hire, private or owner-operator
Trailer fleet size:	1-4, 5-99, 100-499, 500+
Trailer types in fleet:	Dry box van, refrigerated box van, flatbed, container chassis, grain, dump, tanker, lowbed, other

Commodity types transported:	Agriculture, automobiles, base metals, food, forest products, fuel oils, minerals, plastic & chemicals, waste & scrap, other manufactured goods, miscellaneous products, other
Length of haul:	Regional haul (<500 km) or long haul (>500 km)

A detailed understanding of each fleet's operations according to the aforementioned characteristics facilitated the identification of trends within smaller segments of the on-road freight sector (e.g. within for-hire fleets, or within fleets based out of British Columbia).

Survey respondents were then asked to identify the current rates of adoption of fuel-saving devices on their trailers. For the devices that they've adopted, respondents were asked to identify the costs and benefits associated with each device: fuel savings, impact on maintenance costs and overall payback period. To better understand the motivation to adopt fuel-saving devices for trailers, respondents were asked to identify which factors influenced their company's decision to adopt the devices. To inform future policies and programs, survey respondents were also asked to identify what would help spark greater adoption of trailer fuel-saving devices in their fleets.

4.2 Working group meetings

Two working group meetings with industry associations were organized in January 2021 to solicit in-depth commentary on the survey findings. The first meeting was held with approximately a dozen members of the Canadian Trucking Alliance. The second meeting was held with the Manitoba Trucking Association's Vehicle Maintenance Council. Five members were in attendance – three of which represented fleets, one of which represented a maintenance company and one of which represented a truck equipment supplier. These working group meetings took place virtually over the course of 45 minutes to one hour.

In these working group meetings, individuals were asked to elaborate on the key trends that emerged from the survey results and to share their experiences and knowledge on the topic of trailer fuel-saving devices.

4.3 Case studies

Case studies of Canadian trucking fleets were developed to complement results from the survey and working group meetings and provide insight into the experiences that individual companies have had with trailer fuel-saving devices over time. These case studies served as an important way to solicit unstructured feedback on trailer fuel-saving devices and gave trucking fleets the opportunity to provide in-depth commentary on specific barriers or opportunities associated with the devices.

To conduct the case studies, interviews were scheduled with three Canadian fleet operators that responded to the survey. The three fleets were selected based on their expressed interest in participating in a follow-up interview, and because they represent a diverse range in fleet segments. These interviews took place virtually or over the phone and each lasted approximately one hour. They were mostly unstructured to give interviewees the opportunity to provide unsolicited feedback on the fuel-saving devices that their company had adopted, their motivation to adopt these devices, and any specific barriers or opportunities that they had encountered.

5. Survey respondents

A total of 63 responses were received, 60 of which came from fleet operators and 3 of which came from trailer manufacturers. These survey responses have been aggregated and are reported on anonymously in Section 1. One small discrepancy was accounted for among the survey responses: if a respondent indicated that they have not adopted a particular fuel-saving device, their responses to subsequent questions on fuel savings and the estimated payback period for that particular device were coded as N/A. This was done to ensure that results account for real world experience with the devices.

Three leading trailer manufacturers in Canada responded to the survey. These three manufacturers represent a notable share of the Canadian trailer market (at least 13% in 2014).[26] Each represents a different trailer market: one supplies container chassis, another flatbeds and grain containers, and the third tanker trailers. Each of the manufacturers supplies trailers across all of Canada.

An overview of various characteristics of the fleets that responded is presented in Appendix B.

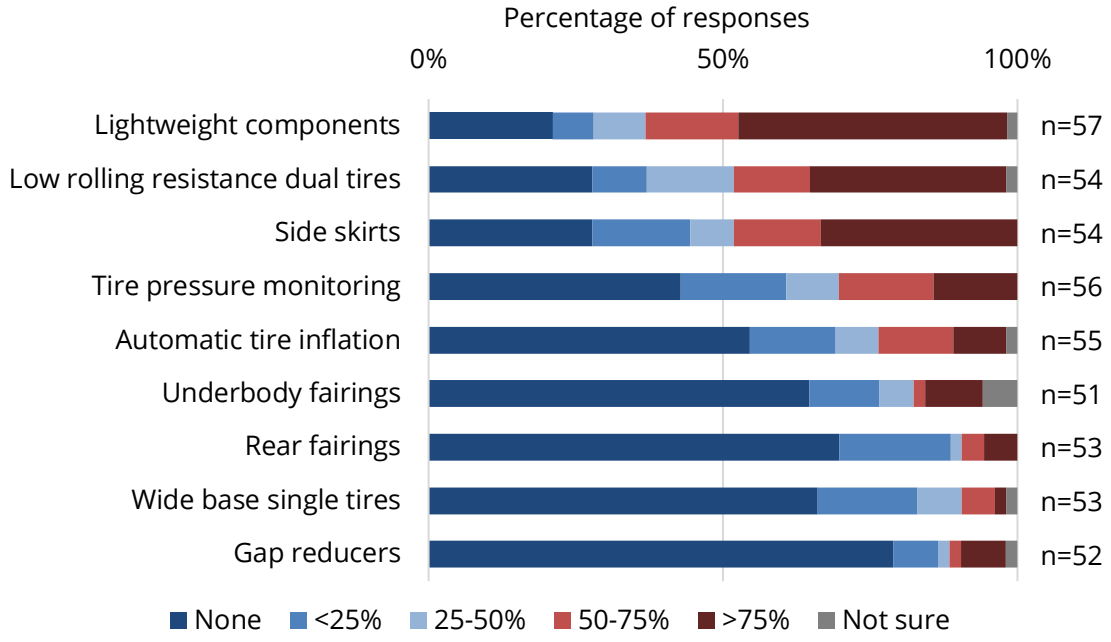
[26] Ben Sharpe, *Market analysis of heavy-duty commercial trailers in Canada* (International Council on Clean Transportation, 2017), 3. https://theicct.org/sites/default/files/publications/Canada-HDV-trailers-market-analysis_ICCT_working-paper_09032017_vF.pdf

6. The state of trailer fuel-saving devices

6.1 Current rates of adoption

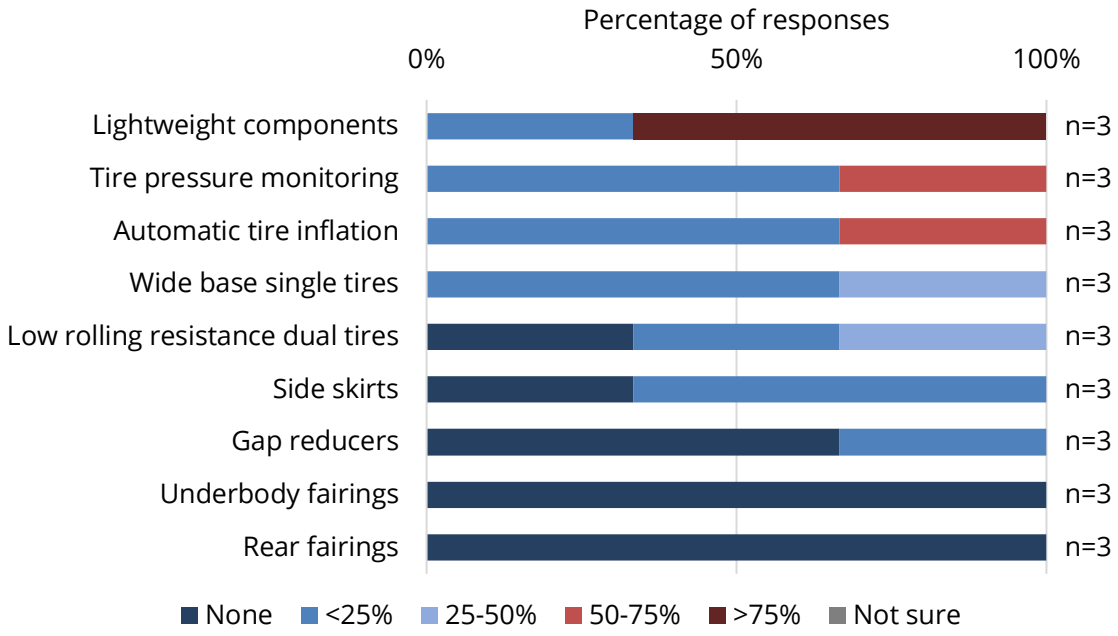
To identify the key trends in rates of adoption, the weighted average of the survey responses was calculated for each device using the midpoint of the range that was reported (e.g. 37.5% for the range 25-50%). This same method has been used to report on key trends in fuel savings and average payback periods in subsequent sections.

A summary of fleet survey responses can be found in Figure 1, while a summary of the manufacturer survey responses can be found in Figure 2. Devices are ordered according to their weighted average rate of adoption, in descending order. The results presented below and in subsequent sections of this report are intended to provide a qualitative overview of the current state of trailer fuel-saving devices within Canada's on-road freight sector and are not intended to be interpreted with statistical significance.



Q: What percentage of your company's trailers are equipped with the following fuel-saving devices?

Figure 1. Percentage of fleets' trailers equipped with fuel-saving devices



Q: Approximately what percentage of the trailers that your company sells are equipped with the following fuel-saving devices?

Figure 2. Percentage of manufacturers' trailers equipped with fuel-saving devices

For fleets and trailer manufacturers, the trailer technologies with the highest rates of adoption differed (see Table 3).

Table 3. Trailer fuel savings with the highest rates of adoption

Fleet operators	Trailer manufacturers
1. Lightweight components	1. Lightweight components
2. Low rolling resistance dual tires	2. Tire pressure monitoring
3. Side skirts	3. Automatic tire inflation

The fleet survey results, in particular, echo trends that have been observed in previous studies. Low rolling resistance tires and side skirts have exhibited some of the highest rates of uptake in the past.[27,28,29] Side skirts are a reliable technology that does not

[27] "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the Canadian On-Road Freight Sector," 23.

[28] "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the North American On-Road Freight Sector," 14.

require driver intervention. These devices were described by a fleet operator in the working group meeting as being virtually indestructible and are associated with very little maintenance requirements. Additionally, some fleet operators noted that they were required to outfit their trailers with side skirts in order to meet GHG emission standards in California. Meanwhile, among the two types of low rolling resistance tires, fleets have demonstrated a preference for low rolling resistance dual tires over wide base singles due to the fact that they never faced regulatory weight restrictions, they tend to be more readily available, and they won't leave drivers stranded in the event of a tire blowout.

Lightweight components have not been as widely studied in past research on trailer fuel-saving devices. It was reported by one fleet operator that their company's primary motivation to use lightweight components is to maximize payload, rather than achieve fuel savings. By reducing the weight of their trailer, they're able to haul more goods per trip. By hauling more goods per trip, however, fleet operators may be able to cut down on the total number of trips required, thereby reducing the overall amount of fuel consumed. This, however, is only applicable for trailers that frequently hit their maximum weight. It's estimated that 88% of North American fleets rarely or never reach their maximum weight.[30] For these fleets, lightweight components can reduce the overall weight of the trailer and result in a reduction in fuel consumption. Previous research suggests that lightweighting is most commonly adopted by companies looking to maximize their payload, rather than reduce fuel consumption.[31] The popularity of trailer lightweighting may also be attributed to the fact that it is one of the few viable technology options for specialized trailers like flatbeds, which aren't well suited for devices like side skirts or rear fairings.

Discrepancies between the results for fleets and trailer manufacturers may be due to the fact that dry box vans make up the highest percentage of trailers used by the surveyed fleets, while the three manufacturers surveyed supply specialty trailer markets. There are specific considerations associated with the use of fuel-saving devices for specialized trailers. For instance, side skirts are not suitable for use on tanker trailers. Additionally, it was noted by fleet operators in the working group meetings that gap reducers may not be suitable for use with both livestock trailers and refrigerated box vans. In the case of

[29] *NACFE Data and Benchmark Tool*

[30] Andrew Halonen, Rob Swim, Mike Roeth, Frank A. Bio, Denise Rondini and Kim Ehrenhaft, *Confidence Report: Lightweighting* (North American Council for Freight Efficiency, 2021), 4. https://nacfe.org/technology/lightweighting-2/

[31] *Confidence Report: Lightweighting*, 5.

livestock trailers, air flow is critical to ensuring the well-being of the animals on-board. Meanwhile, in the case of refrigerated box vans, air flow is critical to cooling the coils of the refrigeration unit. In both cases, gap reducers may limit airflow to areas of need.

There is more overlap between the trailer fuel-saving devices with the lowest rates of adoption among the surveyed fleet operators and trailer manufacturers (see Table 4).

Table 4. Trailer fuel-saving devices with the lowest rates of adoption

Fleet operators	Trailer manufacturers
1. Gap reducers	1. Rear fairings
2. Wide base single tires	2. Underbody fairings
3. Rear fairings	3. Gap reducers

Many of these trends are expected. First, low rates of adoption of underbody fairings are expected as fleets have demonstrated a preference for side skirts over the years. In addition, one of the leading manufacturing of underbody devices, *Smart Truck*, has exited the market.[32] As for rear fairings, several fleets have expressed issues associated with these devices, particularly pertaining to manual deployment and operation. In the working group meetings, there were reports of drivers forgetting that boat tails had been deployed resulting in damage as they backed into loading docks. Meanwhile, increasingly aerodynamic tractors have reduced the need for trailer gap reducers.[33] Finally, fleets reported lower rates of adoption of wide base single tires due regional restrictions of their use on certain roads, past restrictions on axle load limits and the risk of being stranded in the event of a tire blowout.

It was noted in the working groups that a device's weight is a major consideration when considering its adoption. The heavier the device, the less a trailer is able to haul, which can have direct impacts on a fleet's revenue.

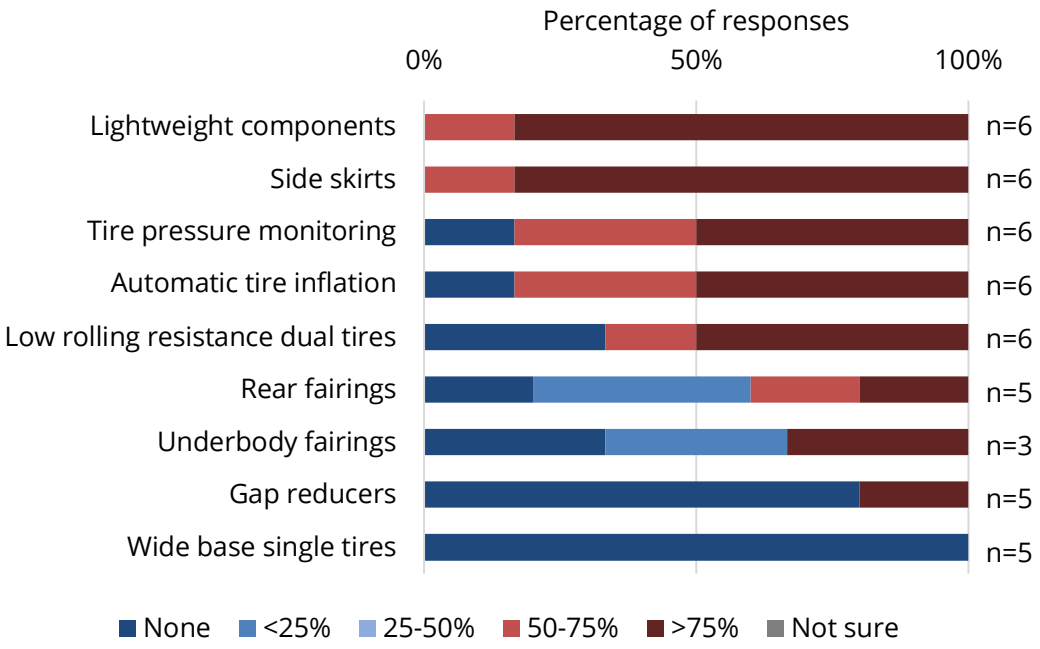
[32] Rick Mihelic, Dave Schaller and Mike Roeth, *Confidence report: Trailer aerodynamic devices* (North American Council for Freight Efficiency, 2020), 54.

[33] *Confidence report: Trailer aerodynamic devices*, 66.

6.1.1 Trends in rates of adoption by fleet segment

6.1.1.1 Headquarter location

Most fleet segments exhibited similar trends in rates of adoption. However, a few distinct trends emerged across three fleet segments. First, companies with headquarters in Canada's Atlantic provinces exhibited the highest rates of adoption of most fuel-saving devices for trailers out of any of the Canadian regions, with the exception of wide base single tires (Figure 3). These trends are based on the survey responses of six fleets from Atlantic Canada.



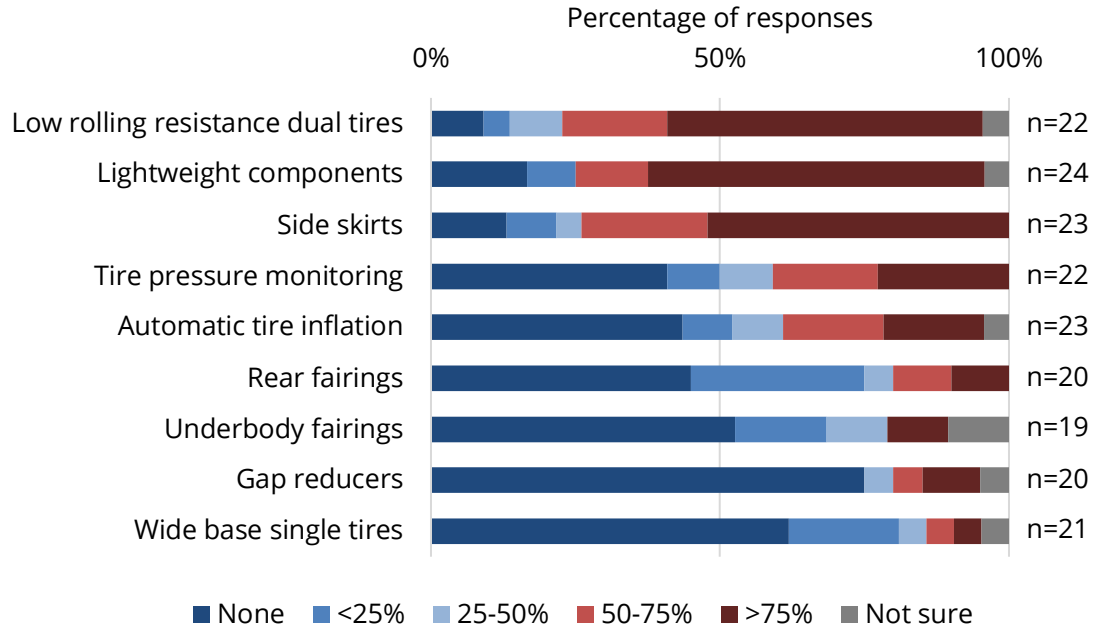
Q: What percentage of your company's trailers are equipped with the following fuel-saving devices?

Figure 3. Trailer fuel-saving device uptake among fleets with headquarters in Atlantic Canada

Second, companies with headquarters in Quebec reported the highest rates of adoption of wide base single tires. These results, however, are only based on responses from three fleets: one fleet reported having wide base single tires installed on less than 25% of its trailers, while the other two fleets reported having them installed on 50-75% of their trailers. Meanwhile, two-thirds of fleets in Canada reported having no trailers equipped with wide base single tires.

6.1.1.2 Length of haul

Companies whose primary trip length would be considered long haul (i.e. >500 km from their home base) generally exhibited higher rates of adoption of each of the fuel-saving devices (Figure 4). This may be due to the fact that the benefit of aerodynamic devices is greater at highway speeds,[34] and long-haul fleets are likely covering greater distances at highway speed. Additionally, long-haul travel results in higher mileage and greater fuel consumed. Hence, due to the larger amount of fuel consumed, these vehicles benefit more than their regional counterparts from a reduction in fuel costs.



Q: What percentage of your company's trailers are equipped with the following fuel-saving devices?

Figure 4. Trailer fuel-saving device uptake among long-haul fleets

Case study: Lightweighting — Specialized trailers in the Prairies

This is a medium-sized for-hire trucking company that operates out of the Prairies. Their trailer fleet is primarily made up of flatbeds. For specialized trailers like flatbeds, opportunities for aerodynamic improvements are limited. Instead, this company has focused its efforts on lightweighting and improving the rolling resistance of their tires.

[34] Transport Canada, "Review of Aerodynamic Drag reduction Devices for Heavy Trucks and Buses," Government of Canada (2011). https://tc.canada.ca/en/programs/non-funding-programs/ecotechnology-vehicles-program/review-aerodynamic-drag-reduction-devices-heavy-trucks-buses

This company has worked with their trailer manufacturer to reduce the average weight of their flatbeds from the typical 10,000-11,000 lbs to under 7,000 lbs. By reducing the weight of their flatbeds, they are now able to haul more cargo. In fact, this company is now able to increase the weight of cargo they carry by 20% resulting in 20% fewer trips and significant fuel savings and GHG emission reductions. Hauling more goods per vehicle can also help this company reduce the impact of current driver shortages on their operations, as fewer drivers are required to transport the same amount of goods.

To lightweight their trailers, this company has replaced steel components with aluminum, which is 40% lighter than traditional steel.[35] In addition to transitioning to lighter materials, they've also removed any unnecessary components, including sections of the floor.

There is, however, a cost associated with these updates. While a typical steel flatbed might cost $35,000, this company has paid up to $55,000 for a lightweight version. While this cost may seem significant, they're certain that it's worth it. Being more efficient allows this company to differentiate themselves from other carriers. They also believe that the equipment tends to last longer, as they experience less corrosion than they otherwise would with steel. Further to this, they're also benefitting the environment. Despite higher capital costs, this company has seen a return on their investment into trailer lightweighting.

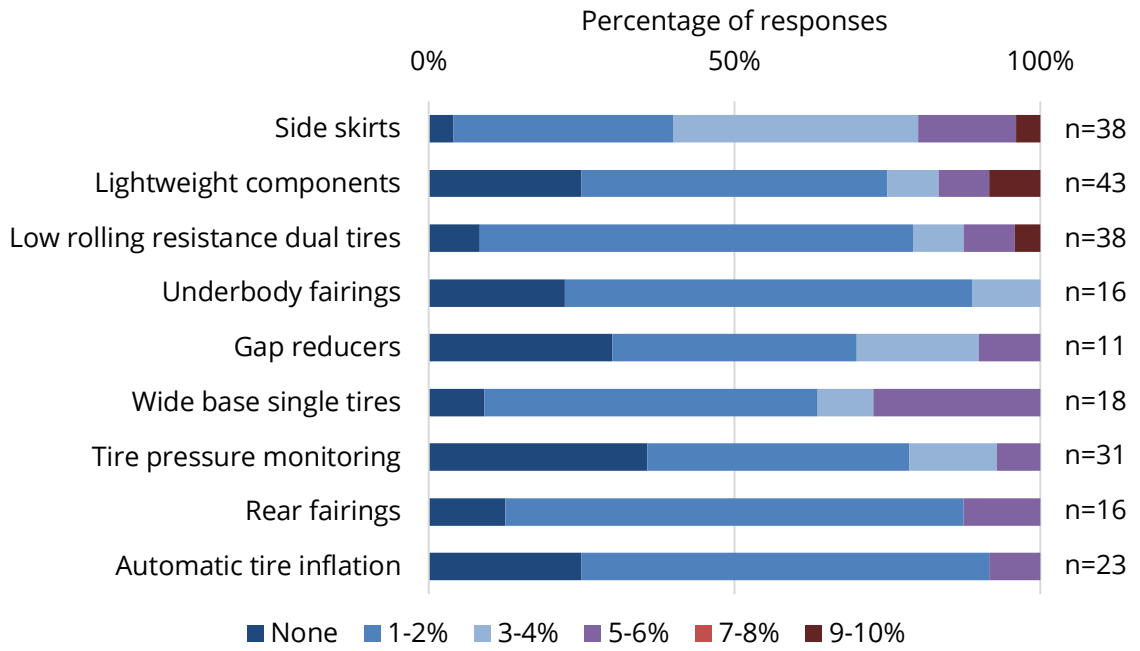
In addition to lightweighting their trailers, this company has also benefitted from the use of wide base single tires, as they can reduce rolling resistance and tend to last longer than traditional tires. They've been an advocate for wide base tires for over 20 years.

6.2 Fuel savings

Fleet operators were asked what percentage fuel savings they experienced as a result of installing each fuel-saving device on their trailers. Fuel savings can also correspond to a change in GHG emissions. If fleet operators are reporting fuel savings that aren't attributed to a drop in the cost of fuel, they've likely reduced their fuel consumption and the associated GHG emissions.

[35] Ruth Heuss, Nicolai Muller, Wolff van Sintern, Anne Starke and Andreas Tschiesner, *Lightweight, heavy impact*, (McKinsey, 2012), 8. https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/automotive%20and%20assembly/pdfs/lightweight_heavy_impact.ashx

Figure 5 shows the range in fuel savings reported by fleets for each device. Devices are ordered according to their weighted average fuel savings, in descending order. For most devices, fuel savings of 1-2% were most commonly reported. Only a small percentage of fleets reported fuel savings above 5% for any of the devices.



Q: What percentage fuel savings have you experienced as a result of installing each of the following devices on your trailers?

Figure 5. Percentage fuel savings achieved from fuel-saving devices

The fuel savings reported by fleets in this study are lower than expected. Past studies have reported fuel savings in the range of 1-2% for tire pressure monitoring and automatic inflation systems, however, estimates have generally been higher for other devices. For example, previous research has reported average fuel savings among the Canadian on-road freight sector of 4% for side skirts, 3% for underbody fairings, 4% for rear fairings, 2% for gap reducers, 2% for low rolling resistance dual tires and 3% for wide base single tires.[36]

Lightweight components are attributed with the largest number of respondents reporting fuel savings of 9-10%. This technology can lead to fuel savings either by reducing the total number of trips required to transport a fixed amount of goods or by reducing the amount of weight that a tractor needs to pull. The effect of lightweight

[36] "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the Canadian On-Road Freight Sector," 24.

components, however, is much lower for heavy-duty vehicles that spend a larger amount of time travelling at highway speeds than it is for light- and medium-duty vehicles which exhibit a greater number of stop-start incidents where fuel usage associated with getting up to speed is higher.[37] Previous research suggests that small investments in tractor and trailer lightweighting, including installing aluminum wheels, lighter trailer hub components and select other lightweight components, would only lead to fuel savings of approximately 1%.[38] Another estimate suggests that a 2,000 lbs reduction in vehicle weight will lead to 1% fuel savings.[39] For fleets that frequently reach their maximum allowable weight, however, trailer lightweighting to maximize payload can lead to considerable improvements in freight efficiency. For example, a 20% increase in payload capacity would require 20% fewer trips to transport a fixed amount of goods.

It was noted in the working group meetings that it can be difficult to reliably track data on fuel savings stemming from specific equipment. This is due to the fact that it can be challenging to isolate the impact of a single device when a trailer may be outfitted with multiple. Participants of the working group meetings noted that, instead, they tend to rely on data from external equipment manufacturers and other independent sources to quantify expected a device's expected fuel savings.

Due to the fact that only three manufacturers completed the survey, and not all of the manufacturers had experience with each of the fuel-saving devices, there was limited data available on the potential fuel savings of each device.

6.2.1 Trends in fuel savings by fleet segment

6.2.1.1 Fleet size

The percentage of responses indicating that fleets were "not sure" about the fuel savings of an installed device was considerably lower for large fleets with 500+ trailers in their fleet, than it was for small (5-99 trailers) and medium (100-499 trailers) sized fleets. Whereas on average 52% of small and medium size fleet respondents indicated that they were "not sure" about the fuel savings of an installed device, only 12% of large

[37] David Brierley, "The Lightweighting Effect," *Fleet Maintenance*, June 12, 2018. https://www.fleetmaintenance.com/equipment/chassis-body-and-cab/article/21006627/lightweighting-for-vehicle-efficiency

[38] *Confidence Report: Lightweighting*, 56 and 62.

[39] "The Lightweighting Effect"

fleets, on average, indicated this as a response. It is possible that larger fleets have greater capacity to research and identify the fuel savings associated with a particular device, or the capital to subscribe to performance-testing services, such as FP Innovations' PIT Group.[40]

6.2.1.2 Fleet type

Private fleets are retailers that control the transportation and distribution of their goods from suppliers to retail stores (e.g. Walmart, Coca-Cola or Tim Hortons). Though there were limited responses for private fleets, this fleet segment more commonly reported no fuel savings from most of the devices (underbody fairings, rear fairings, low rolling resistance tires, wide base single tires, and tire pressure monitoring and inflation systems, in particular) than for-hire or owner-operator fleets. This is likely due to the fact that all of the private fleets surveyed indicated that they perform regional-haul routes, for which the benefit of fuel-saving devices may not be as large as it is for long-haul routes.

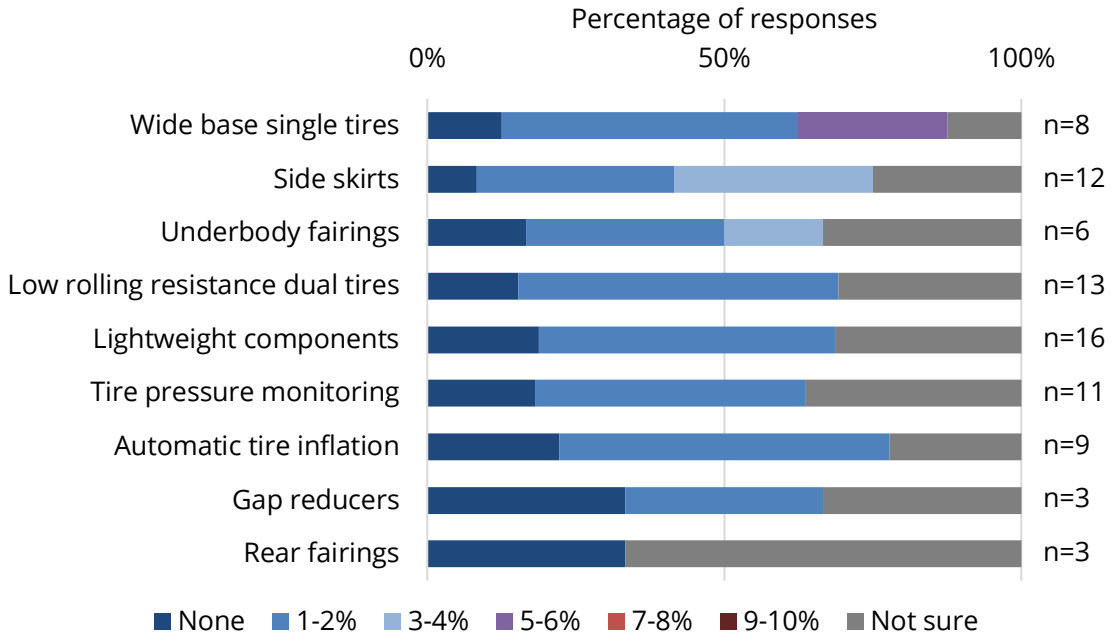
6.2.1.3 Headquarter location

It was somewhat difficult to discern trends across different headquarter locations as a result of small sample sizes for certain regions and devices. Most notably, fleet respondents with headquarters in the Prairies reported some of the highest fuel savings from wide base single tires than any other region. Three out of the five fleets that have adopted wide base single tires reported fuel savings of 5 to 6%.

6.2.1.4 Length of haul

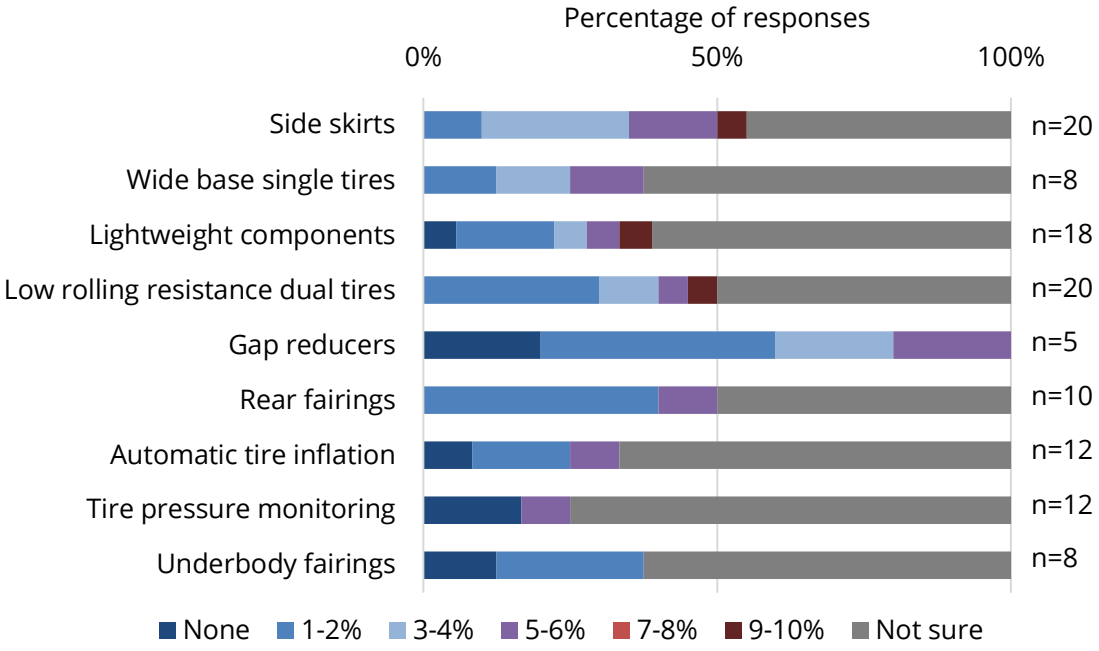
Fleets whose primary length of haul would be considered long haul (i.e. greater than 500 km from their home base) reported greater fuel savings than fleets belonging to the regional haul segment. Regional-haul fleets that responded mostly commonly reported no fuel savings or fuel savings of only 1 to 2% (see Figure 6). Meanwhile, there was a higher frequency of fleets reporting fuel savings over 2% within the long-haul segment (see Figure 7). As noted earlier, the benefit of aerodynamic devices is greater at highway speeds, and it is likely that long-haul fleets are more frequently travelling at these speeds. A higher percentage of long-haul fleets, however, also indicated that they were "not sure" about the fuel savings of the various devices.

[40] "PIT Group." https://thepitgroup.com/energotest/



Q: What percentage fuel savings have you experienced as a result of installing each of the following devices on your trailers?

Figure 6. Regional-haul fleets' percentage fuel savings achieved from fuel-saving devices



Q: What percentage fuel savings have you experienced as a result of installing each of the following devices on your trailers?

Figure 7. Long-haul fleets' percentage fuel savings achieved from fuel-saving devices

Case study: Erb Transport

Erb Transport is a large for-hire trucking company that operates out of Ontario and transports food products across Canada and into the United States. Most of the food products they handle are temperature-controlled, and so their trailer fleet is made up of refrigerated box vans. Erb Transport has tested a wide range of trailer fuel-saving devices, some of which have been more successful than others.

Erb Transport's fleet regularly travels to California. In 2010, the state mandated that fleets travelling within California needed to be SmartWay compliant, Erb Transport began outfitting their trailers with side skirts. They initially tried aluminum side skirts, however, they ran into issues when the side skirts were hitting snowbanks. They've since switched to a composite side skirt that has been relatively maintenance free.

As a result of their success with side skirts, Erb Transport became an early adopter of trailer tails. While the company found that they led to fuel savings, their unanticipated extra costs ended up outweighing their benefits. At the outset of the deployment of tails, drivers would not open the tails resulting in no aerodynamic improvement. Once drivers were conditioned to open the tails the next problem was that they would forget to close the trailer tails before backing into loading docks. This resulted in significant damage to dock doors. Erb Transport had spent in excess of $50,000 to repair damaged dock doors. As a result of this added cost, the company decided to discontinue using trailer tails.

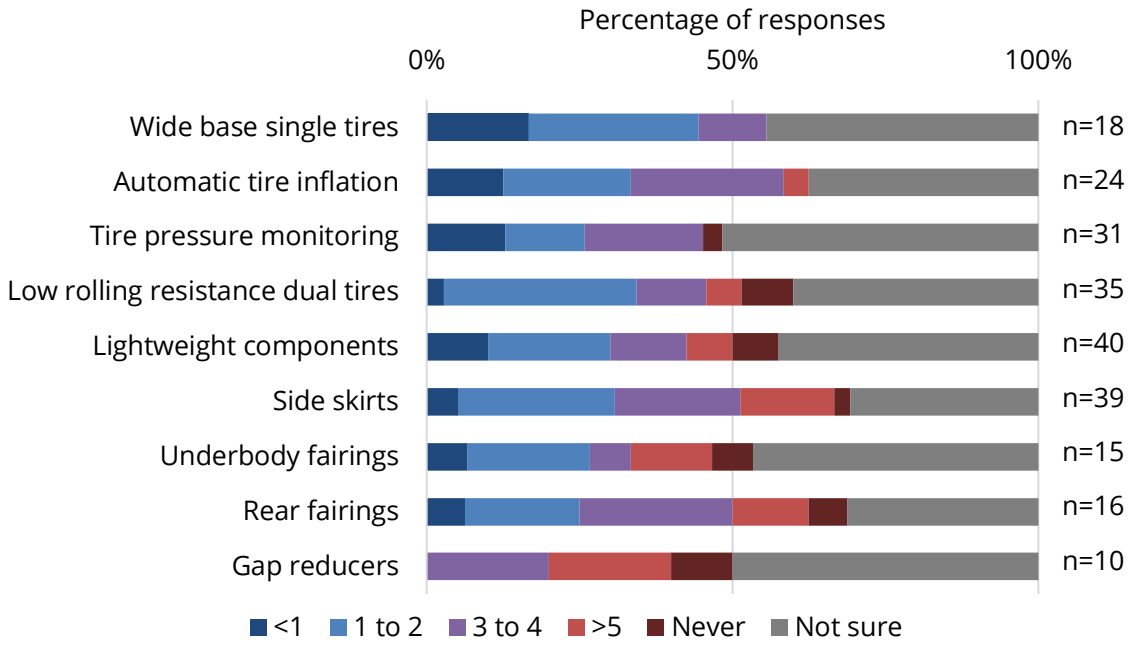
Erb Transport has utilized low rolling resistance dual tires as part of the SmartWay compliant package. They have not tried wide base single tires in many years due to the fact that wide base singles did not have the equivalent load capacity as duals across all Canadian jurisdictions. The weight disparity is largely a thing of the past, however for the sake of fleet uniformity and the excellent availability of dual tires on roadside breakdowns, Erb Transport continues to use dual tires. They also use low rolling resistance dual tires on their tractors, but find that they need to be careful on the application. Trucks that run through the Canadian Rockies or the hills of northern Ontario in the winter will have traction issues with these tires.

In addition to the aforementioned devices, Erb Transport has also adopted tire pressure monitoring and automatic inflation systems, aerodynamic mudflaps, lightweight aluminum wheels, battery-powered auxiliary power units, a stationary fifth wheel on the tractor to keep the tractor-trailer gap consistent, automated transmissions, and a telematics system that allows them to remotely control the temperature of their refrigerated trailers. Their most recent vehicles have improved their fuel efficiency by 2.5 to 3 mpg in comparison to vehicles from 15 years ago. Erb Transport attributes the fuel

economy improvements to a combination of tractor manufacturers, engine manufacturers and trailer specifications in addition to all the aerodynamic improvements. They've found that one of the most important aspects of fuel economy is the driver. A driver who slows down to 100 km/h and idles their engine under 6-8% has a large influence on their fuel efficiency.

6.3 Payback period

Survey respondents were asked to identify the average payback period (in years) for each of the devices installed on their trailers. Figure 8 presents the range in survey responses received, with devices ordered according to their weighted average payback period (in ascending order).



Q: What is your company's estimated payback period for each of the devices you have installed on your trailers (in years)?

Figure 8. Average payback period of fuel-saving devices in years

Overall, there was very little consensus on the average payback period of each of the devices. For most devices, responses ranged from less than a year to never. Gap reducers were reported as having a payback period of at least 3 years. In a past study examining trailer fuel-saving device uptake within Canada's heavy-duty vehicle fleet, the typical payback period of side skirts, underbody fairings, and tire pressure monitoring and

automatic inflation systems was identified as 1 to 2 years, whereas that of rear fairings and gap reducers was identified as 1 to 3 years.[41]

At one of the working group meetings, a representative noted that "diverse payback periods are a function of a diverse industry". It is expected that variations in fleet operations will lead to different payback periods. For instance, fleets that travel long distances and consume large amounts of fuel over a shorter period of time may see a fast return on investment. A participant in the working group meetings also noted that a fleet's owner-operator ratio can influence a device's payback period. If owner-operators are pulling a company's trailers, the company itself is not benefitting from the installation of these devices, and hence, the payback period will be extended. On the other hand, another participant noted that having a more efficient trailer is a good selling point and can help attract more owner-operators.

Due to insufficient data, estimates from trailer manufacturers on the average payback period of each device will not be reported.

6.3.1 Trends in payback period by fleet segment

6.3.1.1 Headquarter location

While fleets overall indicated a relatively short payback period for low rolling resistance tires (the majority of respondents indicated an average payback period of 1 to 2 years), fleets with headquarters in British Columbia reported much longer payback periods. Of the three fleets that responded to this question, one indicated an average payback period of greater than five years, while the other two indicated "never".

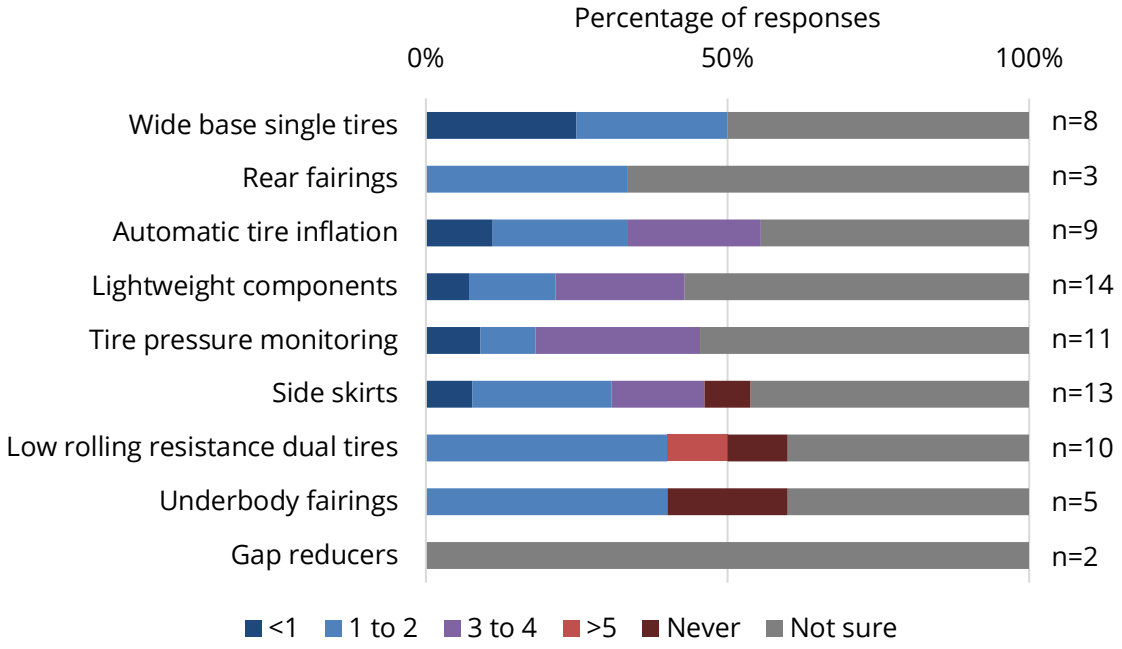
On the other hand, fleets with headquarters located in the Prairies indicated especially low payback periods for wide base single tires. Three of the five fleets reported a payback period of less than a year.

6.3.1.2 Length of haul

As long-haul fleets tend to travel longer distances than regional haul fleets, one would expect them to experience a faster return on investment in fuel-saving devices. Surprisingly, a greater proportion of long-haul fleets reported payback periods over 3 years across nearly all of the devices, the only exception being tire pressure monitoring

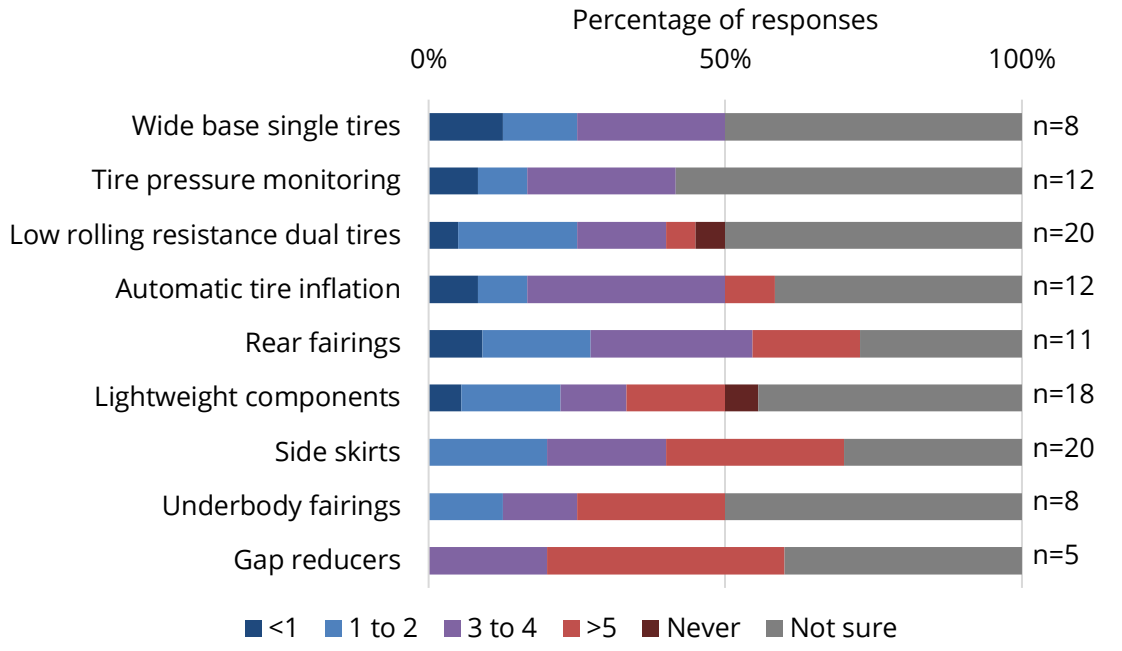
[41] "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the Canadian On-Road Freight Sector," 24.

systems, where both segments exhibited the same distribution of responses (see Figure 9 and Figure 10).



Q: What is your company's estimated payback period for each of the devices you have installed on your trailers (in years)?

Figure 9. Regional haul fleets' average payback period of fuel-saving devices in years



Q: What is your company's estimated payback period for each of the devices you have installed on your trailers (in years)?

Figure 10. Long-haul fleets' average payback period of fuel-saving devices in years

6.3.1.3 Tractor-trailer ratio

It was expected that a fleet's tractor-trailer ratio might have an impact on the payback period of a device. In particular, those with a higher tractor-trailer ratio were expected to report longer payback periods as a result of lower utilization rates of each individual trailer. Due to the small sample size of companies that had adopted each trailer fuel-saving device within each tractor-trailer segment, it was somewhat difficult to validate or invalidate this expectation. Some findings supported this expectation. For example, fleets with a tractor-trailer ratio of 1:1 exhibited the lowest weighted average payback period for underbody fairings and wide base single tires. On the other hand, other findings refuted it: fleets with a tractor-trailer ratio of 1:5 that exhibited the lowest weighted average payback period for side skirts, low rolling resistance tires, lightweight components and tire pressure monitoring and automatic inflation systems.

Case study: Liberty Linehaul

Liberty Linehaul is a small to medium sized trucking fleet that operates out of Ontario and California. Their trailer fleet is made up of dry box vans and lowbeds that transport food, plastic and chemicals, manufactured goods and other miscellaneous items.

Regulations in California prompted Liberty Linehaul's interest in fuel-saving devices. Coupled with this, high oil prices made fuel savings all the more important. Side skirts were the first technology that the company invested in and they proved to be beneficial. The company has developed a preference for the DuraPlate skirt, a product that has been brought to market by Wabash.[42] These skirts have thin, but extremely durable walls and a rubber flap at the bottom. In addition to improving fuel efficiency, Liberty Linehaul's drivers have noted that side skirts improve stability in crosswinds.

To offset the additional weight associated with the side skirts, Liberty Linehaul tested wide base single tires, which are lighter than their dual counterparts. However, the company did not see much success. They found that wide base single tires wore out 30% faster and also exhibited irregular wear due to their wider footprint. Moreover, in the event of tire blowouts, the rim often ended up damaged resulting in even higher repair costs. Drivers were also left stuck on the side of the road in the event of a blowout, and they found it harder to find single tire replacements down south in California. Lastly, they found that they weren't able to haul as heavy loads as a result of weight restrictions

[42] Wabash National, *DuraPlate AeroSkirt: Trailer side skirts*. https://www.wabashnational.com/docs/default-source/component-product-downloads/aerodynamics-downloads/duraplate-aeroskirt.pdf?sfvrsn=97b16e6c_8

associated with the use of wide base single tires in certain regions. Liberty Linehaul has heard that fleets are overcoming some of the issues associated with wide base tires through the use of tire pressure monitoring and automatic inflation systems, however, they've since switched to low rolling resistance dual tires.

While they initially avoided the technology due to some early issues, Liberty Linehaul has since started using tire pressure monitoring and automatic inflation systems. However, the devices are not without their faults. The company has found that while these technologies are well-suited for use in southern climates, the cold climate in Canada inevitably impacts their performance. In particular, the valve of the air inflation tubes that go into each tire are prone to breaking in cold weather. They're also easily corroded by calcium chloride used to melt snow and ice on winter roads. Moreover, there is the inconvenience of needing to remove the inflation system in the event of an issue with the tire. On the flip side, Liberty Linehaul has found that tire pressure monitoring and automatic inflation systems can reduce their maintenance workload in that they don't need to worry about making sure the tire pressure is adjusted every time the external temperature changes. And by ensuring tires are at the right pressure, they can prevent unnecessary tire degradation.

Liberty Linehaul considered adding boat tails to their trailers but decided that the device's complexity would be problematic. Instead, they've adopted Airtabs, which are small plastic tabs that go down the side and across the top of the trailer.[43] Air Tabs compress air into small veins and shoot it off the back of the trailer, which prevents turbulence around the back of the trailer doors. Compared to boat tails, Airtabs are less expensive, require less maintenance and add negligible weight to their trailer. And as a bonus, Airtabs help keep snow off the back of the trailer, which tends to build up more than it used to as a result of the transition to LED lights that produce little heat.

In addition to the aforementioned devices, Liberty Linehaul has also adopted fixed fifth wheels to close the tractor-trailer gap, reduced the weight of their trailers, installed mudflaps and tested aerodynamic splash guards called EcoFlaps.[44] While they've definitely seen gains in fuel efficiency in recent years, it's difficult for them to attribute fuel savings to specific devices. Moreover, tractor efficiency improvements have been significant, with certain 2020 tractors demonstrating 33% improvements in fuel efficiency over 2015 models. Additionally, like with other fleets, driver behaviour can have a huge impact on their fuel consumption. One of their owner-operators saved $25,000 in fuel costs by reducing their speed by 5 km/h.

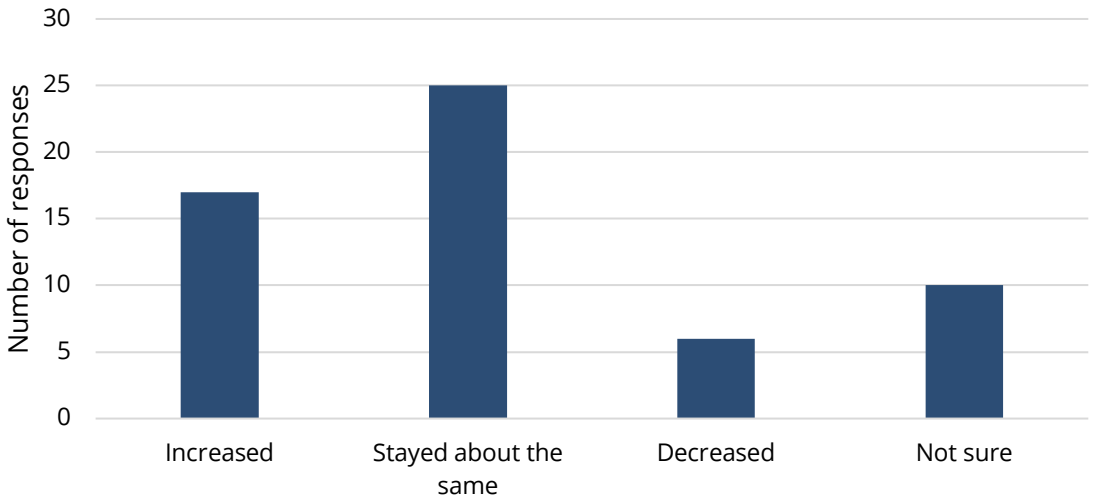
[43] Airtab fuel savers. http://www.airtab.com/

[44] EcoFlaps. https://www.ecoflaps.com/

Unlike some of the respondents in the working group meetings, Liberty Linehaul prioritizes improvements in trailer efficiency over tractor efficiency. This is primarily due to the fact that they run their trailers for at least 12 years, while they only keep their tractors for 4 to 5 years. Hence, they're able to benefit from fuel-saving devices installed on the trailer than they are on the tractor.

6.4 Maintenance costs

Fleets were asked how the installation of fuel-saving devices for trailers has impacted their company's annual vehicle maintenance costs or workload. While 42% of fleets indicated that their maintenance costs/workload stayed the same, 29% of respondents indicated that they increased (Figure 11).



Q: On average, how has the installation of one or more fuel-saving devices for trailers impacted your company's annual vehicle maintenance costs or workload?

Figure 11. The impact of fuel-saving devices on a fleet's maintenance costs

Individuals noted during the working group sessions that it is expected that any device added to a trailer will result in additional maintenance costs, whether it's lubrication or cleaning requirements, salt or calcium chloride build-up, or repairing damaged parts or software. Though, some devices require more maintenance than others. For instance, several fleet operators in the working group meetings reported that side skirts have very little maintenance requirements, which is in line with what's been reported in past

studies.[45,46] On the other hand, fleet operators reported notable maintenance costs associated with tire pressure monitoring and inflation systems stemming from software issues, as well as with boat tails as a result of drivers forgetting that they were deployed when backing up into loading docks. Previous studies have also reported maintenance issues with wide base single tires.[47]

It was also reported, however, that some devices may lead to a reduction in overall maintenance costs. For example, one fleet reported reduced maintenance requirements stemming from the adoption of tire pressure monitoring and automatic inflation systems. Fleets aren't required to check tire pressure manually, and also prevents unnecessary tire degradation. Moreover, fleets interviewed for a past study reported that the adoption of low rolling resistance tires led to a reduction in maintenance costs which was attributed to smoother driving.[48]

6.5 Telematics systems

6.5.1 Rates of adoption of telematics systems

Telematics systems are rich sources of data for fleets. These devices installed either in the cab of a truck or on a trailer provide valuable insights into a vehicle's operations, such as how much time is spent idling or a driver's average fuel consumption, and they also allow fleets to monitor vehicles for any maintenance requirements, such as tire pressure. The data collected using telematics systems can provide insights into a vehicle's operations and allow fleet managers to point to potential areas of improvement.

Fleets were asked whether or not they had installed telematics systems on their trailers and/or tractors. Over 80% of fleets indicated that they have installed telematics systems on their tractors, while only 35% of fleets indicated that they have installed them on their trailers. Nearly all of the fleets that have installed telematics systems on their

[45] "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the Canadian On-Road Freight Sector," 16.

[46] "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the North American On-Road Freight Sector," 8.

[47] "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the North American On-Road Freight Sector,", 16.

[48] "Costs and Adoption Rates of Fuel-Saving Technologies for Trailers in the Canadian On-Road Freight Sector," 18.

trailers have also installed them on their tractors. Less than 20% of respondents have not installed telematics systems.

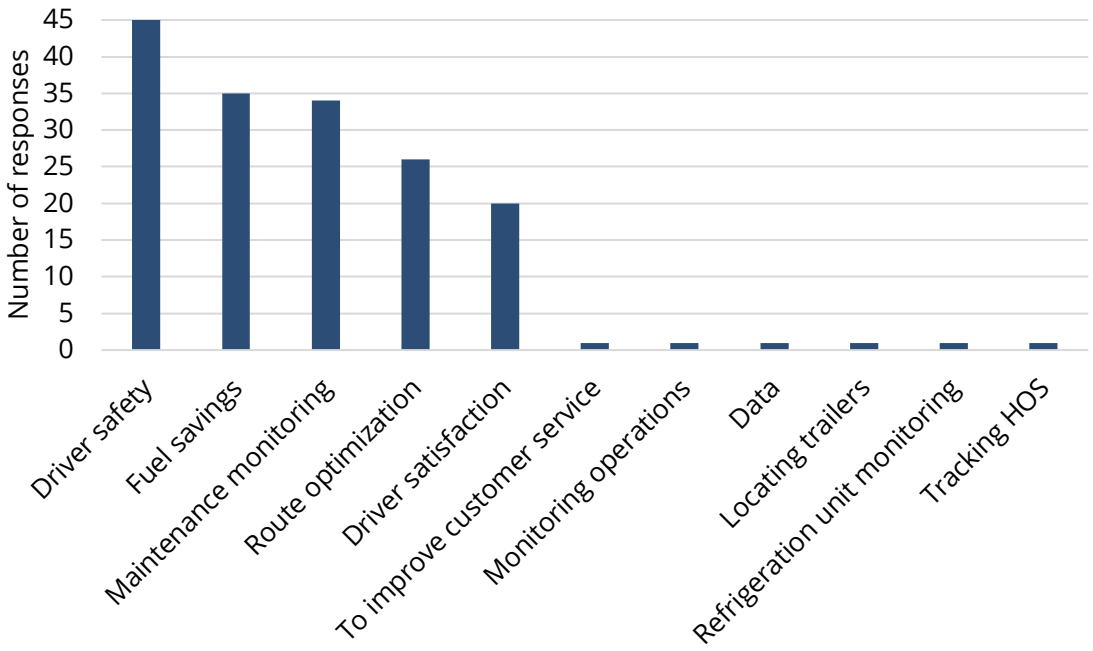
Higher rates of adoption of telematics systems were reported by large fleets with over 500 trailers (95% adoption rate) versus medium-sized fleets with 100-499 trailers (86%) and small fleets with 5-99 trailers (68%). As telematics systems can help fleets identify the location of their trailers, its expected that these devices would be especially beneficial for companies with large trailer fleets.

6.5.2 Benefits of telematics systems

The data collected using telematics devices can provide fleets with a wide range of benefits. In the survey, fleets were asked which benefits they've experienced as a result of installing telematic systems. They were provided with the following list of benefits, but were also given the option to add in their own response:

- Fuel savings
- Maintenance monitoring
- Driver safety
- Driver satisfaction
- Route optimization

The most common response was driver safety, followed by fuel savings and maintenance monitoring (see Figure 12). In addition to the benefits we listed, fleets also noted that telematic systems are a means to improve customer service, monitor operations, collect data, locate trailers, monitor refrigeration units, and track hours of service (HOS) data for their drivers.



Q: What benefits have you experienced as a result of installing telematics systems?

Figure 12. Benefits of telematics systems

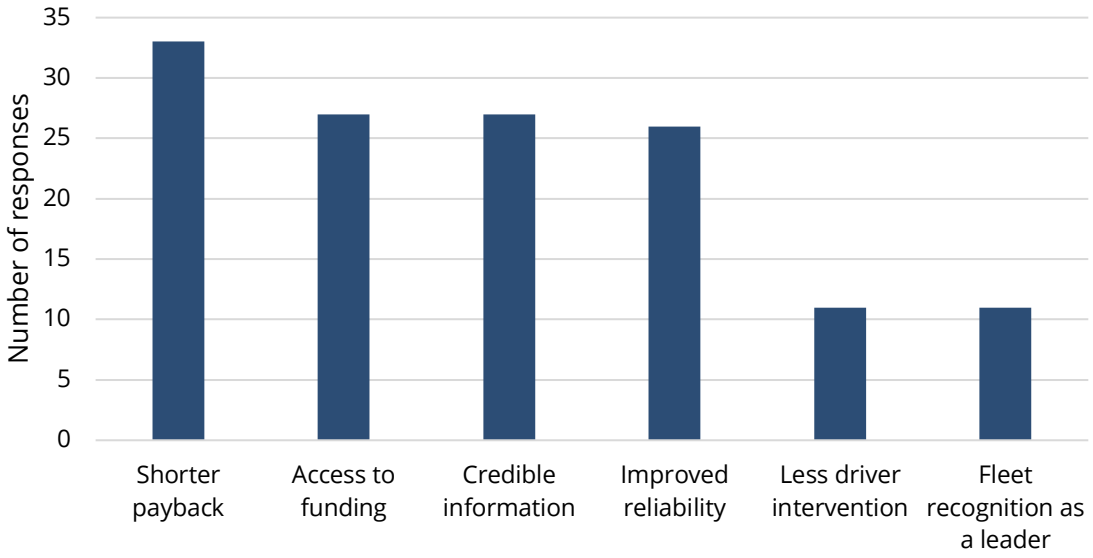
During the working group meetings with fleet operators, it was noted that telematics systems and other on-board devices are critical to fuel management, as these devices provide insights into a drivers' behaviour. It was noted that proper driver training is key to fuel efficiency improvements, as a bad driver can override the efficiency gains stemming from installed fuel-saving devices. It's expected that fuel-efficient driver training can lead to fuel savings of up to 35%.[49]

[49] NRCan, "SmartDriver Training Series," 2019. https://www.nrcan.gc.ca/energy-efficiency/energyefficiency-transportation/greening-freight-programs/smartdriver-training-series/21048

7. Promoting future adoption

Through this study, fleets were asked to comment on what would encourage them to purchase additional fuel-saving devices for trailers in the future to maximize the potential for fuel savings and GHG emission reductions. Study participants identified several factors to improve adoption that are consistent with the literature but also present new insights.[50] Fleet operators desire a shorter payback period, access to funding, improved technology reliability, credible information, technologies that requires less driver intervention, and recognition in the industry for its fuel efficiency efforts.

When asked about the most critical factor to improve uptake, the most popular response from fleet operators was a shorter payback period, followed by access to funding, credible information and improved reliability (see Figure 13).



Q: What would make you want to buy more (or any) fuel-saving devices for trailers?

Figure 13. Factors to promote trailer fuel-saving device adoption

[50] "Barriers to the Increased Adoption of Fuel Efficiency Technologies in the North American On-Road Freight Sector"

7.1 Regulation and policy

Regulation and policy play a key role in driving adoption. One fleet operator noted that the California Air Resources Board (CARB) could spark greater adoption of trailer fuel-saving devices for fleets that travel to the U.S., presumably as a result of more stringent regulations.

When examining the adoption trends of trailer fuel-saving devices over the past 15-years, using data from NACFE's Data and Benchmarking tool (Figure 14), there is evidence that regulations and the availability and accessibility of credible industry information on efficacy of technologies are major influences. Key regulations for heavy-duty vehicle emissions include the California's Tractor-Trailer Greenhouse Gas Regulation, the United States' Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines (Phases 1 and 2), and Canada's Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations (Phases 1 and 2).

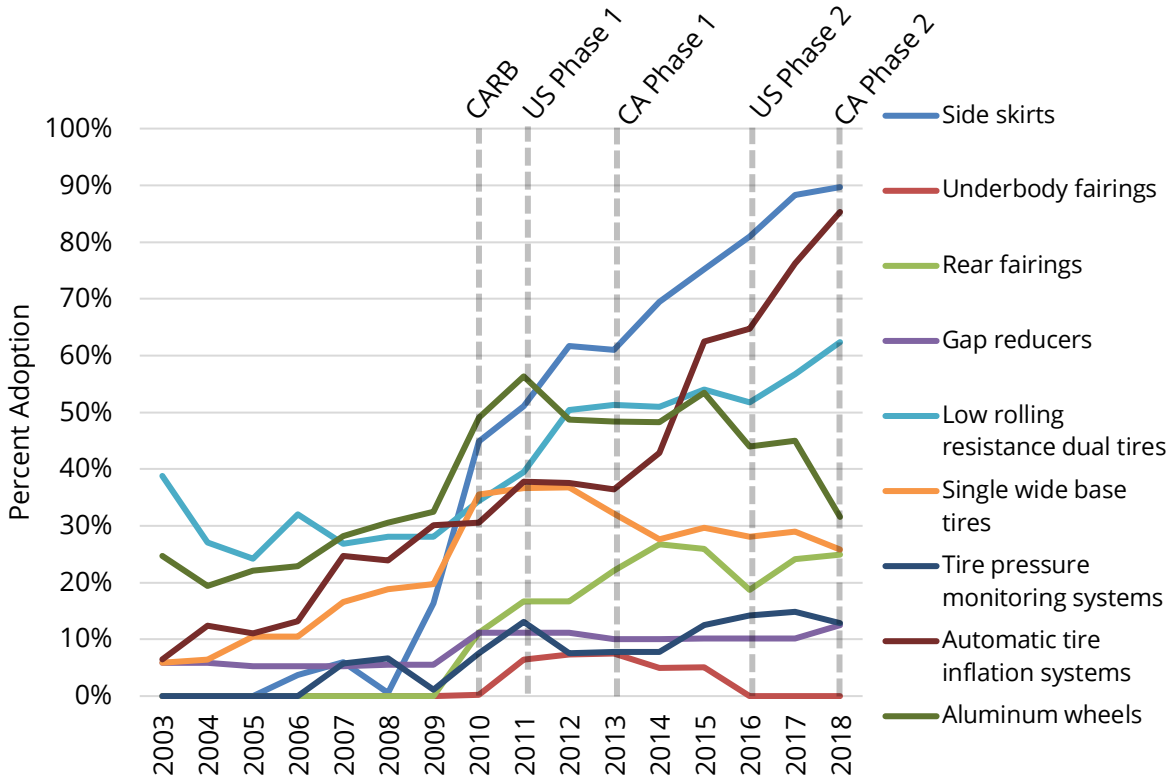


Figure 14. Trailer fuel-saving device adoption in North America between 2003 and 2018.[51]

[51] *NACFE Data and Benchmark Tool*

The particularly sharp increases in rates of adoption of fuel-saving devices between 2008 and 2010 coincided with the CARB's 2008 announcement and 2010 enforcement date of the Tractor-Trailer Greenhouse Gas Regulation. Meanwhile, between 2013 and 2018, there was another sharp rise in rates of adoption, which coincided with the introduction of Canada's Phase 1 Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Standards and the United States' Phase 2 Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines. The introduction of regulations coincided with a considerable increase in the uptake of trailer fuel-saving devices.

7.2 Real world testing

Nearly half of the survey respondents noted that "credible information" would help spark greater adoption of fuel-saving devices for trailers. Working group participants were asked to elaborate on what information is lacking and what it means to be "credible". Several participants noted that real world testing of technologies is important to prove reliability and quantify associated costs and benefits. However, it isn't necessarily credible sources of information that are lacking, but rather it is a lack of applicable information (e.g. related to Canadian climate variability). Where and how a technology is used can have a large impact on its costs and benefits.

To improve the accessibility of credible and applicable information, several Canadian fleets have become members of the PIT group at FP Innovations, which tests technologies that can help improve fuel efficiency in the transportation sector.[52] Members play a key role in the deciding which technologies are tested and under what conditions. It is, however, a paid membership, and so the cost to join can be prohibitive for smaller fleets.

The results of testing performed by the PIT group have been very influential. For instance, in 2013, the group released a report that cited low levels of fuel savings from underbody fairings.[53] The publication of their findings aligns with a dip in the rates of adoption of underbody fairings (see Figure 13).

[52] "PIT Group". https://thepitgroup.com/

[53] Truck News, "Do Trailer Fairings Really Save Fuel?" October 1, 2013. https://www.trucknews.com/features/do-trailer-fairings-really-save-fuel/

7.3 Accounting for harsh environmental conditions

In particular, there is a need to account for local environmental conditions when considering the adoption of fuel-saving devices for trailers. Many fuel-saving devices are tested or made popular in southern climates and regions (e.g. southwestern United States), and so they tend to be especially well-suited for these for those operating conditions. It is assumed that these technologies will be viable for use in other regions, but this isn't always the case. The environment in Canada can impact the effectiveness or suitability of certain fuel-saving devices for trailers. For example, it was noted in the working group meetings that extreme cold temperatures can impact the accuracy of tire pressure monitoring systems. Similarly, low rolling resistance tires can be impacted by the harsh environmental conditions in Canada. Drivers have reported a lack of traction when using low rolling resistance tires on unmaintained roads, or in mountainous regions.

7.4 Preference for tractor fuel-saving devices

Some fleet operators have a preference for fuel-saving devices on tractors as opposed to trailers, as the potential for fuel savings was reported by some to be greater on the tractor than on the trailer. As a result of this, some fleet operators expect that they will see a faster return on investment for tractor fuel-saving devices. It was noted in the working group meetings that in part, this is due to the larger fuel savings that may be achieved. It was also reported that this may be due to the fact that tractors often have a higher utilization rate in comparison to trailers, as demonstrated by the vast majority of fleets owning more than one trailer for every tractor.

8. Conclusion

This research has served to better understand trends, viewpoints and experiences in the adoption of trailer fuel-saving devices among Canadian fleets. Several of the key findings, including trends in rates of adoption, are consistent with those that have been identified in past studies. Fleets in Canada continue to exhibit a preference for side skirts and low rolling resistance dual tires. Though not examined as broadly in past studies on trailer fuel-saving devices, lightweight components have also emerged as a popular technology, as they may reduce fuel consumption considerably and/or allow fleets to maximize their payload capacity. Meanwhile, underbody fairings, rear fairings, gap reducers and wide base single tires continue to be the least popular options.

This study did not yield definite conclusions about fuel savings realized by fleets, average payback periods and operations and maintenance costs of trailer fuel-saving devices. While most fleets reported fuel savings in the range of 1-2% for each of the devices, it was also noted in working group meetings that assigning fuel savings can be challenging, as it can be difficult to isolate the impact of a single device. Survey results showed that there is very little consensus on the average payback period of each fuel-saving device, which is expected given the diversity of the trucking sector in Canada. For instance, fleets travelling longer distances consuming more fuel will experience a faster payback period than those who travel shorter distances and use less fuel. Lastly, while the greatest share of fleet survey respondents noted that fuel-saving devices have little to no impact on their maintenance costs or workload, a considerable share of respondents noted that they expect fuel-saving devices to increase their maintenance requirements. It is, however, expected that these requirements will vary from one device to another – while devices like side skirts are associated with negligible maintenance requirements, devices tire pressure monitoring and automatic inflation systems were reported as requiring higher levels of maintenance.

Telematics systems appear to be a promising technology to understand and optimize the operations of heavy-duty vehicle fleets in Canada. A wide range in benefits were reported by fleet survey respondents, including driver safety, maintenance monitoring, and most notably, fuel savings. Telematics systems can help fleets track their fuel consumption and identify opportunities for fuel savings. While the vast majority of fleets surveyed have installed telematics systems in their tractors, just over a third have installed them on their trailers.

Further interventions are required to promote greater adoption of fuel-saving devices for trailers in Canada. While for some fleets this includes greater access to funding, a shorter payback period, or improved reliability of the technologies, for others, this includes access to more credible information. It was noted by several fleets that many of the technologies are not being tested in conditions that reflect the real-world operating conditions in Canada. For many fleets, it is critical that they have access to credible information that is applicable to their operations.

Fuel-saving devices for trailers have a role to play in the decarbonization of Canada's on-road freight sector, but the applicability of technology and the potential benefits will vary from fleet to fleet. Different technologies and combinations thereof can lead to a wide range in fuel savings and payback periods depending on the specific operating conditions.

Historic data shows that certain trailer fuel-saving devices have experienced notable increases in rates of adoption alongside the introduction of GHG emission standards.[54] Regulations that promote the adoption of fuel-saving devices are critical tools for achieving GHG emission reductions from trailers, but it is important that future regulations reflect the specific needs of various segments of Canada's on-road freight sector, such as an adequate distance between the tractor and trailer for refrigerated box vans. The flexibility of performance-based standards allows fleets and manufacturers to adopt the technologies that work best for them.

While trailer fuel-saving devices can help deliver incremental gains in fuel efficiency in the near- to mid-term, an eye towards long-term transformational solutions, such as near-zero and zero-emission vehicles is also needed to ensure Canada is on track to meeting its climate targets. Fuel-saving devices will continue to play a role in improving the efficiency of heavy-duty trucking in Canada, even as it transitions to technologies like battery electric or hydrogen fuel cell vehicles.

[54] *NACFE Data and Benchmark Tool*

Appendix A. Surveys

Fleet survey: Trailer fuel-saving devices

Survey background

The Pembina Institute is undertaking a study for Environment and Climate Change Canada to better understand the current costs, benefits and rates of adoption of fuel-saving devices for trailers within Canada's heavy-duty vehicle sector.

The survey should take approximately **10 minutes** to complete. A fleet manager would be best suited to respond to this survey.

Survey responses will be reported on anonymously.

Please submit your response by **Friday, December 18, 2020.**

For more information, contact Maddy Ewing, Pembina Institute at maddye@pembina.org or (647) 478-9563 x 241.

Thank you very much for your time!

Company information

1. Your name:

2. Your email:

3. Your company's name:

4. Location of company headquarters:

5. Type of trucking fleet:

   ☐ For-hire ☐ Private ☐ Owner-operator

6. Number of **tractors** in your fleet: _____

a. Number of **trailers** in your fleet: _____

☐ 1-4 ☐ 5-99 ☐ 100-499 ☐ 500+

b. **Ratio** of tractors-to-trailers in your fleet:

☐ 1:1	☐ 1:2	☐ 1:3	☐ 1:4	☐ 1:4	☐ 1:5	☐ 1:6+	☐ Not sure

7. Types of trailers in your trucking fleet (select all that apply):

☐ Dry box van ☐ Refrigerated box van ☐ Flatbed

☐ Container chassis ☐ Grain ☐ Dump

☐ Tanker ☐ Lowbed ☐ Other: ____

8. Commodity types transported by your fleet (select all that apply):

☐ Agriculture ☐ Automobiles ☐ Base metals ☐ Food

☐ Forest products ☐ Fuel oils ☐ Minerals ☐ Plastic & chemicals

☐ Waste & scrap ☐ Other manufactured goods ☐ Miscellaneous products ☐ Other: ____

9. Length of haul that makes up the **majority** of your operations:

☐ Regional haul (i.e. travel within 500 km from base)

☐ Long haul (i.e. travel > 500 km from base)

☐ Other: ____

10. Region(s) of operation in Canada (select all that apply):

☐ Atlantic ☐ Quebec ☐ Ontario

☐ Prairies ☐ British Columbia ☐ Territories

Your fleet's experience with fuel-saving devices for trailers

11. Please indicate approximately what percentage of your company's **trailers** are equipped with the following fuel-saving devices:

Side skirts	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Underbody fairings	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Rear fairings (e.g. boat tails)	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Gap reducers (e.g. nose cones)	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Low rolling resistance dual tires	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Wide base single tires	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Lightweight components (e.g. aluminum wheels)	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Tire pressure monitoring	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Automatic tire inflation	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Other: ____	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure

12. Please indicate what percentage **fuel savings** you have experienced as a result of installing each of the following devices on your trailers:

Side skirts	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Underbody fairings	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Rear fairings	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Gap reducers	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Low rolling resistance dual tires	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Wide base single tires	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure

Lightweight components	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Tire pressure monitoring	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Automatic tire inflation	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Other: ____	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure

13. Which of the following factors influenced your company's decision to adopt fuel-saving devices for trailers? Select all that apply:

    ☐ Fuel savings ☐ Competitive advantage ☐ GHG emission reductions

    ☐ Environmental goals ☐ Other: ____

14. Please indicate your company's estimated **payback** period for each of the devices you have installed on your trailers (in years):

Side skirts	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Underbody fairings	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Rear fairings	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Gap reducers	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Low rolling resistance dual tires	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Wide base single tires	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Lightweight components	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Tire pressure monitoring	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Automatic tire inflation	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Other: ____	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure

15. On average, how has the installation of one or more fuel-saving devices for trailers impacted your company's annual vehicle **maintenance** costs or workload?

☐ Increased ☐ Stayed the same ☐ Decreased ☐ Not sure

16. Has your company installed **telematics** systems?

☐ Yes, trailers ☐ Yes, tractors ☐ No

17. **If yes**, what benefits have you experienced as a result of installing telematics systems? Select all that apply:

☐ Fuel savings ☐ Maintenance monitoring ☐ Driver safety

☐ Driver satisfaction ☐ Route optimization ☐ Other: _____

18. What are the most critical factor(s) to accelerate adoption of fuel-saving devices for trailers? **Select up to three**:

☐ Shorter payback ☐ Access to funding ☐ Improved reliability

☐ Credible information ☐ Less driver intervention ☐ Fleet recognition as a leader

☐ Other: ____

19. Would you like to participate in a follow-up interview? ☐ Yes ☐ No

Trailer manufacturer survey: Trailer fuel-saving devices

Survey background

The Pembina Institute is undertaking a study for Environment and Climate Change Canada to better understand the current costs, benefits and rates of adoption of fuel-saving devices for trailers within Canada's heavy-duty vehicle sector.

The survey should take approximately **10 minutes** to complete.

Survey responses will be reported on anonymously.

Please submit your response by **Friday, December 18, 2020.**

For more information, contact Maddy Ewing, Pembina Institute at maddye@pembina.org or (647) 478-9563 x 241.

Thank you very much for your time!

Company information

This first set of questions will provide us with some insights into your company and allow us to determine what trailer segments you are supplying.

1. Your name:
2. Your email:
3. Your company's name:
4. Location of company headquarters:
5. Types of trailers that your company manufactures (select all that apply):

☐ Dry box van	☐ Refrigerated box van	☐ Flatbed
☐ Container chassis	☐ Grain	☐ Dump
☐ Tanker	☐ Lowbed	☐ Other: ____

6. Region(s) of sales in Canada (select all that apply):

☐ Atlantic ☐ Quebec ☐ Ontario

☐ Prairies ☐ British Columbia ☐ Territories

Your company's experience supplying fuel-saving devices for trailers

7. Approximately what percentage of the **trailers** that your company sells are equipped with the following fuel-saving devices? Only answer for the technologies that you are familiar with.

Side skirts	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Underbody fairings	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Rear fairings (e.g. boat tails)	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Gap reducers (e.g. nose cones)	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Low rolling resistance dual tires	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Wide base single tires	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Lightweight components (e.g. aluminum wheels)	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Tire pressure monitoring	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Automatic tire inflation	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure
Other: ____	☐ None	☐ <25%	☐ 25-50%	☐ 50-75%	☐ >75%	☐ Not sure

8. Approximately what percentage **fuel savings** is each of the following devices expected to lead to? Only answer for the technologies that you are familiar with.

Side skirts	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Underbody fairings	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Rear fairings	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Gap reducers	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Low rolling resistance dual tires	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Wide base single tires	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Lightweight components	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Tire pressure monitoring	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Automatic tire inflation	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure
Other: ____	☐ None	☐ 1-2%	☐ 3-4%	☐ 5-6%	☐ 7-8%	☐ 9-10%	☐ Not sure

9. From the perspective of a trucking fleet, which of the following factors do you expect influences a company's decision to adopt fuel-saving devices? Select all that apply:

   ☐ Fuel savings ☐ Competitive advantage ☐ GHG emission reductions

   ☐ Environmental goals ☐ Other: ____

10. What do you expect to be the average **payback** period for each of the following fuel-saving devices for trailers (in years)? Only answer for the technologies that you are familiar with.

Side skirts	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Underbody fairings	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure

Rear fairings	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Gap reducers	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Low rolling resistance dual tires	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Wide base single tires	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Lightweight components	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Tire pressure monitoring	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Automatic tire inflation	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure
Other: ____	☐ <1	☐ 1-2	☐ 3-4	☐ 5+	☐ Never	☐ Not sure

11. How do you expect the installation of fuel-saving devices to impact a fleet's **maintenance** costs or workload?

    ☐ Increase ☐ Stay the same ☐ Decrease ☐ Not sure

12. Do you expect the use of **telematics** systems to lead to fuel savings?

    ☐ Yes ☐ No ☐ Not sure

13. What needs to change for trucking companies to adopt more (or any) fuel-saving devices? **Select up to three**:

    ☐ Shorter payback ☐ Access to funding ☐ Improved reliability

    ☐ Credible information ☐ Less driver intervention ☐ Fleet recognition as a leader

    ☐ Other: ____

14. Would you like to participate in a follow-up interview? ☐ Yes ☐ No

Appendix B. Overview of fleet survey respondents

Location of headquarters

We obtained responses from fleets headquartered in every major Canadian region, except the territories. The highest number of responses came from fleets with headquarters in Ontario (42%), and the fewest number of responses from fleets in Quebec (5%) (Figure 15).

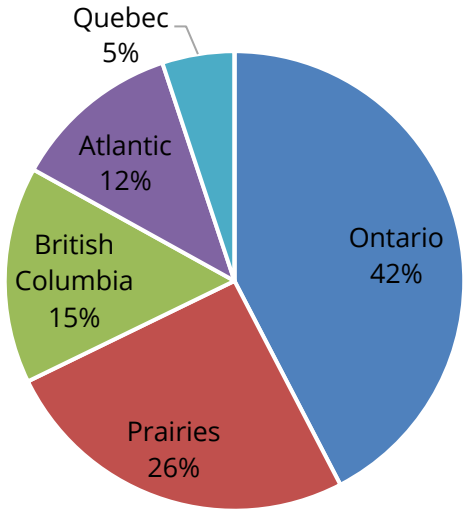


Figure 15. Percentage of survey respondents by headquarter location (n=60)

Regions of operations

Survey respondents were asked to identify their region(s) of operation in Canada. The most common region of operation was Ontario, followed by Quebec and the Prairies (see Figure 16). The least common region was the Atlantic provinces.

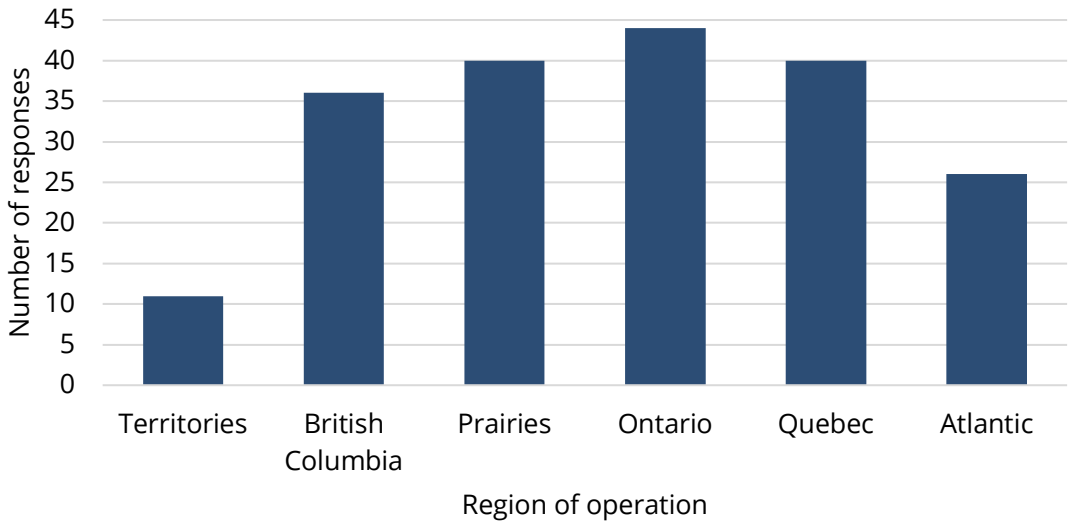


Figure 16. Number of survey responses by region of operation (n=60)

Type of fleet

Survey respondents were asked to identify whether their fleet was best described as for-hire, private or owner-operator. For-hire fleets represented the vast majority of survey respondents (Figure 17).

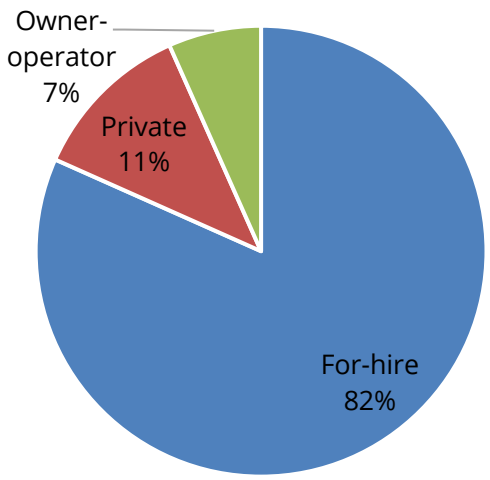


Figure 17. Percentage of survey respondents by fleet type (n=60)

Trailer fleet size

Survey respondents were asked to identify which of the following three ranges of trailer fleet sizes they belonged to:

- 0-4 trailers
- 5-99 trailers
- 100-499 trailers
- 500+ trailers

There was a fairly even distribution of trailer fleet sizes among the survey respondents (Figure 18). However, none of the fleets owned fewer than 4 trailers.

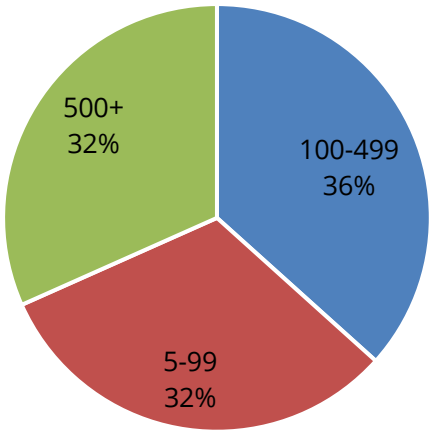


Figure 18. Percentage of respondents by trailer fleet size (n=60)

Survey respondents were also asked to identify their fleet's tractor-trailer ratio. The highest percentage of respondents (40%) have a tractor-trailer ratio of one tractor for every two trailers (1:2), followed by a quarter of respondents that own one tractor for every three trailers (1:3) (Figure 19).

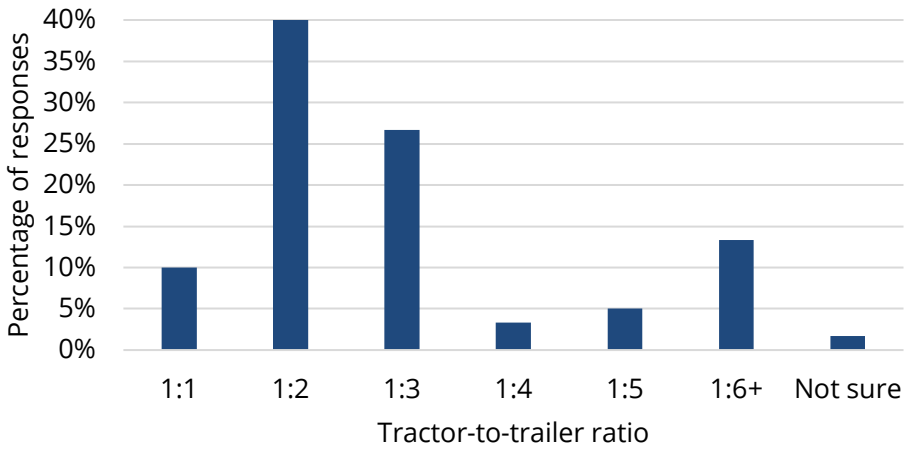


Figure 19. Percentage of respondents by tractor-trailer ratio (n=60)

Trailer types

Survey respondents were asked to identify what trailer types make up their fleet. The most common trailer type across all survey respondents was a dry box van (Figure 20). Out of the 60 fleets that responded, 41 indicated that dry box vans made up at least a portion of their fleet. Refrigerated box vans were the second most common trailer type and were found in just over half of the fleets that responded. Flatbeds were the most common non-box van and were found in one third of the fleets.

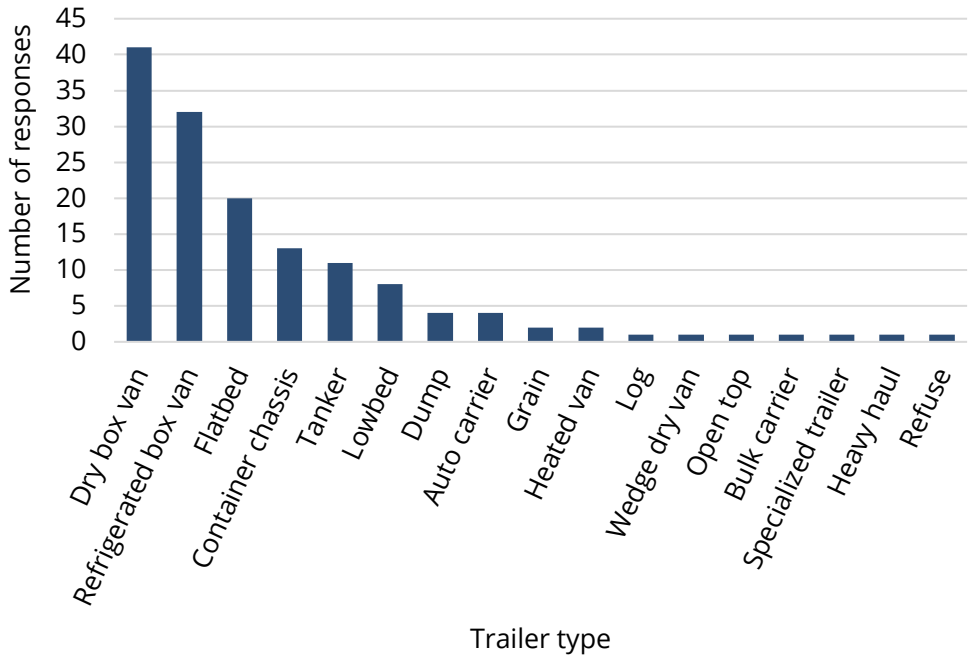


Figure 20. Number of survey responses by trailer type (n=60)

Commodity types transported

Survey respondents were asked to identify the commodity types transported by their fleet. Categories of commodity types found in the Canadian Freight Analysis Framework were used.[55] Nearly two thirds of the fleets identified food as one of their primary markets, while manufactured goods were the second most common (Figure 21). Fuel oils and minerals were the least common commodity types transported.

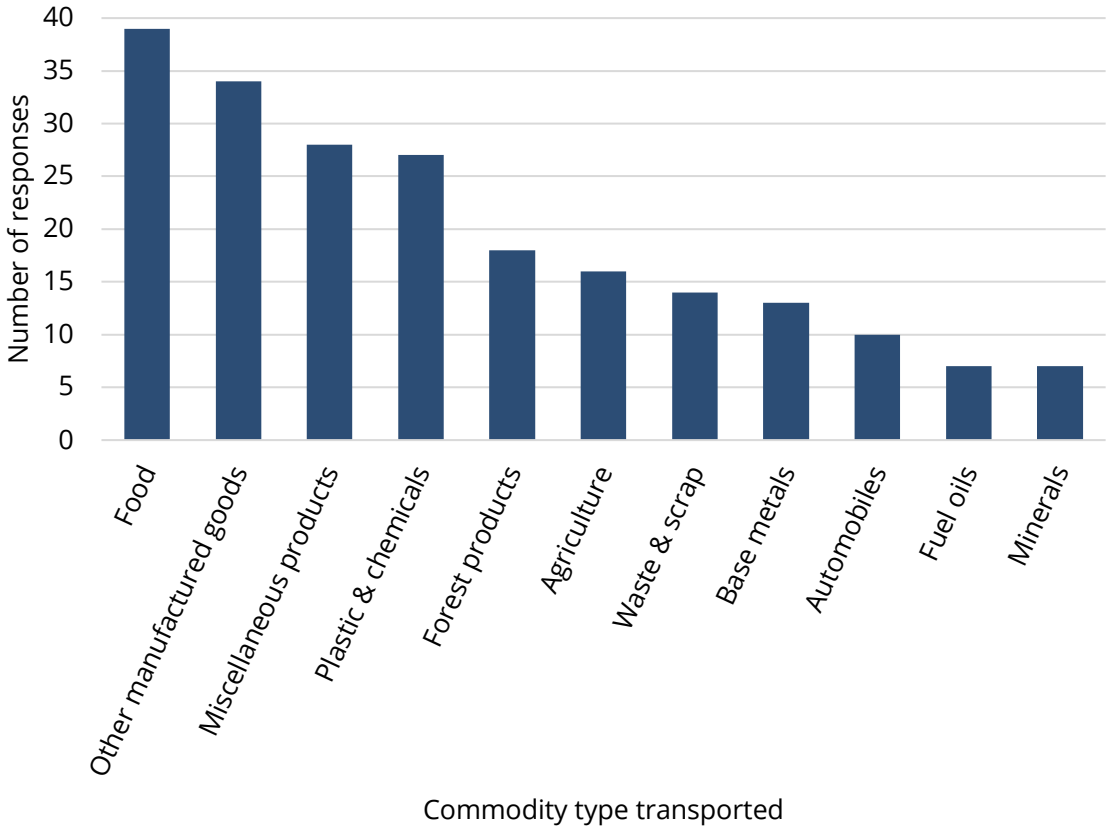


Figure 21. Number of survey responses by commodity type transported (n=60)

[55] Statistics Canada, *Canadian Freight Analysis Framework* (2020). https://www150.statcan.gc.ca/n1/pub/50-503-x/50-503-x2018001-eng.htm

Length of haul

Survey respondents were asked to identify the length of haul that made up the majority of their trips. Regional haul trips were considered those where fleets travelled 500 km or less from their home base, while long haul trips were considered those that went 500 km or longer. There was a fairly even split of respondents who belonged to each segment (Figure 22).

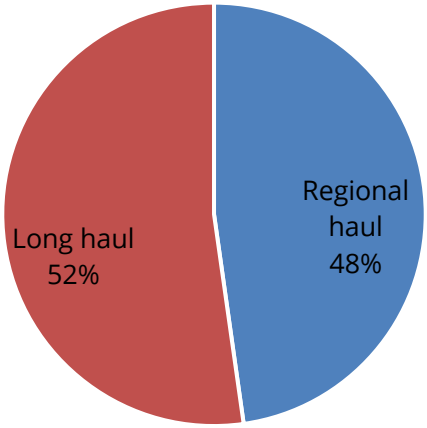


Figure 22. Percentage of survey responses based on typical length of haul (n=60)