ASSESSING THE GHG EMISSIONS EFFECTS OF THE CANADA LINE IN VANCOUVER AND TRAMWAY T2 IN PARIS

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Introduction

Today, the Earth's human population is growing and urbanization is spreading across the globe (Kacyira, 2012). With this growing urban development, residential areas are expanding out beyond urban cores in cities like Paris and Vancouver (Stan, 2013). Consequently, suburban residents often travel farther from their homes to their workplace than those who live in the city. These trips generate greenhouse gas emissions, particularly when people have to use cars; hence the need to develop public transportation linking these peri-urban areas with workplaces, to mitigate the climate impacts from urban traffic. In this paper, we compare two recent additions to urban public transportation networks in different countries to assess their potential in reducing GHG emissions. The selected rapid transit corridors are the Canada Line in Vancouver and Tramway T2 in Paris.

The environmental potential of new rapid transit corridors in Paris and Vancouver

The Canada Line and Tramway T2 are located in areas that offer promise for public transport infrastructure to reduce GHG emissions. Geographically, both new lines link suburban areas with inner-cities and business centres. Both were created to provide people with an alternative to driving cars.

The economy of Vancouver, particularly in the central business district, is one of the most dynamic places in British Columbia and thus the most important destination in the Metro Vancouver region. Vancouver's downtown core has 60% of the region's office space, and is home to Canada's largest and most diversified port. This port activity generated 76,800 jobs in British Columbia in

2012 (InterVISTAS, 2013, p. v). Consequently, this central area has extensive employment in economic sectors like trade and technology but also in film, natural resources, and tourism. The Canada Line also serves the Broadway Health Corridor, also known as the UBC-Broadway Corridor, south of the commercial core and False Creek, is home to the Vancouver General Hospital and “is the second largest business and innovation centre in British Columbia” (KPMG, 2013, p. 1). The rest of the area in the city of Vancouver and the city of Richmond are mostly residential.

The Canada Line is a fully automated rapid transit line that opened August 17, 2009. It is the third of TransLink’s rapid transit lines in Vancouver and connects Richmond and the Vancouver International Airport to downtown Vancouver. This 19-kilometre transit line was expedited into service in time for the 2010 Winter Olympics to carry people from the airport to downtown Vancouver. It was intended to contribute to the Olympics’ green legacy by reducing air pollutants thanks to its ability to displace road vehicle traffic. It cost over $2 billion (2005 Canadian dollars) and was consequently one of the most ambitious transportation projects in the province of British Columbia.

Paris is the unrivalled centre of economic activity in the Ile-de-France region. With its 1.6 million jobs it boasts 31% of the region’s jobs, while the Paris region has the most intense economic activity of the country (CCI Paris Ile-de-France, 2008). An important settlement for more than two millennia, the creative arts and universities made Paris an important cultural centre. Today, the city serves an important hub of intercontinental transportation and is home to higher education, sport events, opera companies, and museums of international renown making it one of the most popular tourist destinations in the world. The Tramway Line T2 is located in this region, in the Hauts-de-Seine department (Paris’ Western suburbs). It connects Porte de Versailles in Paris with Bezons via the business centre of La Défense, which is the largest purpose-built business district in Europe and the second highest concentration of working professionals in France after Paris. T2 has experienced great success, and each segment of the line surpassed ridership forecasts. Soon after opening in 1997, the line carried its maximum designed passenger load until the trams were doubled in length in 2005.

Thus, the Canada Line, like the tramway T2, links a major employment area with a residential area. People commute from these residential areas to these employment centres, and a large share of these commuters drive cars. Consequently, introducing rapid transit enables people to switch from driving to public transportation. If this occurs, the modal shift would reduce GHG emissions. However, this raises the question of people's willingness to take public transportation when they are likely to already own a car.

Assessing the Canada Line's and the T2's potential to reduce GHG emissions

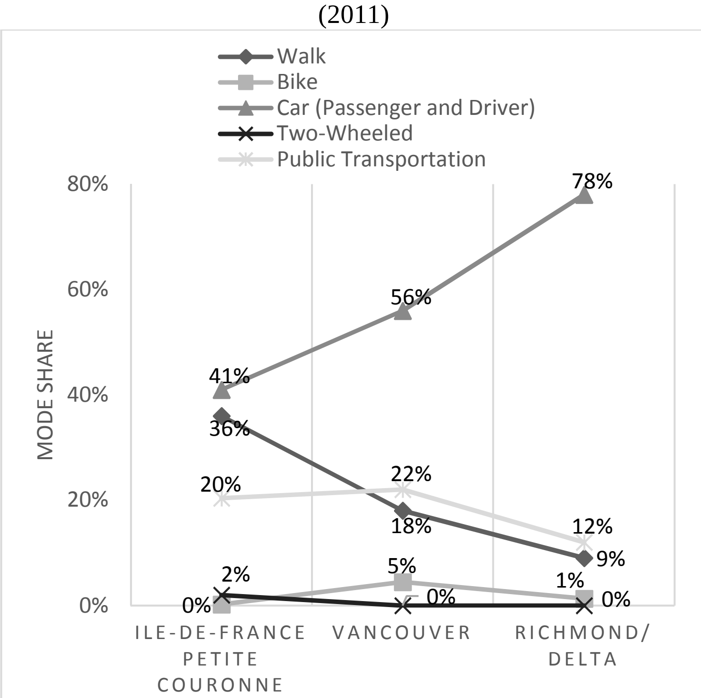
For this study, we have sought a way to assess the potential for GHG emissions reduction created by the introduction of rapid transit. This has been facilitated by travel behaviour studies including: *Les Déplacements des Franciliens en 2001-2002, Enquête Globale Transports Plan de Déplacements Urbains* (Préfet De La Région D'Ile-De-France, 2012); *Le Tramway Au Secours des Hauts-de-Seine* (Favier & Mouranche, 2007); and Translink's (2013) *2011 Metro Vancouver Regional Trip Diary Survey*. We also obtained data about the lines' operation thanks to *Avis sur le bilan LOTI de l'opération du tramway T2* (Bacot & Taroux, 2011) about the Tramway T2 and a Transport Canada (2012) report entitled *The Canada Line Retrospective*. We obtained operational data from the Paris Urban Transport Authority (RATP) for the Tramway T2 (Personal Communication, July 9, 2014). To assess the amount of CO_2 emission savings that can be attributed to transit modal shift on each line during 2012, we relied upon the reported traffic from cars and from other means of transportation and also estimates of the induced traffic that had been generated by the establishment of the new rapid transit infrastructure. Our assumptions about the reported traffic and the induced traffic are based on research about willingness to take public transportation and about induced travel (Cervero & Hansen, 2002; Goodwin, 1996; Litman, 2010; Litman, 2005; Noland & Lem, 2002; Pagliara & Preston, 2013; and Yao & Morikawa, 2005). We then translate these reported and induced traffic levels into CO_2 emissions estimates to calculate the GHG reduction that these new lines have enabled.

Willingness to take public transportation and induced travel

Studying travel in the areas where T2[1] and the Canada Line[2] were built revealed that public transportation is well developed and was already being used by some commuters before the rapid transit infrastructure was introduced.

Moreover, the trend in mode share in the two regions proves that demand for public transportation has been increasing during the study period. These trends reflect different factors that could have deterred car use and encouraged modal shift, even in the absence of rapid transit. The price of oil, for instance, increased between November 2004 at US$48.45 per barrel and US$75.70 per barrel in November 2014 with a peak price of US$133.93 per barrel in July 2008 (IndexMundi, 2014). Finally, with the growing awareness about climate change, governments are imposing more green taxes on drivers who can no longer park for free, or use new roads or bridges for free (see Palma & Lindsey, 2006 for examples in the Paris region and BC Transportation Investment Corporation, 2007 for a Vancouver region example).

Figure 1: Regional Mode Share in Paris (2010) and Vancouver (2011)



Sources: Préfet De La Région D'ile-De-France, 2012 & TransLink, 2013

As transportation trends continue to shift, as illustrated above, alternative modes of transportation can play an important role in meeting changing demand. However, in developing alternate transportation infrastructure, municipalities need to be aware of the effects of induced travel. Induced travel occurs when an increase in capacity stimulates more trips until that capacity is reached (Goodwin, 1996; Cervero and Hansen, 2002; and Noland and Lem, 2002). As Pagliara and Preston (2013) and Yao and Morikawa (2005) concluded this occurs in both roadways and rail transit the latter relying on customer satisfaction, comfort, frequency and length of trips, among others to create the induced travel. Table 1 demonstrates that the potential for induced travel in both Paris and Vancouver is high, based on our measures which devote a score (from 1 to 5, where 1 is low induced demand, 2 medium and 3 is high) to different factors leading to induced travel.

Table 1: Potential for Induced Travel along New Transit Corridors in Paris and Vancouver

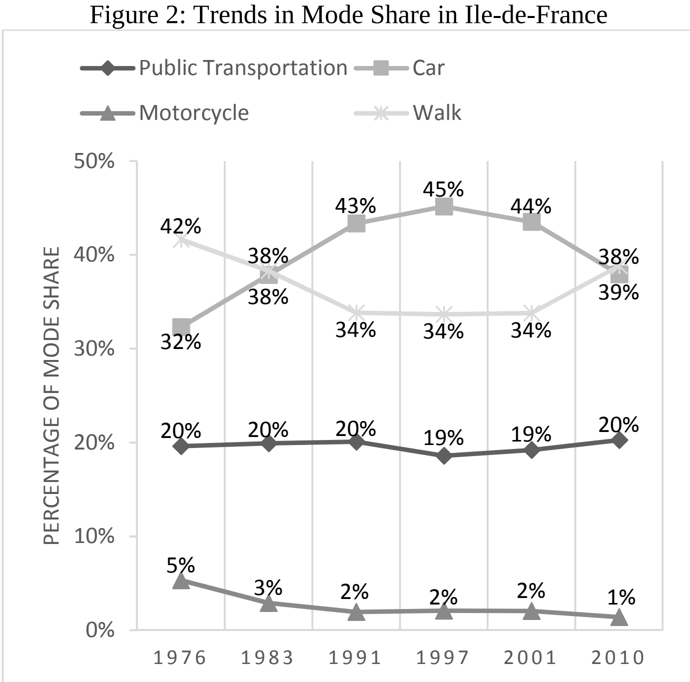
Factor	T2	Canada Line
1. Ridership on the new line or on the other means of public transport in the corridor	3	3
2. Latent demand	2	3
3. Degree to which the line reduces daily congestion and improves travel conditions	2	3
4. Degree to which the line increases access to potentially developable land	2	2
5. Population and employment growth rates in the transportation corridor	3	3
6. Disutility of travel alternatives on the corridor, including other roads and modes.	1	3
TOTAL	**13**	**17**

The total scores reveal a higher potential for induced demand from the Canada Line's new infrastructure than from T2 in the Ile-de-France. These scores were calculated based on quantitative data about the Canada Line and the T2 with the following attributes. The tramway T2 has higher ridership at 210,000 per day compared to the Canada Line at 122,000 per day (Protrans BC, 2014). Vancouver's road network is more congested than that in the Hauts-de-Seine, particularly the bridges linking Vancouver to the surrounding suburbs, such as Richmond (TransLink, 2012; and

Préfet De La Région D'ile-De-France, 2012). The Canada Line avoids this congestion by moving along a fully grade separated guideway. Based upon rider opinion surveys on both lines, users are saving up to 40 minutes compared to driving and the trip is more comfortable than driving in stop-and-go traffic (Préfet De La Région D'ile-De-France, 2012; and TransLink, 2013).

Effectively, the Tramway T2 and the Canada Line have both stimulated induced traffic. In the Bilan LOTI (2011, p. 17), the underestimation of transit usage is striking where the actual growth was 12 percent against the three percent projected. However, these figures are to be compared with an increase in the Ile-de-France road network traffic by 2.3% per year between 1997 and 2004.

Figure 2: Trends in Mode Share in Ile-de-France



Source: Préfet De La Région D'ile-De-France, 2012

According to Translink (2013), there have been significant changes in the mode share in Richmond between 2008 and 2011. These changes are “the most substantial changes” in the Metro Vancouver region during this period (p. 57). The changes are directly attributed to the opening of the Canada Line with the growth in trips from Richmond/Delta being accommodated by transit. However, Richmond/Delta residents are the most likely to drive compared to the whole Vancouver region (TransLink, 2013). Despite these tendencies vehicle kilometres travelled decreased between 2008 and 2011, dropping approximately 300,000 km. This decrease “is significant and is likely an outcome of the opening of the Canada Line” (p.58).

CO_2 emissions and reduction

The Canada Line uses a fleet of trains built by Rotem, a division of Hyundai Motor Group. The trains are powered by conventional electric motors, unlike Bombardier’s Advanced Rapid Transit cars, operating on Vancouver’s two other SkyTrain lines which use Linear Induction Motor (LIM) technology. The tramway T2 uses vehicles called *rames Citadis 302* constructed by Alstom.

The RATP provided data about the energy consumption of the T2 line, including the electricity needed for the traction (11,920,483 kWh per year) and for the stations (603,490 kWh per year). The T2 thus consumed 12,523,973 kWh during 2013. Through information provided by Hyundai Rotem it was determined that the Canada Line uses 6.848kWh per vehicle kilometre (Personal Communication, November 8, 2014). From this energy consumption we were able to calculate the power consumption of the Canada Line. Using the frequency of trips of weekdays and weekends it was determined that 93,660 trips were run in 2014 (TransLink, 2014). Multiplying the number of trips by the energy consumption provided by the Hyundai Rotem and the length of the track it was calculated the Canada Line uses 12,314,566.66 kWh per year for traction. In addition, Translink’s *Sustainability Report 2012: Tracking Progress* revealed that Canada Line stations use 9,438,373.38 kWh per year. Aggregating this station energy consumption with the energy required for traction reveals that the Canada Line consumes a total of 21,752,940.03 kWh per year.

Table 2: Electricity Consumption and Emissions of Rapid Transit

	T2	Canada Line
Electricity Need	(kWh per year)	(kWh per year)
Traction	11,920,483.00	12,314,566.66
Stations	603,490.00	9,438,373.38
Total	12,523,973.00	21,752,940.03
Supplier	**EDF**	**BC Hydro**
GHG emissions for 1kWh of electricity production	41.08 (g equivalent CO_2)	9 (g equivalent CO_2)
	T2	**Canada Line**
GHG Emissions	(tonnes equivalent CO_2)	(tonnes equivalent CO_2)
Per Year of Operation	514.48	195.78

EDF and BC Hydro publish an annual inventory of atmospheric emissions created to produce their electricity. BC Hydro emitted **9 g CO_2 eq/kWh** during 2012 (BC Hydro, 2012). For EDF, the average for 2013 is **41.08 g CO_2/kWh** (EDF, 2013). We can thus calculate the emissions by multiplying the two lines' annual energy consumption with these reported emission rates. We can thus estimate that the Tramway T2 emitted 514 tonnes of CO_2 during 2013, while the Canada Line emitted 196 tonnes.

To assess the CO_2 reduction thanks to the tramway T2 we based our study on the figures of the *Avis sur le bilan LOTI de l'opération du tramway T2* (Bacot & Taroux, 2011). The latter had already assessed the proportion of reported traffic from other modes and induced travel. Then we used the tendency of people to take public transportation and the characteristics of the area to assess the progress of this redistribution.

From the Bilan LOTI study we know the ridership growth for each year. Using this, we determined the percentage of trips that switched mode of transportation leading to the 2013 ridership levels of the T2. We now know the share of trips from reported traffic (from cars, trains and buses) and from induced traffic. The average length trip on the T2 is 5.5 km. So we used the emissions estimates made by ADEME (Deloitte, 2008) for other transportation modes order to calculate the CO_2 that would have been emitted without the presence of the tramway T2.

Finally, about 16,150 tonnes equivalent of CO_2 would have been emitted in 2013, if the T2 had not been built. In 2013, the T2 emitted 395 tonnes equivalent CO_2, which is 40 times less than the 16,150 tones equivalent CO_2 that would have been emitted if people would have used their former means of transportation. In other words, the T2 prevented the emission of 15,755 tonnes equivalent CO_2 during the first operational year. However, the T2 has contributed to 5,170,000 induced trips that generated 49 tonnes equivalent CO_2. This cannot be ignored, but this is extremely low compared to the amount of CO_2 emissions that were avoided.

The Canada Line was projected by Transport Canada (2012) to reduce air pollutants. This decrease would come from its ability to displace road vehicle traffic along the transit corridor. The potential for such change was also influenced by the cost of driving which has been rising in recent years, and by growing traffic congestion in Vancouver during peak hours.

The reduction in vehicle traffic was projected to reduce both local air pollutants and greenhouse gases. These reductions were proportional to the vehicle kilometres displaced by modal shift to transit. It is estimated that 3.3 million kilometres of bus, and diesel and electric trolley travel along with 41 million kilometres of automobile travel were displaced in 2010. By 2021, these figures were projected to increase to 5.6 million and 49 million kilometres for buses and cars respectively (Transport Canada, 2012). Transport Canada estimated that the net emissions had decreased by **8.1 to 10.5 thousand tonnes in 2010** and that these reductions would grow to between **11.5 to 14.0 thousand tonnes in 2021**.

Since there have been no comprehensive travel surveys and that the regional transportation model has not been updated with new data between the opening of the line and the writing of the report we cannot make definitive conclusions about overall changes in regional travel to estimate net changes in GHG emissions or air quality. However, if the assumptions regarding increased ridership are correct, and if ridership gains have affected auto demand, as in the projection, they assume that more automobiles would have been displaced than originally projected, having a positive impact on GHG reductions. This may also be supported by the usage of parking adjacent to the Canada Line. Bridgeport Park and Ride facility was running at just over 75% utilization for available transit parking at 911 weekdays vehicles in 2014. The old facility at Sexsmith Road held only about 400 spaces, and so they suggest that some of the 511 additional vehicles may be avoiding the 14-kilometre drive to downtown from Richmond. Further analysis is required to confirm that this park and ride usage represents a specific number of avoided auto trip kilometres.

InTransit British Columbia considers that the additional ridership does not result in a proportionate increase in power consumption as the same number of trains are running, just more efficiently on a power per passenger basis. However, even if the assumed additional ridership would suggest that reduction in GHG emissions would exceed the projections set out in the Business Case, those reductions may be partially offset by the fact that there are additional buses travelling in the corridor.

Available evidence thus supports the claim that both the Canada Line and T2 make possible reductions in GHG emissions. The amount of CO_2 saved in both cases is roughly the same order of magnitude. The T2 avoided emitting 15.8 thousand tonnes of GHG equivalent in 2013 and the Canada Line avoided emitting between 9 and 11 thousand tonnes of GHG in 2013[3]. With the Canada Line's GHG savings anticipated to continue to grow. Both the T2 and the Canada Line have made significant contributions to the reduction of CO_2 emissions in their respective urban environments.

Conclusion

Besides the fact that both the Canada Line and T2 have reduced GHG emissions, some other results can be highlighted. Rail rapid transit infrastructure is able to attract people from other transportation modes which are more polluting, reducing the net GHG emissions. Rail infrastructure also offers a way to develop more sustainable communities through transit oriented development.

Both the tramway T2 in Paris and the Canada Line in Vancouver have proven to be successful additions to the urban transportation networks of their respective regions. Both have exceeded their forecast ridership and as a result are allowing commuters to travel in a more environmentally friendly manner. With the induced demand of each line ridership above projections and the low output of GHG emissions from their electric power sources, 196 tonnes for the Canada Line and 395 tonnes for the T2, substantial GHG emission reductions are occurring. The Canada Line is expected to reduce GHG emissions by as much as 14 thousand tonnes annually. By 2021 and the T2 has reduced GHG by 15,755 tonnes annually. Through the creation of these two lines and the subsequent reduction in GHG emissions both metropolitan regions are able to create and maintain greener and healthier environments improving the quality of life for their residents.

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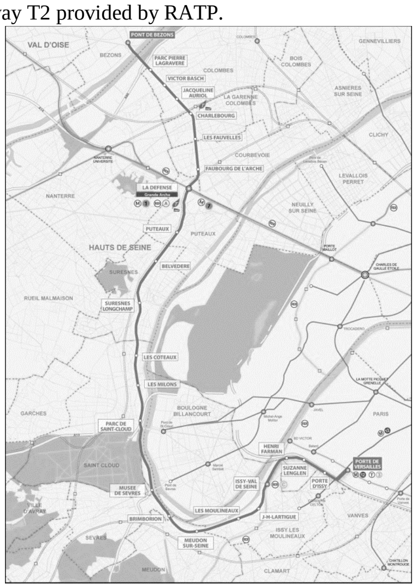
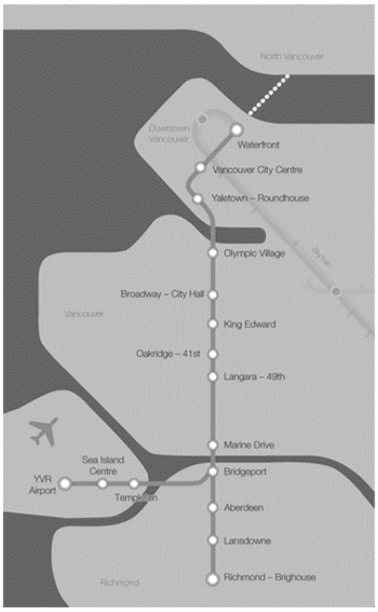
[1] Map of Tramway T2 provided by RATP.



[2] Map of the Canada Line (Protrans BC, 2015).



[3] These savings were calculated using Transport Canada's estimates and estimating the growth of GHG savings over the period 2010 to 2021.