ELECTRIC BICYCLES:
CAN THEY REDUCE DRIVING AND EMISSIONS IN CANADA?

By Alexander Bigazzi and Elmira Berjisian

SUMMARY

Increasing use of electric bicycles (e-bikes) could help Canadian cities achieve goals of reducing emissions and increasing physical activity. A key assumption underlying this hope is that adoption of e-bikes will displace a substantial amount of travel by car. Existing studies suggests that on average each additional e-bike adoption will reduce around 2,000 vehicle-kilometers travelled per year, yielding a net reduction of 460 kg per year in CO_2 emissions and a net increase of 21 minutes per week of physical activity. These expected benefits support policies to promote e-bike adoption such as purchase incentives and improved riding and parking facilities.

RÉSUMÉ

L'utilisation accrue des vélos électriques pourrait aider les villes canadiennes à atteindre leurs objectifs de réduction des émissions et de hausse de l'activité physique. L'une des hypothèses clés qui sous-tendent cet idéal est que l'adoption des vélos électriques permettra de remplacer une grande partie des déplacements en voiture. Des études existantes suggèrent qu'en moyenne, l'adoption d'une bicyclette électrique supplémentaire entraîne une réduction d'environ 2 000 véhicules-kilomètres par an, soit une diminution nette de 460 kg par an des émissions de CO_2 et une augmentation nette de 21 minutes par semaine de l'activité physique. Ces avantages escomptés appuient les politiques visant à promouvoir l'adoption des vélos électriques, notamment les incitations à l'achat et l'amélioration des installations de circulation et de stationnement consacrés aux cyclistes.

INTRODUCTION

Electric-assist bicycles (e-bikes) are an emerging mode of personal transportation that could potentially help Canadian cities move toward their climate and health goals. E-bikes are bicycles equipped with an electric motor that provides pedalling assistance (limited to 500 W and 32 km/hr in Canada), although exact definitions vary by jurisdiction.[1] E-bikes offer a sustainable alternative to cars that may be utilized by a wider range of people than conventional bicycles. They make it easier to ride up hills, and allow higher speeds with less effort from the rider. E-bikes can be more attractive than conventional bicycles for certain travellers and trips because they require less effort, time, and perspiration. If e-bikes are adopted by travellers as a substitute for motorized modes of travel (particularly driving), they have the potential to help reduce congestion and emissions, while increasing physical activity and related health benefits.

Limited data are available on the size of the e-bike market in Canada, but various sources suggest it is growing.[2] E-bike adoption can be bolstered by the actions of cities, regions, and provinces such as developing e-bike friendly building codes, modifying vehicle regulations, providing purchase incentives, establishing lending programs, and improving bicycle facilities, among other strategies.[3] A key challenge for planners is to estimate the impacts of e-bike promotion policies on outcomes of interest – particularly vehicle-kilometers travelled, greenhouse gas emissions, and physical activity. The objective of this article is to summarize the known impacts of e-bike adoption on car travel, emissions, and health. We draw from a more detailed summary of the literature on e-bike adoption,[4] available online.[5]

Travel	Weekly travel	Lifecycle CO_2 emissions rate (g/PKT*)	Weekly CO_2 emissions (kg)	Minutes MVPA** per PKT	Weekly minutes MVPA
Car (displaced)	-39 km	260	-10.1	0	0
Public transit (displaced)	-9 km	100	-0.9	0.7	-6
Conventional bicycle (displaced)	-14 km	20	-0.3	2.4	-34
Walking (displaced)	-3 km	0	0	9.8	-29
E-bike	60 km	40	2.4	1.5	90
Total	-12 km	NA	-8.9	NA	21

* PKT: passenger kilometers travelled
** MVPA: moderate to vigorous physical activity

Table 1. Emissions and physical activity impacts of displacing trips by other modes.

E-BIKE USAGE AND DISPLACEMENT OF TRAVEL BY OTHER MODES

Dozens of studies over the past decade have characterized the travel habits of early e-bike adopters, who tend to be older than conventional cyclists and have higher incomes. These studies have been concentrated in Europe, with a smaller number available from China and North America. Based on 17 studies from Europe and North America, e-bike trip speeds average around 20 km/hr, 10% to 30% faster than conventional bicycles. Average riding frequency of early adopters is two to four days per week, with average single-trip distances around 6 km and average weekly riding distance of 60 km.

There is less literature on displacement of travel by other modes after e-bike adoption, again concentrated in Europe. The results of those studies suggest that on average 44% (±17%) of e-bike trips replaced car trips, 30% (±13%) replaced trips by conventional bicycle, 12% (±5%) replaced trips by public transit, and 6% (±2%) replaced walking trips. These percentages are illustrated in **Figure 1**, with the remaining trips (8%) assumed to be new (induced) trips (past estimates of induced e-bike trips have ranged from 1% to 38%). Fewer studies have reported travel distance displaced by e-bike adoption, rather than number of trips. Based on those studies, around 39 km of driving per week is displaced by the average e-bike adopter (ranging from 25 to 50 km), along with 14 km of travel by conventional bicycle, 9 km by public transit, and 3 km of walking. Studies from Asia report lower substitution of car trips and higher substitution of transit trips, due to different baseline mode shares.

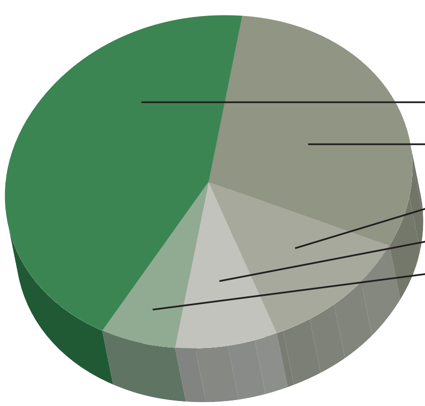

Figure 1. E-bike mode substitution.

Impact	Weekly	Annually
Displaced car travel (VKT)	38	1980
Displaced public transit travel (PKT)	10	520
Reduction in lifecycle CO_2 emissions (kg)	8.9	460
Increase in minutes of moderate to vigorous physical activity (MVPA)	21	1092

Table 2. Estimated impacts of each additional e-bike.

IMPACTS ON POLLUTION EMISSIONS AND HEALTH

Using typical lifecycle CO_2 emission rates by travel mode and the travel displacement estimates above, the estimated weekly travel emissions reduction attributable to e-bike adoption is summarized in **Table 1**. Each e-bike adoption is expected to result in approximately 460 kg CO_2 net emissions reduction per year, on average (similar to the emissions from about 2,000 km of driving, a bit more than 10% of the average Canadian's annual driving distance). The net climate impact is limited because only a portion of e-bike travel is displacing car trips, the car trips that e-bikes replace tend to be short, and e-bike trips still consume some fossil-derived energy from the electric grid (although much less than driving). From the perspective of local air quality, the potential emissions benefits of e-bikes are higher because on-road emissions are zero, but that distinction will decrease over time with electrification of the automobile fleet.

Common health guidelines recommend at least 150 minutes per week of moderate to vigorous physical activity.[6] Based on early research, e-bike trips are at an intensity of physical activity around 25% lower than trips on conventional bicycles. Most e-bike travel qualifies as moderate physical activity, although intensity varies greatly with individual, trip, and environmental factors (trip purpose, weather, terrain, speed, level of power assistance, etc.). **Table 1** summarizes physical activity and travel displacement estimates, indicating a net increase of 21 minutes of moderate to vigorous physical activity per week for the average e-bike adoption. The 60 km of e-bike riding per week is estimated to achieve about 60% of the target minutes of physical activity.

Several studies have investigated the safety impacts of e-bike travel in terms of crash and injury risks, with mixed results. Higher speeds for e-bikes than conventional bicycles could elevate risks, but risk is heavily mediated by the characteristics and riding behaviours of early adopters. In terms of perceived safety, e-bike riders in North America have reported feeling safer riding an e-bike compared to a conventional bicycle.[7] Overall, there is a lack of robust evidence on the safety of e-bike riding, particularly in a Canadian context. More information may become available as e-bike adoption increases and crash data are employed in safety research. A major impediment, however, will be the lack of reporting of e-bike specific crashes, as most crash databases currently do not distinguish e-bikes from other types of bicycles.

SUMMARY AND IMPLICATIONS

Combining the information above, the estimated average impacts of each additional e-bike adoption are given in **Table 2**. E-bike adoption is expected to provide net benefits in the forms of reduced motor vehicle travel, reduced greenhouse gas emissions, and increased physical activity. Around half of e-bike trips are expected to displace travel by motor vehicles (44% car trips and 12% transit trips), which is sufficient to provide substantial emissions benefits. Reduced walking and conventional cycling is not expected to outweigh the added physical activity of e-biking. Note that there is significant uncertainty in these estimates, and they should be interpreted as approximations only.

The expected benefits can support policies to promote e-bike adoption such as purchase incentives, e-bike lending programs, and improved bicycle infrastructure.[8] The most important action to promote e-bikes is improvement of general cycling conditions – something that is already underway in many Canadian cities. Safety and comfort concerns are typically the largest barriers to usage of both conventional and electric bicycles. Hence, the crucial element to e-bike promotion is a broader cycling strategy, in particular an extensive network of protected bicycle infrastructure. In addition to riding infrastructure, trip-end facilities are particularly important for e-bikes due to concerns about theft. Municipal by-laws should be amended to require sufficient secure bicycle parking with power access in new buildings.

Beyond general cycling strategies, purchase incentives (discounts and rebates) have worked well for initiating e-bike adoption, sometimes combined with a vehicle scrappage program such as BC's SCRAP-IT. Public and private entities have also established lending libraries and free rental programs to expand awareness of and familiarity with e-bikes. Along with promotion strategies, there is a need to clarify e-bike vehicle regulations to exclude 'scooter-style' vehicles, and ensure that cycling infrastructure is comfortable for cyclists of all types.

The impact estimates summarized here should be applied with caution. These estimates reflect average, aggregate effects and the impacts on an individual level will vary widely. Many factors influence e-bike travel behavior such as cycling infrastructure, weather, and topography in a city, as well as traveller characteristics such as age, gender, physical capability, and attitudes. The estimates rely largely on e-bike research from Europe, which has limited applicability in Canada. We would expect greater benefits in Canada since the baseline auto use is higher (as suggested by the several studies that have come out of the United States). To refine these estimates and adapt them for specific locations, more research is needed on e-bike travel behavior among different population segments and in different urban settings throughout Canada and elsewhere. E-bike research in the Canadian context is sparse, and more is needed to clarify the expected outcomes of adoption and to guide planners in designing policies to maximize the positive potential of e-bikes. Toward that end, e-bike promotion projects should include an evaluation component to help build the body of knowledge. Despite these limitations, it is clear that e-bike promotion is one tool Canadian cities can use to work toward their goals of active, healthy, and sustainable transportation systems.

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ENDNOTES

1. People for Bikes (https://peopleforbikes.org/) provides a summary of e-bike laws in the United States.
2. Randy Shore, "E-Bike Sales Accelerating as Riders Seek an Added Spark for Hilly Routes," Vancouver Sun, Nov. 26, 2016. https://vancouversun.com/business/local-business/e-bike-sales-accelerating-as-riders-seek-an-added-spark-for-hilly-routes; WATT Consulting Group, *Capital Region Local Government Electric Vehicle (EV) + Electric Bike (E-Bike) Infrastructure Backgrounder* (Report, Victoria, BC: Capital Regional District, 2018)
3. Saki Aono and Alexander Bigazzi, "Industry Stakeholder Perspectives on the Adoption of Electric Bicycles in British Columbia," *Transportation Research Record: Journal of the Transportation Research Board*, no. 2673 (2019): 1-11. 0361198119837158; John MacArthur, Jennifer Dill, and Mark Person, "Electric Bikes in North America: Results of an Online Survey," *Transportation Research Record: Journal of the Transportation Research Board*, no. 2468 (2014): 123–30.
4. Elmira Berjisian and Alexander Y. Bigazzi, "Summarizing the Impacts of Electric Bicycle Adoption on Vehicle Travel, Emissions, and Physical Activity" (Vancouver, Canada: University of British Columbia, 2019) http://civil-reactlab.sites.olt.ubc.ca/files/2019/07/BerjisianBigazzi_ImpactsofE-bikes_Report_July2019.pdf
5. http://civil-reactlab.sites.olt.ubc.ca/files/2019/07/BerjisianBigazzi_ImpactsofE-bikes_Report_July2019.pdf
6. Department of Health, Physical Activity, Health Improvement and Protection, "Start Active, Stay Active: A Report on Physical Activity for Health from the Four Home Countries' Chief Medical Officers" (Report, London, UK: Department of Health, 2011).
7. MacArthur, Dill, and Person, "Electric Bikes in North America: Results of an Online Survey," 123–30.
8. Aono and Bigazzi, "Industry Stakeholder Perspectives on the Adoption of Electric Bicycles in British Columbia," 1-11.

REFERENCES

Aono, Saki, and Alexander Bigazzi. "Industry Stakeholder Perspectives on the Adoption of Electric Bicycles in British Columbia." Transportation Research Record: *Journal of the Transportation Research Board*, no. 2673 (2019): 1-11. 0361198119837158.

Berjisian, Elmira, and Alexander Y. Bigazzi. "Summarizing the Impacts of Electric Bicycle Adoption on Vehicle Travel, Emissions, and Physical Activity." Vancouver, Canada: University of British Columbia, 2019. http://civil-reactlab.sites.olt.ubc.ca/files/2019/07/BerjisianBigazzi_ImpactsofE-bikes_Report_July2019.pdf.

Department of Health, Physical Activity, Health Improvement and Protection. "Start Active, Stay Active: A Report on Physical Activity for Health from the Four Home Countries." Report, London, UK: Department of Health, 2011.

Dill, Jennifer, and Geoffrey Rose. "Electric Bikes and Transportation Policy." *Transportation Research Record: Journal of the Transportation Research Board*, no. 2314 (2012): 1–6. https://doi.org/10.3141/2314-01.

MacArthur, John, Jennifer Dill, and Mark Person. "Electric Bikes in North America: Results of an Online Survey." *Transportation Research Record: Journal of the Transportation Research Board*, no. 2468 (2014): 123–30.

Shore, Randy. "E-Bike Sales Accelerating as Riders Seek an Added Spark for Hilly Routes." *Vancouver Sun*, Nov. 26, 2016. https://vancouversun.com/business/local-business/e-bike-sales-accelerating-as-riders-seek-an-added-spark-for-hilly-routes.

WATT Consulting Group. *Capital Region Local Government Electric Vehicle (EV) + Electric Bike (E-Bike) Infrastructure Backgrounder*. Report, Victoria, Canada: Capital Regional District, 2018.