INFO SHEET GRAPHIC

TURKSTRA CHAIR IN URBAN ENGINEERING

UNIVERSITY OF WATERLOO
FACULTY OF ENGINEERING
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# STATUS ON SUSTAINABILITY | TRANSPORTATION

Sustainable transportation, as a concept, refers to the development and use of transport modes, infrastructures, and operations that are low- or zero-emission, energy-efficient, and affordable. This includes the use of electric and alternative-fuel vehicles, as well as domestically-sourced fuels, all of which are integral for achieving sustainable transport systems (Energy.Gov, ; Rodrigue, 2020).

## TRENDS IN TRANSPORTATION

### GLOBAL TRENDS

TRANSPORTATION TYPES:

- Road transport vehicles, such as cars, trucks, vans, and motorcycles, primarily dominate passenger transportation. In the US, approximately 87% of passenger miles travelled in 2020 were by automobile and light truck road transport (CSS, 2022).
- Passenger cars are the leading mode of inland transport. The impact of COVID-19 led to an increase in passenger car usage. In the EU, the share of passenger cars in transport grew from 83.1% in 2019 to 87.2% in 2020 (Eurostat, 2022).
- About 80% of global goods trade is transported by sea, with the figure rising in many developing countries (UNCTAD, 2022).

FUEL TYPES:

- The major transportation energy sources in the U.S. are petroleum products, biofuels, natural gas, and electricity from various sources (EIA, 2023).

Table 1. Fuel Type (EIA, 2023; IMO, 2020; MacArthur & Cherry, 2017; U.S. Department of Energy, 2023)

**Fuel Types for Different Modes of Transportations**

| | | |
|---|---|---|
| Petroleum | Gasoline (Petrol) | Road |
| | Diesel | Road, Rail and Public |
| | Jet Fuel | Air |
| | Heavy Fuel Oil (HFO) | Marine |
| | Marine Diesel Oil (MDO) | Marine |
| Biofuels | Ethanol/Biodiesel | Road |
| | Sustainable Aviation Fuels (SAFs) | Air |
| Natural Gas | Compressed Natural Gas (CNG) | Road and Public |
| | Liquefied Petroleum Gas (LPG) | Road and Public |
| | Liquefied Natural Gas (LNG) | Marine |
| Electricity | From different sources | Road, Rail. Marine, Public and Non-motorized |
| Others | Hydrogen | Road |
| | Human Power | Non-motorized |

### TRENDS IN CANADA

- In Canada, road transport serves as the predominant mode for both freight and passenger movement, underscored by the registration of nearly 25 million road vehicles (Transport Canada, 2021a).
- Canada has 41,465 route-kilometres of railway track, and in 2018 moved 330 million tonnes of freight and 4.8 million intercity passengers (Transport Canada, 2021a).
- In Canadian waters, there are 42,000 active commercial vessels and 20,000 pleasure crafts, with 550 ports handling 340 million tonnes of cargo, 43% of which goes through the Port of Vancouver (Transport Canada, 2021a).
- Canada is the world's third-largest aviation market by area, managing 18 million square kilometers of airspace. As of 2018 Canada hosts over 1,400 air carriers and 37,000 registered aircrafts that facilitate 156 million passengers and generates $25.5 billion in annual revenue. (Transport Canada, 2021a).
- In June 2023, Canada's urban public transit systems logged nearly 120 million trips, reaching 78.8% of pre-pandemic ridership levels, a significant indicator of public health recovery, economic revitalization, and renewed public confidence in mass transit (Statistics Canada, 2023).

### TRENDS IN ONTARIO, CA

- Ontario together with Québec, Saskatchewan, and Alberta comprise over 75% of Canada's total road length (Transport Canada, 2020).
- Ontario has over 250,000 km of roads, including a network of 400-series highways which are some of the busiest in Canada (Ontario, 2022).
- In 2022, Ontario's Port of Toronto moved over 2 million metric tonnes of cargo, underlining its key role in Canada's national supply chain (Ports Toronto, 2023).
- In 2022, Toronto Pearson Airport's passenger traffic rose 180.8% from 2021, reaching 70.5% of pre-COVID levels and generating a net income of $72.3 million (GTAA, 2022).
- Ontario's major land border crossings (eg., Windsor, Sarnia, Fort Eerie) are major economic connections to the US which is Canada's largest trade partner (Shahraki & Bachmann, 2019a).
- The Ambassador Bridge (Windsor, ON) alone is responsible for more than 50% of the trade from Canada to the US (Shahraki & Bachmann, 2019b).

### TRENDS IN WATERLOO, ON

- In Waterloo Region, the TravelWise program partners with organizations to promote sustainable commuting, reporting approximately 47% solo driving, 31% remote work, 7% transit, 4% carpooling, and 10% biking or walking (Waterloo Region, 2022).
- In Waterloo Region, Statistics Canada reports 87.7% of commuters use a car, truck, or van, while 5.9% take public transit (Statistics Canada, 2020). 6.4% is other modes.
- In 2021, the Region of Waterloo International Airport ranked as Canada's 6th busiest airport with 133,293 aircraft movements and saw a record-breaking 245% increase from 2019 in passenger traffic to 171,828, largely due to Flair Airlines' operations (Statistics Canada, 2022; YKF, 2022).
- Waterloo Region is landlocked; nearest relevant maritime port is Hamilton.

### UNIVERSITY OF WATERLOO RESEARCH

Research at the University of Waterloo (University of Waterloo, 2023a; University of Waterloo, 2023b) include:

- Centre for Pavement and Transportation Technology (CPATT) - Sustainable infrastructure, smart materials, and climate impact on transport.
- Innovative Transportation System Solutions (iTSS) Lab-Winter Road care, traffic safety, and vehicle route optimization.
- Transportation Systems Research Group - Planning, design, and management of transport systems.
- Past research includes Waterloo Public Transportation Initiative (WPTI), focuses on public transportation issues.
- Transportation Research for Improving Performance and Safety (WATTRIPS), focuses on traffic detection, travel time analytics, and adaptive signal systems.

## SUSTAINABILITY DIMENSIONS

### ENVIRONMENTAL IMPACT

- The 2019 Canadian Council of Academies report highlighted that three of Canada's top six climate risks are directly tied to transportation: physical infrastructure, coastal regions, and northern communities (Transport Canada, 2021a).
- The transportation sector is Canada's second-largest contributor to GHG emissions, making up about 25%, primarily from on-road vehicles (Transport Canada, 2021a).

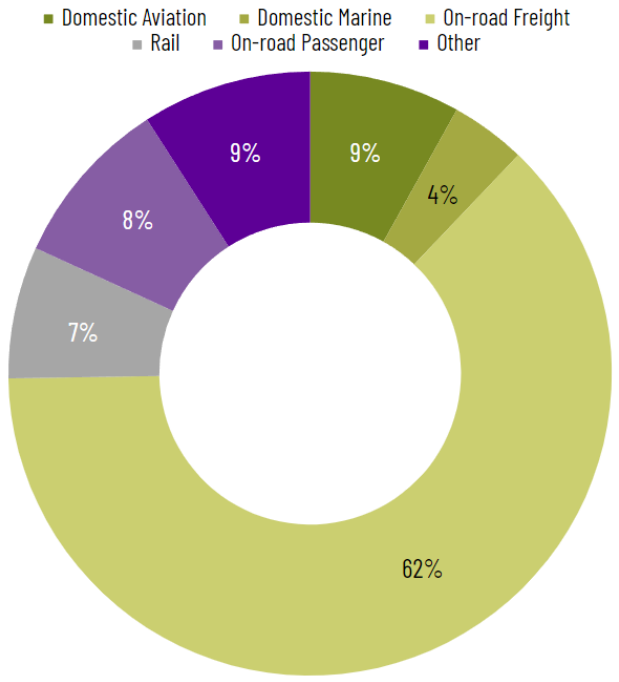


Figure 1. Distribution of Transportation GHG Emissions by Mode in 2019 (Transport Canada, 2021a; Transport Canada, 2021b)

- Waterloo Region aims to cut greenhouse gas emissions by 80% by 2050, focusing on active transportation and public transit, with all remaining vehicles being zero-emissions (Waterloo Region, 2022).

### ECONOMIC IMPACT

- In 2021, Canada's transportation and warehousing sector contributed 3.6% to the total gross domestic product (GDP) and employed over 5.2% of the workforce, with trucking being the dominant mode for domestic freight, accounting for 77.7% of volume on roads (Fan & Heminthavong, 2022).

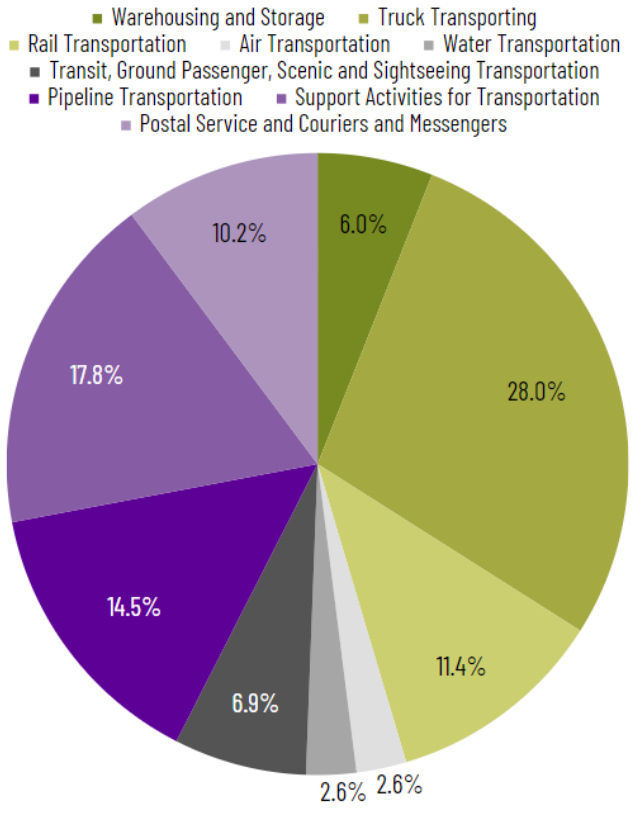


Figure 2. Distribution of the Transportation and Warehousing Sector's 3.6% Share of Canada's GDP (Fan & Heminthavong, 2022)

- In terms of household expenditures, transportation ranks as the second most significant outlay, following shelter, constituting 16% of the total financial allocation (Transport Canada, 2021a).

## SOCIAL IMPACT

- The trucking industry, crucial to 3.6% of Canada's workforce, is grappling with challenges like an aging workforce (32% over 55) and low gender diversity (only 3.5% women drivers) (Fan & Heminthavong, 2022).
- Issues in the trucking industry not only affect the transportation sector but also have broader social and economic implications for Canada (Fan & Heminthavong, 2022).

## RELEVANCE TO UNITED NATIONS SUSTAINABLE DEVELOPMENT GOAL (UN SDG)

### 3 GOOD HEALTH AND WELL-BEING

3.6: Halving global deaths and injuries from road traffic accidents can be directly impacted by safer, smarter transportation systems

### 7 AFFORDABLE AND CLEAN ENERGY

7.3: Doubling the rate of energy efficiency improvements is directly related to energy-efficient transportation modes

### 9 INDUSTRY, INNOVATION, AND INFRASTRUCTURE

9.1: Developing sustainable, resilient infrastructure, including transport systems

### 11 SUSTAINABLE CITIES AND COMMUNITIES

11.2: Providing safe, affordable, accessible, and sustainable transport systems for all

### 12 RESPONSIBLE CONSUMPTION AND PRODUCTION

12.c: Reducing fossil fuel subsidies can influence public transportation to shift towards more sustainable options

### 13 CLIMATE ACTION

13.2: Integrating climate change into policies can include transformation in the transportation sector to reduce emissions

### 17 PARTNERSHIPS WITH THE GOALS

17.16: Enhancing multi-stakeholder partnerships can include collaborations to make transportation more sustainable. (United Nations, 2023)

# TOWARDS SUSTAINABILITY

## INNOVATIONS IN PRACTICE

Emerging technologies in AI and automation are transforming Canadian transportation, enhancing efficiency and safety but necessitating regulatory updates for data privacy and congestion (Transport Canada, 2021a; Transport Canada, 2021c). The following trends emerge:

- Connectivity and Data Analytics: Utilizes the Internet of Things for infrastructure efficiency, employs cloud logistics in supply chain management, and leverages advanced analytics for data-driven decision-making.
- Automation and Robotics: Incorporates automated vehicles to address urban challenges and utilizes robotics to optimize freight supply chains.
- Artificial Intelligence and Blockchain: Applies AI for managing transportation demand and supply and uses blockchain to enhance transparency in supply chains.
- Infrastructure and Safety: Employs satellite monitoring for infrastructure health and uses automated inspection systems for rail safety.
- Energy and Environment: Focuses on electric vehicles for reduced emissions and assesses the feasibility of hydrogen locomotives for cleaner rail transport.
- Policy and Regulation: Forms advisory groups and task forces to guide policy on emerging technologies and urban mobility issues.

## POLICY AND REGULATIONS

- Transportation 2030 is Canada's strategic framework for a safer, greener, and more efficient transportation system (Transport Canada, 2019; Transport Canada, 2020).


Figure 3. Transportation 2030 (Transport Canada, 2019; Transport Canada, 2020)

- Vision Zero is a global road safety policy aimed at eliminating traffic fatalities and serious injuries through systematic safety countermeasures, with widespread adoption and ongoing growth in North America and Europe (Kim, Fu, Bachmann & Aminghafouri, 2021).

## FUTURE PROJECTIONS

- The Canadian transportation sector is key to meeting the country's Paris Agreement commitments, specifically targeting a 30% reduction in GHG emissions from 2005 levels by 2030 (Transport Canada, 2021a).
- Canada is advancing towards zero-emission goals in light-duty vehicles, targeting 10% by 2025, 30% by 2030, and 100% by 2040 (Transport Canada, 2021a).


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## REFERENCES


CSS, U. (2022). *Personal transportation factsheet.* (). Michigans, US: Center For Sustainable Systems, University of Michigan. doi:CSS01-07

EIA. (2023). Use of energy explained - energy use for transportation. Verkregen van https://www.eia.gov/energyexplained/use-of-energy/transportation.php

Energy.Gov.Sustainable transportation and fuels. Verkregen van https://www.energy.gov/eere/sustainable-transportation-and-fuels

Eurostat. (2022). *Key figures on european transport.* (). Luxembourg: Eurostat.

Fan, D., & Heminthavong, K. (2022). *Road transportation: Heavyweight of the canadian economy.* (). Ottawa, Canada: Library of Parliament.

GTAA. (2022). *GTAA annual report 2022 – upward, together.* (). Toronto, Canada: Greater Toronto Airports Authority.

IMO. (2020). IMO 2020 – cutting sulphur oxide emissions. Verkregen van https://www.imo.org/en/MediaCentre/HotTopics/Pages/Sulphur-2020.aspx

Kim. T., Fu. L., Bachmann. C., Aminghafouri. R. (2021) Advancing Vision Zero Road Safety With Operational AI and Smart City Data

MacArthur, J., & Cherry, C. (2017). A north american survey of electric bicycle owners. Verkregen van https://nitc.trec.pdx.edu/research/project/1041/A_North_American_Survey_of_Electric_Bicycle_Owners

Ontario. (2022). Ontario road network: Road net element. Verkregen van https://data.ontario.ca/dataset/ontario-road-network-road-net-element

Ports Toronto. (2023). PortsToronto releases 2022 annual report and financial statements. Verkregen van https://www.portstoronto.com/portstoronto/media-room/news/portstoronto-releases-2022-annual-report-and-fina.aspx#:~:text=PortsToronto%20reported%20strong%20operating%20revenues,million%20year%2Dover%2Dyear.

Rodrigue, J. (2020). *The geography of transport systems* (Fofthe Edition ed.). New York: Routledge. doi:rg/10.4324/9780429346323

Shahraki. J., & Bachmann, C. (2019a). Optimizing Canada-U.S. Border Crossing Investments for Export Competitiveness, Transporation Research Record: Journal of the Transportation Research Board, 2673, 3. https://doi.org/10.1177/0361198119834299

Shahraki. J., & Bachmann, C. (2019b). Integrating a Computable General Equilibrium model with empirically calibrated transportation models for border crossing investment analysis, Research in Transportation Economics, 78. https://doi.org/10.1016/j.retrec.2019.100767

Statistics Canada. (2020). Census profile, 2016 census, waterloo, regional municipality . Verkregen van https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page_Figures.cfm?Lang=E&Tab=1&Geo1=CD&Code1=3530&Geo2=PR&Code2=35&SearchText=Waterloo&SearchType=Begins&SearchPR=01&B1=Journey%20to%20work&TABID=1&type=0

Statistics Canada. (2022). Total aircraft movements at the top 10 canadian airports, 2019 to 2021. Verkregen van https://www150.statcan.gc.ca/n1/daily-quotidien/220224/cg-c002-eng.htm

Statistics Canada. (2023). Urban public transit, june 2023. Verkregen van https://www150.statcan.gc.ca/n1/daily-quotidien/230818/dq230818d-eng.htm?indid=3661-6&indgeo=0

Transport Canada. (2019). Transportation 2030: A strategic plan for the future of transportation in canada. Verkregen van https://tc.canada.ca/en/initiatives/transportation-2030-strategic-plan-future-transportation-canada

Transport Canada. (2020). Transportation in canada 2019. Verkregen van https://tc.canada.ca/en/corporate-services/transparency/corporate-management-reporting/transportation-canada-annual-reports/transportation-canada-2019#toc_8

Transport Canada. (2021a). Overview of canada's transportation sector. Verkregen van https://tc.canada.ca/en/corporate-services/transparency/briefing-documents-transport-canada/20191120/overview-canada-s-transportation-sector

Transport Canada. (2021b). *Transportation in canada 2021Comprehensive report.* (). Canada: Transport Canada.

Transport Canada. (2021c). Trends in innovation. Verkregen van https://tc.canada.ca/en/corporate-services/transparency/corporate-management-reporting/transportation-canada-annual-reports/trends-innovation

U.S. Department of Energy. (2023). Alternative fuels data center. Verkregen van https://afdc.energy.gov/fuels/

UNCTAD. (2022). Review of maritime transport report 2022. Verkregen van https://unctad.org/rmt2022

United Nations. (2023). Sustainable development - the 17 goals. Verkregen van https://sdgs.un.org/goals

University of Waterloo. (2023a). About waterloo transportation research for improving performance and safety. Verkregen van https://uwaterloo.ca/transportation-research/about

University of Waterloo. (2023b). CEE, transportation research centres, groups and labs. Verkregen van https://uwaterloo.ca/civil-environmental-engineering/research/transportation

Waterloo Region. (2022). *Sustainable waterloo region 2022.* (). Waterloo, ON, CAnada: Waterloo Region.

YKF. (2022). Region of waterloo international airport (YKF) ranked the 6th busiest airport in canada in 2021. Verkregen van https://www.waterlooairport.ca/Modules/News/index.aspx?newsId=023d8bd7-de7d-4c53-a9bf-816f6c695ddb



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