

# The results

Information Bulletin on the testing of hybrid buses at the STM

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### Conclusion

Following a year of in-service trials, the test results demonstrate the efficiency of hybrid biodiesel-electric propulsion in reducing GHG emissions.

The principal findings of the study indicate that based on the conditions in effect at the STM, the hybrid bus consumes some 20 litres/100 km less than the standard bus when the number of stops per kilometre varies between two and ten, and when its average speed is maintained at close to 18 km/h.

Cold weather has a greater effect on fuel consumption for the hybrid bus. At 18 km/h, it increases by 16% when the outside temperature goes from + 15 °C to - 15 °C. For the standard bus, it varies by barely 2%. Despite this, the hybrid bus consumes less than the standard bus in cold weather, and remains more ecological.

Fuel consumption is affected by the acceleration required for a standard bus. Aggressive acceleration generates 42% higher fuel consumption than gentle acceleration in the case of the standard bus. This variation is in the order of 18% for the hybrid bus.

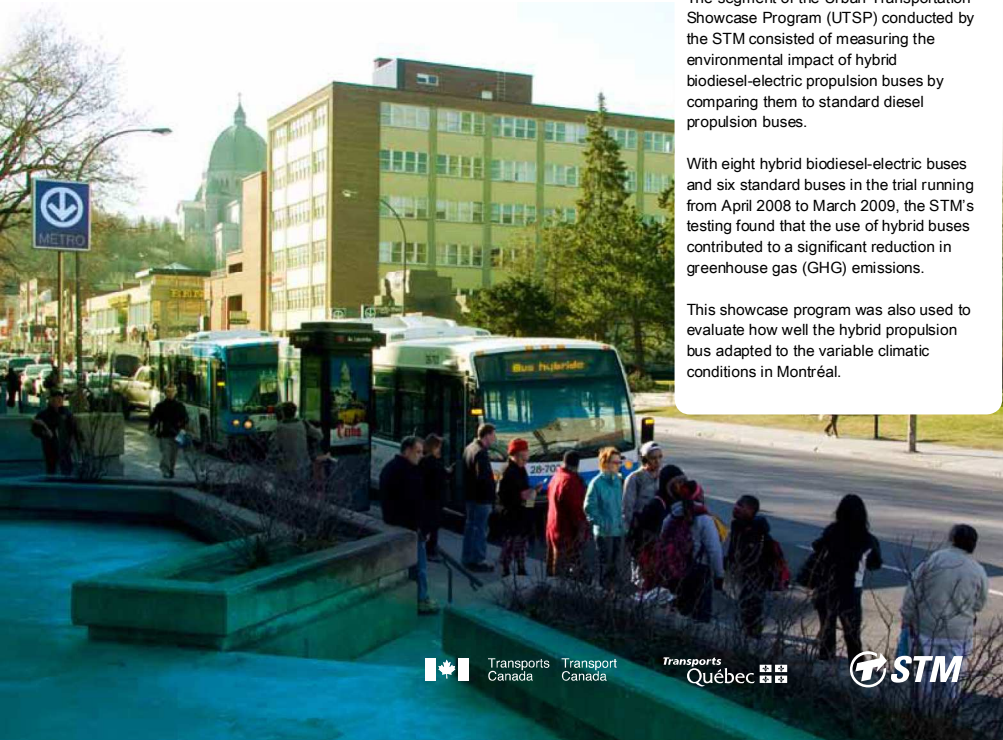
Finally, at the end of a full year in circulation on the same routes, the hybrid buses have consumed 30% less fuel than the control buses.

### Hybrid biodiesel-electric propulsion at the STM

The segment of the Urban Transportation Showcase Program (UTSP) conducted by the STM consisted of measuring the environmental impact of hybrid biodiesel-electric propulsion buses by comparing them to standard diesel propulsion buses.

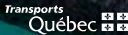
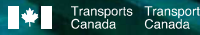
With eight hybrid biodiesel-electric buses and six standard buses in the trial running from April 2008 to March 2009, the STM's testing found that the use of hybrid buses contributed to a significant reduction in greenhouse gas (GHG) emissions.

This showcase program was also used to evaluate how well the hybrid propulsion bus adapted to the variable climatic conditions in Montréal.



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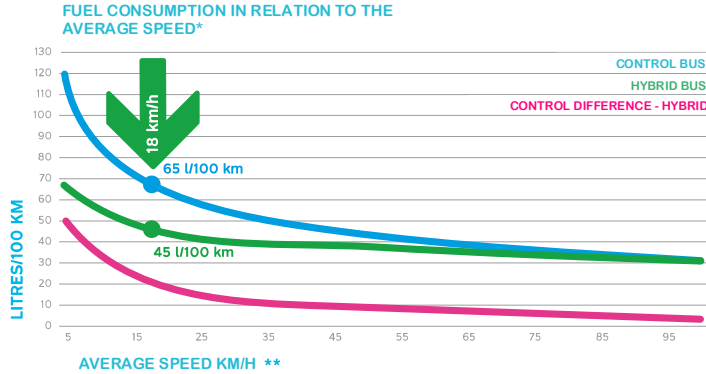
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## Hybrid technology and fuel consumption

During the in-service trials on the road, the average speed, the number of stops per kilometre, the outside temperature and the type and force of acceleration were some of the factors analyzed with the help of tools that compiled more than 20 billion multiple data. These variable factors were also analyzed in relation to fuel consumption.

The following chart illustrates the fuel consumption in relation to the average speed of the hybrid buses and the standard buses.



\* NOVA BUS 2008 buses = the heating system consumption is not included.

\*\* Including time stopped with engine running The STM's overall average speed is approximately 18 km/h.

## ... as regards the reduction of GHG emissions

The reduction of GHG emissions is directly proportional to the reduction in fuel consumption. Using the hypothesis that a bus travels a distance of 70 000 km annually, one notes a reduction of 36 tonnes of GHGs per hybrid bus. While a hybrid bus emits 5% more oxides of nitrogen (Nox) than a standard bus, it emits 36% less carbon dioxide (CO<sub>2</sub>). In addition, the engines of buses acquired since 2008 do not emit significant quantities of particles or total hydrocarbons (THC).

This annual reduction of 36 tonnes of GHGs is the equivalent of removing more than seven automobiles from the road. In fact, an automobile that travels 20 000 km/year produces approximately five tonnes of GHGs per year.

## ... and employee and customer satisfaction

STM bus drivers enjoy driving the hybrid buses. The reduced noise level and smoothness of the ride are two benefits that are very much appreciated by the drivers. They also feel that the hybrid propulsion bus helps to protect the environment, and they would like to see a greater number of this type of vehicle in the STM's fleet.

As for clients who have travelled on a hybrid bus, they recognize the fact that this propulsion method is quieter and has a smoother ride. Clients who have heard about it are of the opinion that the hybrid propulsion bus helps to protect the environment.

### STANDARD BUS NOVA BUS MODEL APS 2008

Speed 18 km/h  
Fuel consumption: 65 litres/100 km

### HYBRID BUS NOVA BUS MODEL APS 2008

Speed 18 km/h  
Fuel consumption: 45 litres/100 km

**REDUCTION IN FUEL CONSUMPTION: 20 LITRES/100 KM OR 30%**

When speeds approach 100 km/h, the two types of buses consume a similar quantity of fuel.

## Other observations:

The type of acceleration has much less effect on fuel consumption for the hybrid bus than for the standard bus.

With fast acceleration, the reduction in consumption for the hybrid bus is at its best in comparison with the standard bus.

When slow acceleration is required, consumption is reduced for all the buses. However, the hybrid bus still holds the advantage.



The low-voltage electric ventilator system (1) was installed on the outside of the radiator on an STM hybrid bus and an STM standard bus. A section for cooling the hybrid transmission fluid (2) was added on the roof of the hybrid bus.

## Beyond hybrid technology Two promising technological solutions

Thanks to analysis techniques developed as part of this project, the engineering team at the STM has evaluated two technological solutions whose promising environmental benefits have yet to be demonstrated:

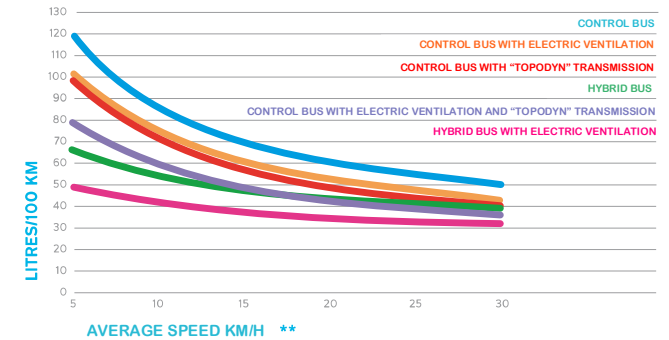
- low-voltage electric engine ventilation (rather than hydraulic engine ventilation) to cool the engine.
- optimized programming of the transmission on the standard bus using the "Topodyn" software.

Two days of on-road testing were required to install the "Topodyn" programming on the transmission of the standard bus. During these trials, the programming was calibrated and optimized based on the STM's operating conditions.

The effects of the "Topodyn" programming are as follows:

- It provides smoother acceleration.
- It increases the temperature and fuel combustion pressure, which translates into a reduction in consumption.

### TESTS OF THE ELECTRIC VENTILATION AND THE PROGRAMMING OF THE TRANSMISSION ON FUEL CONSUMPTION \*



\* Note that the hybrid bus does not have mechanical transmission.

\*\* Including time stopped with engine running The STM's overall average speed is approximately 18 km/h.

## Impact on fuel consumption and the reduction of GHGs

On the standard bus, electric ventilation and optimized programming of the transmission (Topodyn) result in a reduction of 31% in fuel consumption.

On the hybrid bus, electric ventilation results in a reduction of approximately 22% in fuel consumption. It is thus almost 20% more economic in comparison with the standard bus equipped with electric ventilation and the "Topodyn" programming.