Green Bond Program

Estimation of GHG benefits of Azur trains and Hybrid buses

February 2019

Green Bond Program

- Since 2017, the Government of Quebec has issued bonds as part of the province's Green Bond Program.
- It is a financing program dedicated to projects generating quantifiable benefits in terms of environmental protection and more specifically:
    1. Greenhouse gas emission (GHG) reduction
    2. Climate change adaptation
- The Government of Quebec has committed to publish an annual Report on Project Progress and Tracking of Benefits in Greenhouse Gas Emission Reduction and Climate Change Adaptation.
- Green Bonds have funded the acquisition of the new Azur trains and hybrid buses, as well as other projects.
- This presentation explains the methodology used to estimate the GHG benefits related to putting Azur trains and hybrid diesel-electric buses into service.

GHG Emission reduction from Public Transit

- Public transit is a known effective mean in reducing GHG emissions
- In 2016, a study conducted by the firm Golder for various municipal and provincial partners and transit authorities shows that the total GHG emissions avoided from public transit in the Greater Montréal area are **3,911,000 million tons of CO_2e per year**.
- Quantification of GHG emissions avoided was realized according to the guidelines proposed in the **American Public Transportation Association's** *Recommended Practice for Quantifying Greenhouse Gas Emissions from Transit*, based on three factors:

   1. **Mode shift to transit**: "Because of public transit, there are fewer cars on the road."
   2. **Congestion relief**: "Because of public transit, there is less road congestion, idling and stop and go traffic."
   3. **Land-use multiplier**: "Because of public transit, the territory has a greater density that promotes shorter trips, walking and cycling, and reduced car use."

General methodology

- The GHG benefits of the projects are quantified using two approaches:
  - The **GHG emissions avoided** that correspond to car trips avoided by public transportation users. In this presentation, only the **mode shift to transit** factor is quantified for Azur trains and hybrid buses. Other GHG emissions avoided (congestion relief and land-use multiplier), which demonstrate significant GHG benefits, are too complex and cannot currently be estimated.
  - The **STM's GHG emission reductions.** This type of GHG benefits only apply to hybrid buses.

- Temporal scope: The benefits have been calculated since the first Azur trains and hybrid buses were put into service, from 2016 to 2018. Note that as real data for 2018 was not available when preparing this presentation, calculations are based on projected data.

- **Quantified GHG benefits 2016-2018:**
  - **213,265 tons of CO_2e for Azur trains**
  - **9,838 tons of CO_2e for hybrid buses**

GHG benefits of Azur trains

Key assumptions and results

- Mode shift to transit effect associated with Azur : If Azur had not been put into service, a part of the métro service could not be offered. As a result, trips made on Azur trains would have, in part, been made by car.
- The calculation is based on the following steps, which will be presented in more detail:
  - Step 1: Conversion of ridership into passenger-km by métro
  - Step 2: Estimation of passenger-km on Azur trains
  - Step 3: Estimation of vehicle-km by car avoided thanks to Azur
  - Step 4: Conversion of vehicle-km by car avoided into GHG emissions avoided.
  - **Based on this methodology, we estimate that the service offered by Azur trains from 2016 to 2018 made it possible to avoid the emission of 213 265 tons of CO_2e.**
  - Note: this quantification aims to identify the ongoing benefits associated with Azur trains in terms of GHG emissions avoided from public transit use.

Step 1: Ridership conversion into passenger-km by métro and bus/métro (1/2)

- Passenger-km correspond to the annual accumulated distance travelled by users on the STM network.

- Passenger-km are calculated using: STM ridership (total number of annual trips) and the results of the Enquête Origine-Destination 2013 (2013 Origin/Destination Survey), which enables us to differentiate the distribution of trips and distances travelled by mode (bus, métro, bus and métro).

Trip mode	Percentage of mode of total STM trips	Average distance by métro	Average distance by bus
Métro only	41,7%	7.9 km	0.0 km
Bus only	30,6%	0.0 km	4.9 km
Bus and métro	27,7%	7.8 km	5.1 km

- We aim to quantify the passenger-km travelled on “métro only” trips.

Step 1: Ridership conversion into passenger-km by métro (2/2)

- Passenger-km by métro = (total annual trips X percentage of métro trips (%) X average distance of métro trips (km)) + (total annual trips X percentage of bus/métro trips (%) X average distance of métro trips in bus/metro trips).
- **From 2016 to 2018, total passenger-km by métro (accumulated distance travelled by users on métro) were 7,058,826,583.**

Step 2: Estimation of passenger-km on Azur trains

- At this step, we aim to identify the distance travelled on trips made on Azur trains.
- There is no data that enables us to identify métro ridership or passenger-km by métro by type of rolling stock. In this case, we estimate the passenger-km by métro in proportion to the service offered in seat-km.
- Seat-km offered to users correspond to the number of seats available over the distance travelled by buses and métro cars during the year.
- Passenger-km by Azur = *Passenger-km by métro X Percentage of métro seat-km travelled by Azur.*
- **From 2016 to 2018, the passenger-km by Azur (accumulated distance travelled by users on Azur trains) are estimated at 1,996,525,564.**

Step 3: Estimation of vehicle-km by car avoided by Azur

- At this step, we aim to identify what percentage of passenger-km by Azur would be travelled by car if Azur had not been put into passenger service. We therefore consider that the portion of the service performed by Azur could not be offered to users who would use other modes of transport, such as single occupant vehicle use, taxi, carpools, bike, walking, no trips.
- To do this, we use the modal transfer rate obtained by a survey in the Quantification des émissions de GES évitées par le transport collectif study (quantification of greenhouse gas emissions avoided from public transit) (see section 3.1.2.)
- In this calculation, Montréal's modal transfer rate (47%) was used because the calculations relate to trips made by métro.
- Vehicle-km by car avoided by Azur = *Azur passenger-km X modal transfer rate.*
- **From 2016 to 2018, the vehicle-km by car avoided by Azur (accumulated distance travelled by users if Azur had not been put into service) are estimated at 938,367,015.**

Step 4: Conversion of vehicle-km by car avoided into GHG emissions avoided

- At this step, we aim to convert vehicle-km by car avoided by Azur into GHG emissions avoided.

- To do this, we use the emission rate per kilometre of an average car in Montréal provided in the Quantification des émissions de GES évitées par le transport collectif (quantification of greenhouse gas emissions avoided from public transit) study (see section 3.1.4.)

- Tons of GHG emissions avoided by Azur = *Vehicle-km by car avoided by Azur X average emission rate per kilometre.*

- **From 2016 to 2018, GHG emissions avoided by Azur are estimated at 213,265 tons of CO_2e.**

Methodology summary

- Mode shift to transit effect associated with Azur from 2016 to 2018: If Azur had not been put into service, a part of the métro service could not be offered. As a result, trips made on Azur trains would have, in part, been made by car.

STM Ridership 2016-2018 (trips made by users)**: 1,293.4 million**

Step 1
Data from the 2013 Origin/Destination Survey

Distance users travelled by métro: **7,059 million passenger-km**

Step 2
Azur seat-km/ total métro seat-km

Trips made on Azur trains: **1,997 millions**

Step 3
Public Transit (PT) modal shift rate to car without PT

Distance users would travel by car without Azur: **938 million vehicle-km by car avoided**

Step 4
Average fuel consumption and emission rate of cars in Montréal

GHG emissions avoided by putting Azur into service: **213,265 tons CO_2e**

GHG benefits of hybrid buses

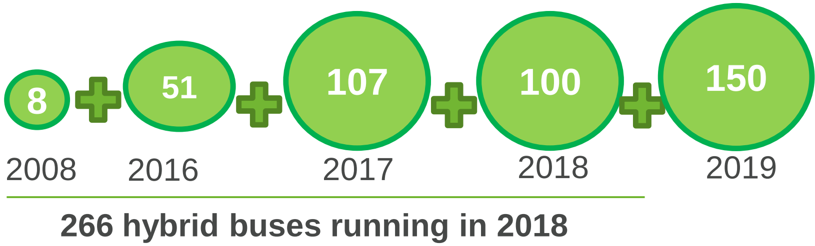
Key assumptions and results

- The GHG benefits associated with putting the hybrid buses into service are quantified in several steps:

  1. GHG emissions avoided that correspond to car trips avoided by public transit users.
  2. GHG emissions of hybrid buses in operation are to be deducted from their related GHG emissions avoided.
  3. The STM's GHG emission reductions: Replacing diesel buses with hybrid buses reduces STM fuel consumption per km travelled. Hybrid buses therefore reduce the STM's GHG emissions.

- The results are presented in the table below:

Data in tons of CO_2e	**Total 2016-2018**
1. GHG emissions avoided by users (mode shift from car to hybrid buses)	-26,084
2. GHG emissions of hybrid buses	20,314
3. The STM's GHG emission reduction (fuel savings of hybrid buses vs. diesel buses)	-4,068
GHG Benefits of Hybrid Buses	**-9,838**



1/ GHG emissions avoided

Key assumptions and results

- Mode shift to transit effect associated with hybrid buses : If new hybrid buses had not been put into service, a part of the bus service could not be offered. As a result, trips made on hybrid buses would have, in part, been made by car.

- The calculation is based on the following steps, which will be presented in more detail:
  - Step 1: Conversion of ridership into passenger-km by buses
  - Step 2: Estimation of passenger-km on new hybrid buses
  - Step 3: Estimation of vehicle-km by car avoided thanks to hybrid buses
  - Step 4: Conversion of vehicle-km by car avoided into GHG emissions avoided.

- **Based on this methodology, we estimate that the service offered by hybrid buses from 2016 to 2018 made it possible to avoid the emission of 26 084 tons of CO2e.**

- Note: this quantification aims to identify the ongoing benefits associated with new hybrid buses in terms of GHG emissions avoided from public transit use.

1/ GHG emissions avoided

Step 1: Ridership conversion into passenger-km by bus (1/2)

- Passenger-km correspond to the annual accumulated distance travelled by users on the STM network.
- Passenger-km are calculated using: STM ridership (total number of annual trips) and the results of the Enquête Origine-Destination 2013 (2013 Origin/Destination Survey), which enables us to differentiate the distribution of trips and distances travelled by mode (bus, métro, bus and métro).

Trip mode	Percentage of mode of total STM trips	Average distance by métro	Average distance by bus
Métro only	41,7%	7.9 km	0.0 km
Bus only	30,6%	0.0 km	4.9 km
Bus and métro	27,7%	7.8 km	5.1 km

- We aim to quantify the passenger-km travelled on “Bus only” trips.

1/ GHG emissions avoided

Step 1: Ridership conversion into passenger-km by bus (2/2)

- Passenger-km by bus = (total annual trips X percentage of bus trips (%) X average distance of bus trips (km)) + (total annual trips X percentage of bus/métro trips (%) X average distance of bus trips in bus/metro trips).
- **From 2016 to 2018, total passenger-km by bus (accumulated distance travelled by users on bus) were 3,789,097,538.**

1/ GHG emissions avoided

Step 2: Estimation of passenger-km on new hybrid buses

- At this step, we aim to identify the distance travelled on trips made on new hybrid buses.
- There is no data that enables us to identify bus ridership or passenger-km by bus by type of rolling stock. In this case, we estimate the passenger-km by bus in proportion to the service offered in seat-km.
- Seat-km offered to users correspond to the number of seats available over the distance travelled by buses and métro cars during the year.
- Passenger-km by new hybrid buses = *Passenger-km by bus X Percentage of métro seat-km travelled by new hybrid buses.*
- **From 2016 to 2018, the passenger-km by new hybrid buses (accumulated distance travelled by users on new hybrid buses) are estimated at 244,190,501.**

1/ GHG emissions avoided

Step 3: Estimation of vehicle-km by car avoided by new hybrid buses

- At this step, we aim to identify what percentage of passenger-km by new hybrid buses would be travelled by car if new hybrid buses had not been put into passenger service. We therefore consider that the portion of the service performed by the new hybrid buses could not be offered to users who would use other modes of transport, such as single occupant vehicle use, taxi, carpools, bike, walking, no trips.

- To do this, we use the modal transfer rate obtained by a survey in the Quantification des émissions de GES évitées par le transport collectif study (quantification of greenhouse gas emissions avoided from public transit) (see section 3.1.2.)

- In this calculation, Montréal's modal transfer rate (47%) was used because the calculations relate to trips made by métro.

- Vehicle-km by car avoided by new hybrid buses = *new hybrid buses passenger-km X modal transfer rate.*

- **From 2016 to 2018, the vehicle-km by car avoided by new hybrid buses (accumulated distance travelled by users if the new hybrid buses had not been put into service) are estimated at 114,769,535.**

1/ GHG emissions avoided

Step 4: Conversion of vehicle-km by car avoided into GHG emissions avoided

- At this step, we aim to convert vehicle-km by car avoided by new hybrid buses into GHG emissions avoided.

- To do this, we use the emission rate per kilometre of an average car in Montréal provided in the Quantification des émissions de GES évitées par le transport collectif (quantification of greenhouse gas emissions avoided from public transit) study (see section 3.1.4.)

- Tons of GHG emissions avoided by new hybrid buses = *Vehicle-km by car avoided by new hybrid buses X average emission rate per kilometre.*

- **From 2016 to 2018, GHG emissions avoided by new hybrid buses are estimated at 26,084 tons of CO2e.**

1/ GHG emissions avoided by new hybrid buses from 2016 to 2018

- Mode shift to transit effect associated with new hybrid buses from 2016 to 2018: If new hybrid buses had not been put into service, a part of the bus service could not be offered. As a result, trips made on new hybrid buses would have, in part, been made by car.

STM Ridership 2016-2018 (trips made by users)**: 1,293.4 million**

Step 1
Data from the 2013 Origin/Destination Survey

Distance users travelled by buses: **3,789 million passenger-km**

Step 2
New hybrid buses seat-km/ total métro seat-km

Trips made on new hybrid buses: **244 millions**

Step 3
Public Transit (PT) modal shift rate to car without PT

Distance users would travel by car without new hybrid buses : **115 million vehicle-km by car avoided**

Step 4
Average fuel consumption and emission rate of cars in Montréal

GHG emissions avoided by putting New hybrid buses into service: **26,084 tons CO_2e**

2/ GHG emissions of new hybrid buses

Key assumptions and results

- At this step, we aim to quantify GHG emissions of new hybrid buses
- The calculation is based on the diesel and biodiesel consumption of hybrid buses and using the emission factors from the NIR 2016 (National Inventory Report 1990-2016: Greenhouse gas sources and sinks in Canada).
- Tons of GHG emissions produced by hybrid buses = (*Litres of diesel X diesel emission factor*) + (*Litres of biodiesel X biodiesel emission factor*).
- **Between 2016 and 2018, we estimate that hybrid buses have emitted 20,314 tons of CO_2e.**

3/ GHG emission reduction of hybrid buses

Methodology summary

- Putting hybrid buses into service enables the STM to reduce its emissions compared to diesel buses. The present calculation aims to estimate this emission reduction.
- First, we estimate the emissions that would have been produced if the service provided by hybrid buses had been delivered by diesel buses. We do this by using the service provided, in terms of kilometres, by hybrid buses and the average emission rate per kilometre of regular STM diesel buses and hybrid buses.
  - Diesel bus GHG emissions produced to deliver service by hybrid buses = *km travelled by hybrid buses X average emission rate per kilometre of regular diesel buses*.
- Next, we compare these emissions with the real emissions of hybrid buses.

Data in tons of CO_2e	**Total 2016-2018**
GHG emissions of hybrid buses (2016-2018)	20,314
GHG emissions of diesel buses for km travelled by hybrid buses (2016-2018)	24,382
STM GHG emission reduction (fuel savings of hybrid buses vs. diesel buses)	**- 4,068**