

**GHG Accounting in a Construction Project:
The Case of Montréal's Turcot Project**

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SUMMARY

The *Ministère des Transports du Québec* has undertaken the Turcot project whose central element, the Turcot Interchange, one of the most important in Québec on which more than 300,000 vehicles travel daily, must be rebuilt. The Turcot project also includes the reconstruction of three other interchanges, as well as sections of adjacent highways. The work began in 2011 and will last until 2020. The cost of the project as a whole is estimated at more than \$3.5 billion.

The Ministère has decided that the Turcot project should be a carbon-neutral construction project and wants the greenhouse gas (GHG) emissions linked to the construction activities to be subjected to a compensation so that the construction activities result in a carbon-neutral footprint.

Since this is a new way of doing things at the Ministère and few attempts have been made with regards to construction sites in Québec, the Ministère has developed a methodology to account for GHG emissions linked to construction activities. To do so, the first step was to identify the activities selected for measuring emissions and develop a method of accounting easy to use on worksites in order to draw a faithful portrait of GHG emissions.

The first constructions for the Turcot project were carried out with traditional methods and the Ministère performed a pilot project on a worksite to account for GHG resulting from the work performed, which was expected to result in a better method of estimating GHG emissions for the overall project.

The experience gained in the first constructions lots shows that accounting for GHG emissions on a construction worksite as large as that of the Turcot project presents a certain number of challenges as there are numerous sources of emissions and the activities themselves are "mobile" in nature.

Background

The *Ministère des Transports du Québec* (the "Ministère") has undertaken the Turcot project whose central element, the Turcot Interchange, must be rebuilt. The Turcot project also includes the reconstruction of three other interchanges and sections of adjacent highways, as well as work on the local road network. Located on the island of Montréal, west of the downtown area, the Turcot interchange is one of the most important highway interchanges in Québec since more than 300,000 vehicles travel on it on a daily basis, including some 30,000 trucks. It links Autoroutes 15, 20 and 520 which provide access, in particular, to downtown Montréal and to Montréal's international airport.

The Turcot project is located in an urban setting and its completion involves some important challenges, including the maintenance of traffic flow while work is carried out and the presence of built-up sectors close by, including several residential neighbourhoods. Work started in 2011 by way of so-called "preparatory" projects and will last until 2020. The cost of the project as a whole is estimated at more than \$3.5 billion, which makes it one of the most important construction worksites in Québec.

Early in the planning phase of the project, the Ministère wanted the Turcot project to be exemplary on the environmental and sustainable development levels and undertook a reflection on the ways and means to be implemented to reach this objective. It is within this context that the Ministère decided that the completion of the Turcot project would be carbon neutral. This commitment implies that greenhouse gas (GHG) emissions associated with construction activities are accounted for and become the object of voluntary compensation, since up to now there is no regulatory framework in Québec imposing compensation for a road construction project.

This document details the methodology retained by the Ministère to meet this commitment, as well as the ways implemented up to now to account for GHG emissions with a view to their compensation. It also covers the challenges involved in taking an inventory of GHG emissions in a concrete situation such as a vast construction worksite like that of the Turcot project.

Identifying Targeted Activities

Right from the start of the project's planning phase, the Ministère had to provide definitions of the construction activities that would be used to establish what would compensate for GHG emissions. The activities retained were:

- emissions linked to construction activities on the project's worksite (use of mobile equipment such as bulldozers, graders, cranes, loaders, etc. or fixed equipment like generators);
- emissions associated with the transport of all construction materials to the project site and between the various sectors within the site;

- emissions associated with transporting demolition and excavated materials off site.

Accounting for GHG emissions thus excludes those emissions associated with activities that take place before materials are transported such as, for example, extracting raw materials and transforming them into construction materials, as well as emissions linked to transporting workers towards their employment site. Activities associated with moving the railway lines (one of the components of the Turcot project) are also excluded as this will be done by the railway company, owner of the installations.

Preliminary Estimates of GHG Emissions

In 2009, following the decision to make the Turcot project carbon neutral, the Ministère had preliminary estimates made of GHG emissions associated with completing the project.¹ This study also allowed the exploration of possible compensation methods for the project.

The study included two phases, one was to research typical emission factors for the construction of similar projects, as well as the identification and evaluation of data associated with the Turcot project that was necessary for the preliminary estimates of emissions such as, for example, the type of construction equipment used, the volume of materials to be transported, etc.

A review of the literature was also undertaken to identify a method to estimate emissions based on typical emission factors for the construction of similar works, for example, the rate of GHG emissions per unit of length of road constructed, per cubic metre of concrete poured, or per cubic metre of fill and excavation material manipulated, per cubic metre of pavement, etc. The review of the literature did not succeed in locating the type of data required, based on the particular characteristics of the Turcot project (construction in great part on fill material, several engineering structures, etc.) which are different from those of the construction of standard roads.

The classical approach to evaluating GHG emissions, based on using emission factors associated with each source of emissions, was chosen for the preliminary estimate of GHG emissions from the Turcot project. These emission factors can be based, either on the consumption of fossil fuels, or on the distances travelled, or on the length of time different types of machines are in operation.

In order to prepare the preliminary estimates of GHG emissions for the Turcot project, an evaluation of the quantities of materials needed for the project was carried out. The project was then divided into different categories of work:

- earthworks: estimated quantities of fill and excavation materials;
- construction of roadways: quantities of granular material, bituminous coated material and concrete for rigid roadway surfacing;
- construction of drainage infrastructures: number of lines, sumps and manholes to be installed;

- construction of engineering structures: quantities of steel and concrete needed to build bridges, retaining walls and sound attenuation barriers, etc.;
- the quantity of material generated by the demolition of existing structures.

This evaluation allowed us to deduce the number of trucks that would be necessary to supply the site and are presented in Table 1.

Table 1 Quantity of materials used for the preliminary estimates of GHG emissions for the Turcot project

Type of work and materials	Estimated Total Quantity of Materials	Estimated Total Number of Trucks
Earthworks		
Fill and Excavation Materials	1,630,000 m ³	135,900
Roadway Structure		
Granular Materials	1,790,000 t	71,600
Bituminous Coated Material	180,000 t	7,200
Rigid Roadway Surfacing	123,000 m ³	15,400
Drainage Infrastructures		
Lines, Manholes, Sumps	48,000 t	2,000
Engineering Structures		
Structures, Walls and Sound Attenuation Barriers (concrete)	140,000 m ³	17,500
Structures, Walls and Sound Attenuation Barriers (steel)	105,000 t	4,200
Demolition	300,000 m ³	25,000
Total Number of Trucks		253,800

At the time this preliminary estimate was carried out, detailed information on the transportation of materials (distances to be covered) and on the length of time various equipment would be used on the worksite was not available. Hypotheses were developed to establish the distances to be covered to transport materials based on the location of potential sources of supply for various types of materials. The distances considered varied between three and fifty kilometres which gave a total estimated distance of more than 7,350,000 kilometres.

Afterwards, on the basis of the quantities of materials that would need to be put in place, an estimate of the operating times of various equipment was calculated based on productivity hypotheses. An example of the hypotheses used for the construction of roadways is presented in Table 2.

Table 2 Estimate of operating time for the construction of roadways for the Turcot project

Activity	Quantity	Production	Time	Type of equipment needed
Placing of granular materials	1,790,000 t	120 t/h	14,920 h	Bulldozer 149 kW
		120 t/h	14,920 h	Roller
		120 t/h	14,920 h	Water truck (10-wheeler)
Placing of bituminous coated material	180,000 t	60 t/h	3,000 h	Paver
		60 t/h	3,000 h	Tanker truck (10-wheeler)
		60 t/h	3,000 h	Roller
Placing of bituminous coated material	123,000 m ³	51 m ³ /h	2,400 h	Spreader
		51 m ³ /h	2,400 h	Backhoe
		51 m ³ /h	2,400 h	Grader 140 kW
		51 m ³ /h	2,400 h	Dump truck (6-wheeler)

In summary, the basic data used for the preliminary estimate of the GHG emissions for the Turcot project are:

- for emissions from transporting materials (including demolition materials):
 - the type of vehicle;
 - the total volume of each type of material to be transported;
 - the average distance to be covered to deliver each type of material;
 - the average fuel consumption to evaluate total fuel consumption;
 - the emission factors according to the type of fuel (g/l);
- for emissions from operating machinery on the construction site:
 - the average operating time (in hours) estimated for each type of equipment and for each phase of the project;
 - the type of equipment (power and load factor);
 - the emission factors according to the type of equipment (g/hp/h).

The estimate takes into account GHG emissions associated with the use of fossil fuels, mainly carbon dioxide (CO₂) and, to a lesser degree, methane (CH₄) and nitrous oxide (N₂O). Emissions are reported in CO₂ equivalent tons taking into consideration the climate warming potential of various greenhouse gases as compared to CO₂.

This attempt to estimate GHG emissions establishes that the emissions associated with the construction of the Turcot project would be in the order of 17,400 metric tons of CO₂ equivalent, or:

- 10,259 tons of CO₂ equivalent for emissions associated with equipment used on the worksite;
- 7,126 tons of CO₂ equivalent for emissions associated with transporting materials.

Compiling Data on GHG Emissions During the Work

In the summer of 2011, construction work on the Turcot project began with a first worksite (construction of an overpass). This was the moment to reflect on a method for compiling data on GHG emissions in a real-life construction worksite involving roadway infrastructures. Since no such method existed at the Ministère, the approach chosen to collect information on the first worksites associated with the Turcot project was to collect and compile data on fuel consumption by the various equipment used on the worksite and on fuel consumption associated with transporting construction, demolition and excavated materials.

In cases where information on fuel consumption is not available, compiling other types of data such as, for example, the length of time equipment is operating or the distances covered, is needed to evaluate GHG emissions. This second avenue can thus be a good alternative if fuel consumption data is not available and can also serve to validate the fuel consumption data provided by contractors.

Requirements relative to the compilation of data were included in the construction specifications which become part of the contracts linking contractors to the Ministère. The contractors are paid to carry out the compilation according to an amount established by the Ministère and which is included in the bill of quantities and prices. This amount varies based on the worksite's duration.

A data compilation table (Excel worksheet) was developed and is given to each contractor at the start of work in order to ensure uniformity in data collection between the various worksites of the Turcot project. The table also includes the instructions needed to complete it.

According to the specifications, contractors must supply the Ministère on a weekly basis with the information identified in the specifications. Although the data on fuel consumption is what will allow a more accurate estimate of GHG emissions, the Ministère also chose to collect other information, such as the distance covered and the number of hours equipment is in operation, to provide an estimate of GHG emissions

when fuel consumption data is not available as well as to validate the original data. For example, for equipment present on the worksite for construction work, the contractor must provide on a daily basis the type of equipment, its brand and model, the type of fuel used, the consumption of fuel in litres and the length of operation in hours. For transporting materials to or from the site, the contractor must provide on a daily basis the type of vehicle, the type of fuel, fuel consumption and/or the distance covered, the nature of the materials transported as well as their point of origin and their destination.

Experience over close to two years on the four completed or current worksites of the Turcot project show that collecting the data needed to estimate GHG emissions on a worksite is, all in all, a tedious activity for contractors since it requires the daily compilation of data. On vast construction worksites, the sources of emissions are multiple and the quantity of information to be collected daily can be significant. It becomes difficult, for instance, to trace all truck movements. Moreover, the general contractor does not necessarily have all the information on hand to complete the tables required by the Ministère. Some data concerning fuel consumption or the distances covered by truck fleets operated by transportation sub-contractors are not automatically supplied by the latter, which can result in an emissions estimate that is too low.

Taking into account the newness of this approach in road construction worksites in Québec, contractors and job supervisors do not necessarily understand the final goal of the process, although the objective which is the foundation of the process was clearly explained in the specifications. A greater effort to increase awareness must therefore be expended when a worksite starts up to ensure the contractor and the job supervisor are informed of the necessity of providing data that is as exact as possible and this, on a continuing basis.

This observation brings with it questions on how to carry on for the rest of the project as well as for future projects. Mostly, though, it is a plea for the development of a tool that will be capable of estimating GHG emissions and that is adapted to road construction worksites.

Estimating GHG Emissions Associated with the Completion of the Turcot Project

The data collected by contractors in the context of the first construction lots of the Turcot project will allow the Ministère to calculate GHG emissions associated with the work in order to establish compensation. An evaluation model for GHG emissions (Excel worksheet) was developed for the Turcot project. In addition to the data collected on the construction worksites which is entered into the model, the latter includes GHG emission factors according to the type of equipment or vehicles used and according to the type of fuel consumed. The emission factors used are those retained by Environment Canada in the last version of their National Inventory Report on Greenhouse Gas Sources and Sinks in Canada.²

A validation of the data provided by contractors must also be done by the Ministère before undertaking the phase of estimating GHG emissions. To this end, data from different worksites are compared and adjustments can be made if the Ministère notices, for example, that certain activities generating GHG emissions have not been compiled within the scope. The validation of the data collected by contractors within the framework of the Turcot project construction lots completed in 2011 and 2012 is presently under way, which should allow us, within the next few months, to estimate GHG emissions by construction activities carried out up to now.

In light of the first analyses performed on the data, it would seem that GHG emissions associated with construction activities are, in all likelihood, higher than the preliminary estimate prepared in 2009 before the start of construction work on the Turcot project. Several factors can explain this situation, including the fact that the preliminary estimate of GHG emissions was done on the basis of substantial quantities of materials coming from the preliminary project and that certain activities were not taken into consideration (such as the transportation of materials needed for temporary constructions such as formwork or the consumption of fuel from fixed equipment like generators).

Moreover, subsequent stages in project planning allowed us to refine information regarding the quantities of materials required and the quantities of materials excavated. For example, in one sector of the project, it was decided to excavate a layer of peat under the topsoil in place which action will generate approximately 1.5 million cubic metres of additional material to manage, thus having a significant impact on the operating time of equipment and on the transportation of material to and from the site.

This observation sheds a light on the need to develop prediction models for GHG emissions adapted to road construction projects that are sufficiently detailed to take into account all the emission sources found on a construction worksite. The current exercise in accounting real data from GHG emission sources in the Turcot project could be used to develop such an estimation tool, if it proves possible to deduce typical GHG emission rates by category of works or activities or even by unit built of a particular infrastructure type (roadway, structure, etc.).

Compensation

To start with, the Ministère wants the planting of trees on the Turcot project site to be the privileged mode of compensation. However, this option will only compensate a small portion of GHG emissions associated with the completion of the Turcot project. In fact, an estimate in 2009 on the basis of plantings within a preliminary landscaping concept for the project shows that a surface of some seven hectares will be available for planting trees, thus compensating directly on the site a quantity of approximately 1,400 tons of CO₂, which represents approximately 8% of GHG emissions.¹

Other alternatives must therefore be found. Compensation projects carried out in Québec and within the framework of the Western Climate Initiative (WCI) will be privileged. Selected compensation projects will have to be verified and certified compliant with a recognized standard confirming that reductions in GHG associated with these compensation projects are real, permanent and verifiable.

Conclusion

Completing a carbon-neutral road project is a first for the Ministère des Transports du Québec. This objective obligates the Ministère to develop tools and processes to ensure that the measurement of GHG emissions is as accurate as possible. The current exercise to account for GHG emissions within the framework of construction worksites, in addition to establishing compensation, aims at developing estimation tools that are more effective and that could in the long-term replace the daily compilation of data for the duration of worksite activities. Experience shows, in fact, that compiling data within the framework of a construction worksite where emission sources are multiple, and often mobile, requires efforts that are quite significant.

¹ Gestion TECSULT-BPR, mai 2009. Bureau de projet du Complexe Turcot – Émissions de gaz à effet de serre (GES), estimation préliminaire et approche de compensation, 6 pages + annexes.

² Environment Canada, National Inventory Report 1990-2010: Greenhouse Gas Sources and Sinks in Canada, 2012