GRAND PARIS EXPRESS

Greenhouse gas emissions balance
Summary and conclusion of the balance 2018

August 2019

1. CONTEXT

The public transport network project Grand Paris Express (GPE) consists in the creation of a new automatic subway covering about 200 km and including 68 stations and 7 technical centers associated with the different lines. This network will connect Paris city to the major poles of development of the Ile-de-France region and will be closely linked with existing main transport lines. More than just a transport infrastructure project, the Grand Paris Express network is first of all an ambitious urban, social and economic project aiming at connecting the major strategic territories of the Ile-de-France region and promoting the sustainable, solidary and job-creating economic development of the capital region[1]. The scope of this project is therefore very large, not only on a geographical level, as its impact is expected to cover the entire Ile-de-France region and beyond, but also regarding to the activity sectors, as it is expected to have effects on the mobility, the economy, the demography, the environment, etc.

This project will have a tremendous impact on the future developments of the Ile-de-France region, in its various economic, social and territorial dimensions. All these aspects will have a significant effect on the greenhouse gas (GHG) emissions.

1.1. Objectives of the project

The Grand Paris Express will have beneficial effects, not only on transportation but also on economic, social, territorial and environmental levels. It will help improving the quality of life by preserving natural and agricultural spaces and reducing pollution and nuisances. It will therefore guarantee a more sustainable development of Ile-de-France region.

Better transport provision

Today, 70% of the travelling within Ile-de-France region concerns trips between suburbs, and 80% of these trips are made by car, as there is no performant public transport alternative available. Indeed, people who want to travel from one suburb to another using public transport have generally no other way than passing through the center of Paris, which extends the travel time and saturates the lines of both the subway and the regional express network (RER).

The Grand Paris Express project aims to improve the transport provision in order to:
- meet the transportation needs of people travelling from one suburb to another;
- reduce congestion on the most overloaded lines of the current network by allowing people to bypass Paris when travelling between suburbs;

[1]Article 1 of the Law nr. 2010-597 of 3 June 2010 with regard to the Grand raris

- improve the access to the TGV (High Speed Train) railway stations and the airports (Roissy-CDG, Orly, Le Bourget) from every location in the region.

The project will provide better transport services and improve the quality and the comfort of public transports in Ile-de-France region, and thus lead to a modal shift from car to public transport.

Economic and urban effects

The Grand Paris Express transport network will foster the economic development of Ile-de-France region:

- by facilitating the access to territories that are currently poorly integrated in the metropolitan structure, and by connecting them to the region's major employment poles;
- by interconnecting the major activity poles which are economic growth generators for the region;
- by improving the territory's attractiveness, the functioning of the job and housing markets, and the exchanges between activities.

All these aspects are drivers of job creation and productivity gains for both companies and public services.

The subway should also contribute to a better development of the Paris conurbation. Indeed, the new provision of public transport will go hand in hand with urbanization of station neighborhoods, associating housing and employment. Accompanying measures will be implemented to provide a new dynamism to the surroundings of the Grand Paris Express stations and to control the urban spread. These policies include building control, urban parking, pricing of the public transport in favor of the GPE, more qualitative public spaces and intermobility. These accompanying measures will support a more compact conurbation structure as well as denser urban projects.

Participation in sustainable development

The GHG emissions per kilometer travelled in mass transit transport are largely inferior to the emissions produced by private cars. In this way, the modal shift, which might be significant with time, will lead to a global reduction of emissions linked to the travelling of Ile-de-France inhabitants.

GHG emissions related to housing and employment vary according to the density of the urban fabric and the quality of public transports. By opening up certain territories, by bringing inhabitants and jobs closer together and by promoting a denser urban fabric, the Grand Paris Express will also have a positive effect of the GHG emissions.

1.2. Environmental approach of the Société du Grand Paris

In 2010, the Société du Grand Paris set up a strategic environmental assessment of the project. It has since been completed with many environmental, technical and socio-economic studies.
From the first steps of this environmental approach, the Société du Grand Paris decided to adopt construction methods adapted to each subway section, station and building, in order to turn the Grand Paris Express project into a major lever in the climate change mitigation policies.

The studies address all the environmental challenges of the new subway and its construction sites. This approach allowed to assess the foreseeable environmental effects of the project and to identify upstream the measures aiming to prevent or reduce the negative impacts of the subway, both during the construction and after when the subway will be operated.

The first environmental studies pointed out the various sources of GHG emissions and savings generated by the project, as well as the necessity to adopt a highly innovative approach to assess these effects. A consortium of independent engineering firms was therefore mobilized to develop a specific tool able to take into account the multiple impacts of the project and to assess in the most accurate way the GHG emissions linked to the Grand Paris Express.

A specific method, called CarbOptimum method was then developed, based as much as possible on the existing tools for assessing the GHG emissions of major projects, and the extensive research that has been conducted over the years on this topic. The elements available in the literature and the existing methodologies were used, although most of them needed to be adapted to the regional context of the Ile-de-France and the Grand Paris Express project. Indeed, their parameters used to calculate the impact were generally based on national or international averages and were related to the short-time economic and demographic effects of transport infrastructure projects, while the effects of the Grand Paris Express project will mainly be felt in the long or very long terms.

Compared to the existing methods, CarbOptimum tool provides a much more prospective vision of the GHG emissions and takes into account the evolutive character of the emissions factors. It allows to consider all the project phases and covers the period from the pre-studies until 20 or 30 years after the putting into service of the first subway lines. It is set up around five major topics: (1) Pre-construction studies and works, (2) Construction of the GPE, (3) GPE operation, (4) Mobility in the Ile-de-France and (5) Territorial development. The tool has been conceived to assess the emissions that have been produced and avoided year after year, allowing as such to visualize the changes over time.

2. ASSESSMENT OF THE IMPACT OF THE GPE ON THE GHG EMISSIONS

The Grand Paris Express project has already been the subject of several GHG emission balances, established for the needs of the different authorizations necessary for projects deemed to be in the national interest (called in France “déclaration d’utilité publique”). These assessments considered two scenarios differentiated by population and employment growth hypotheses.

The update undertaken in 2018 allows to take into account several new elements with regard to the retained perimeter, the construction techniques and the emission factors. It also considers two new scenarios, named A and B, that are based on various hypotheses related to the emission factor levels and the intensity of the effects of the Grand Paris Express project. Scenario A, considered as the lower part of the range is based on minimizing hypotheses while scenario B, considered as the higher part of the range, includes hypotheses that are probably more realistic and still cautious. Furthermore, both scenarios only consider the effects of the Grand Paris Express that are commonly recognized and quantified. Indeed, studies carried out by the Société du Grand Paris show that the Grand Paris Express could also generate a large number of indirect, long-term effects, more specifically with regard to the changing mobility behaviors and the ways of living and working. These long-term behavior changes have not been modelled precisely yet and therefore were not included in these balances, although these changes may involve considerable GHG savings in the long term.

2.1. Pre-construction studies and works

Several emission factors for tertiary services available in the literature, such as the factors proposed by ADEME[2] and Defra[3] methods, have been analyzed during the development and the update of CarbOptimum tool. These

[2] Guide des emission factors V6.1, ADEME, 2010 et Base carbone mai 2019.
[3] Guidelines to Defra / DECC’s GHG Conversion Factors for Company Reporting.

emission factors have also been compared to specific assessments to finally retain an emission factor of 110g CO_2eq per euro spent in scenario A, and of 68g CO_2eq per euro spent in scenario B. As the energetic efficiency of these services constantly improves, an annual reduction of 1% of these emissions has also been considered.
The budgets of the pre-construction studies and works include the expenses born by the Société du Grand Paris as well as the budget allocated to all the Grand Paris Express related studies, assigned to several independent engineering firms through public procurement (design and general contracting studies, environmental studies, legal services, etc.).

The most up to date estimations of the budgets allocated to the different studies and to the project management (about 3.85 billion euros, which represents about 10% of the global construction budget) have been used to assess the emissions in terms of tons of CO_2 equivalent. These emissions have been spread over the period 2010-2030, given the fact that a steering activity will remain in place until the complete entering into service of the GPE in 2030.

Based on these hypotheses, GHG emissions (expressed in tons of CO_2 equivalent) have been estimated at 419,935 t CO_2eq for scenario A and 259,596 t CO_2eq for B over the entire period considered (2011-2030).

2.2. Grand Paris Express construction

Construction of major transport infrastructures produces large amounts of GHG emissions, not only in terms of organization of the construction site (travelling of workers, use of construction machinery and equipment, etc.) but also in terms of production and transportation of building materials: energy consumption on construction sites (electricity, combustion of fuel by the machinery and the power generators, etc.); depreciation of construction machinery; materials (especially concrete and steel whose production produces important GHG emissions); transportation of materials as well as evacuation and disposal of large quantities of excavated materials that will require the use of heavy load trucks, trains or barges which also produce GHG emissions; and finally, the 'home to work trips' of the construction site workers who will also produce GHG emissions when they travel by car or motorcycle.

Overall, the construction phase will generate about 4,811,082 t CO_2eq (i.e. about 23,230 t CO_2eq per km of double-track railway) according to scenario A, and 4,618,100 t CO_2eq (i.e. about 22,299 t CO_2eq per km of double-track railway) according to scenario B. The table below shows the distribution of the GHG emissions per type of construction and material type, according to scenario A.

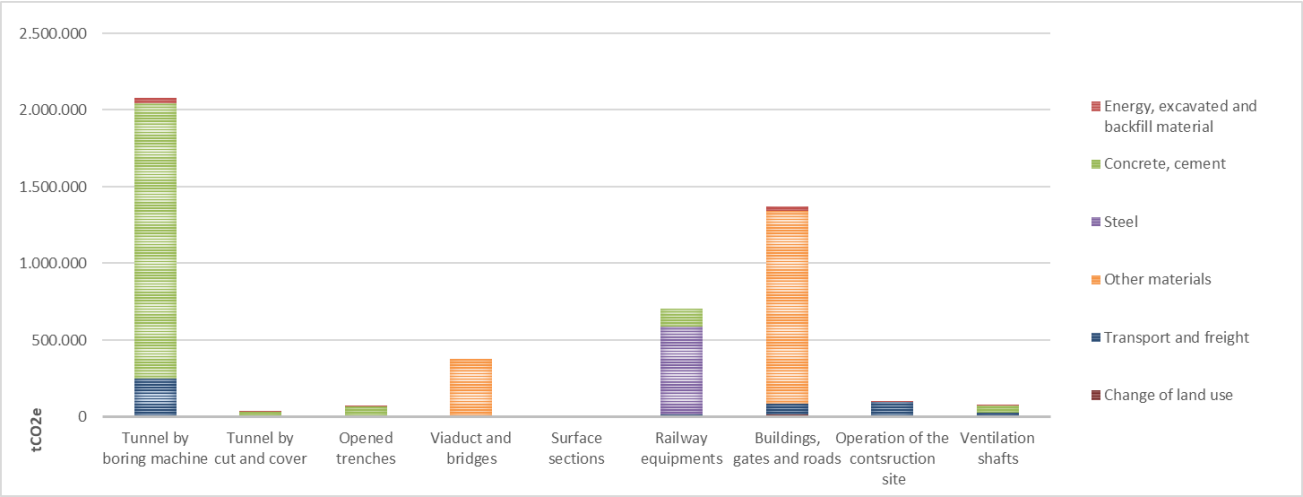

Figure 1: Global GHG emissions linked to the construction, per category, scenario A (source: CarbOptimum, 2019)

2.3. Grand Paris Express operation

Operating the Grand Paris Express will generate significant flows of greenhouse gases. They will mainly concern energy consumption and all the inputs linked to the operation of trains and stations. These flows consist of the following components: the energy required to move the trains; the energy consumption of the buildings, more specifically of the stations (lighting, heating/cooling, natural ventilation, etc.) and the technical buildings (train storage areas, maintenance workshops, etc.); emissions produced by all management, marketing, monitoring and steering activities; and, finally, the emissions linked to the maintenance and the renovation of the infrastructure (railway, trains and buildings require constant and permanent maintenance throughout their life cycle, which includes the use of replacement parts, maintenance products, etc.).

The calculation of the annual emissions related to the traction of the subway lines is based on traffic hypotheses, totaling 265,830.000 train.km per year for all the lines together. For the period between 2021 and 2050, the emissions linked to the traction have been estimated at about 696.091 t CO_2eq for scenario A, and 470,562 t CO_2eq for scenario B.

Over the same period, scenario A evaluates that the energy consumption of stations and technical buildings will produce 113,720 t CO_2eq (i.e. 75,013 t CO_2eq produced by the stations and 38,708 t CO_2eq by the exploitation and maintenance centers); while scenario B assesses these emissions at 71,038 t CO_2eq.

The maintenance and management related emissions represent a substantial part of the emissions related to the operation of the infrastructure. For the period between 2021 et 2050, the total for all the lines together is 1,115,295 t CO_2eq according to scenario A. The budget is allocated as the infrastructure is gradually being opened, proportionally to the lines that have been put into service. Scenario B assesses the emissions at 689,455 t CO_2eq.

For the period between 2021 and 2050, the emissions produced by the renovation of the railway equipment and the buildings are estimated at about 1,185,223 t CO_2eq in scenario A and at 996,401 t CO_2eq in scenario B.

Scenario A assesses the global CO_2 emissions linked to the general operation of the infrastructure at 3,110,329 t CO_2eq. This covers the emissions produced by the traction of the trains; the energy of the buildings (stations, technical facilities, both in terms of electricity and heating); the renovation, including the management and maintenance activities. Scenario B evaluates these emissions at 2,227,456 t CO_2eq.

The figure below shows the distribution of the emissions related to the operation of the infrastructure per item, according to scenario A.

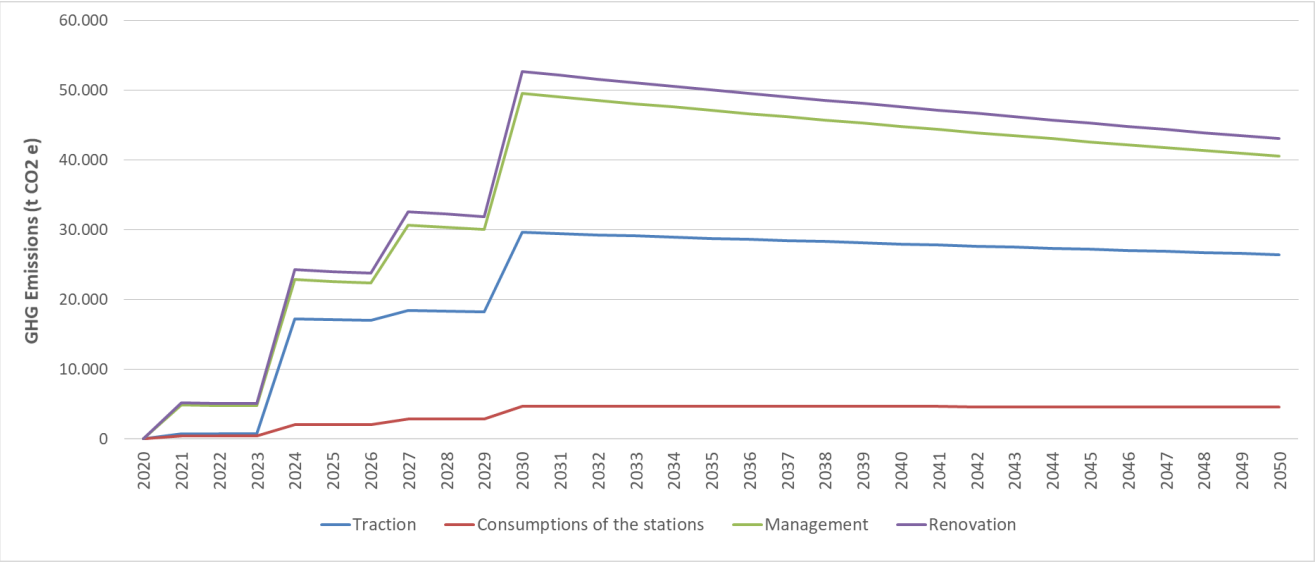

Figure 2: Annual emissions (t CO_2eq) related to the operation of the infrastructure, for lines, stations and maintenance centers, scenario A (source: CarbOptimum, 2018)

It appears that renovations represent the highest contributor to GHG emissions followed closely by the management, steering and maintenance activities. Traction energy and the energy consumption of the stations and technical buildings rank third and fourth, to a lesser extent.

2.4. Mobility

The Grand Paris Express project will reduce the use of cars and will as such lead to a reduction of the GHG emissions. Based on traffic models results, scenario A considers a traffic reduction of 1,988 million of veh.km per year; scenario B considers a higher but likely reduction of 3,290 million of veh.km per year. The graph below shows the emissions that the project will avoid throughout time, according to scenario A. It points out the differences between the emissions related to the distances travelled and the emission linked to the speed of the vehicles.

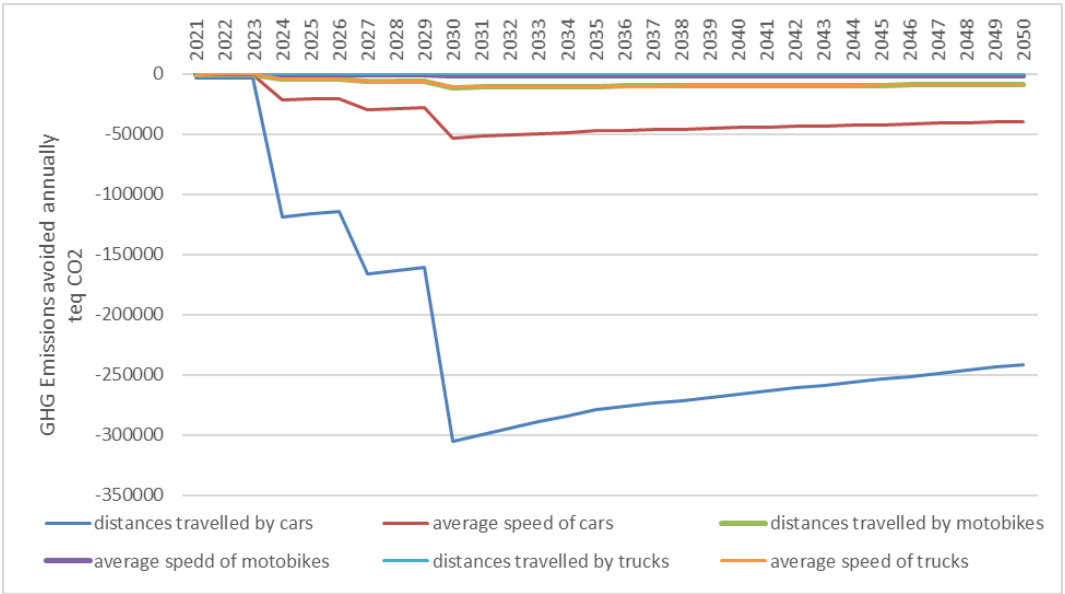

Figure 3: Annually avoided emissions (t CO_2eq) as a result of the beneficial effects of the GPE on road traffic, scenario A (source: CarbOptimum, 2018)

According to scenario A, when the entire network will be in operation, it will allow to save almost 400,000 t CO_2eq annually (-382,193 t CO_2eq in 2030). For the period between 2021 and 2050, the reduction in road traffic and better driving conditions would allow to save 8,078,899 of t CO_2eq.

Over the same period of time, scenario B assesses the avoided emissions at 13,298,166 CO_2eq.

2.5. Territorial development

The public transport network project 'Grand Paris' provides a unique opportunity of densification, linked to a greater attractiveness of the spaces located within the heart of the Paris conurbation, inducing as such a more attractive and sustainable urbanization that takes into account the energy constraints and the commitments made in terms of CO_2 emission reduction. CarbOptimum is based on a certain number of territorial forecasts provided by the "Land Use Transport Interaction" models used by the Société du Grand Paris, which allow to calculate the residential and commercial surfaces, needed to accommodate new residents and workers, as well as the hectares of wasteland, agricultural land or forests, saved from urbanization as a result of the GPE.

For the period between 2015 and 2050, the overall avoided emissions resulting from the beneficial effects of the Grand Paris Express on the territorial development, are assessed at -14,501,943 t CO_2eq according to scenario A, and -22,381,051 t CO_2eq according to scenario B. The graph below shows the emissions related to the effects generated by the territorial development as indicated in scenario A, in a cumulative way.

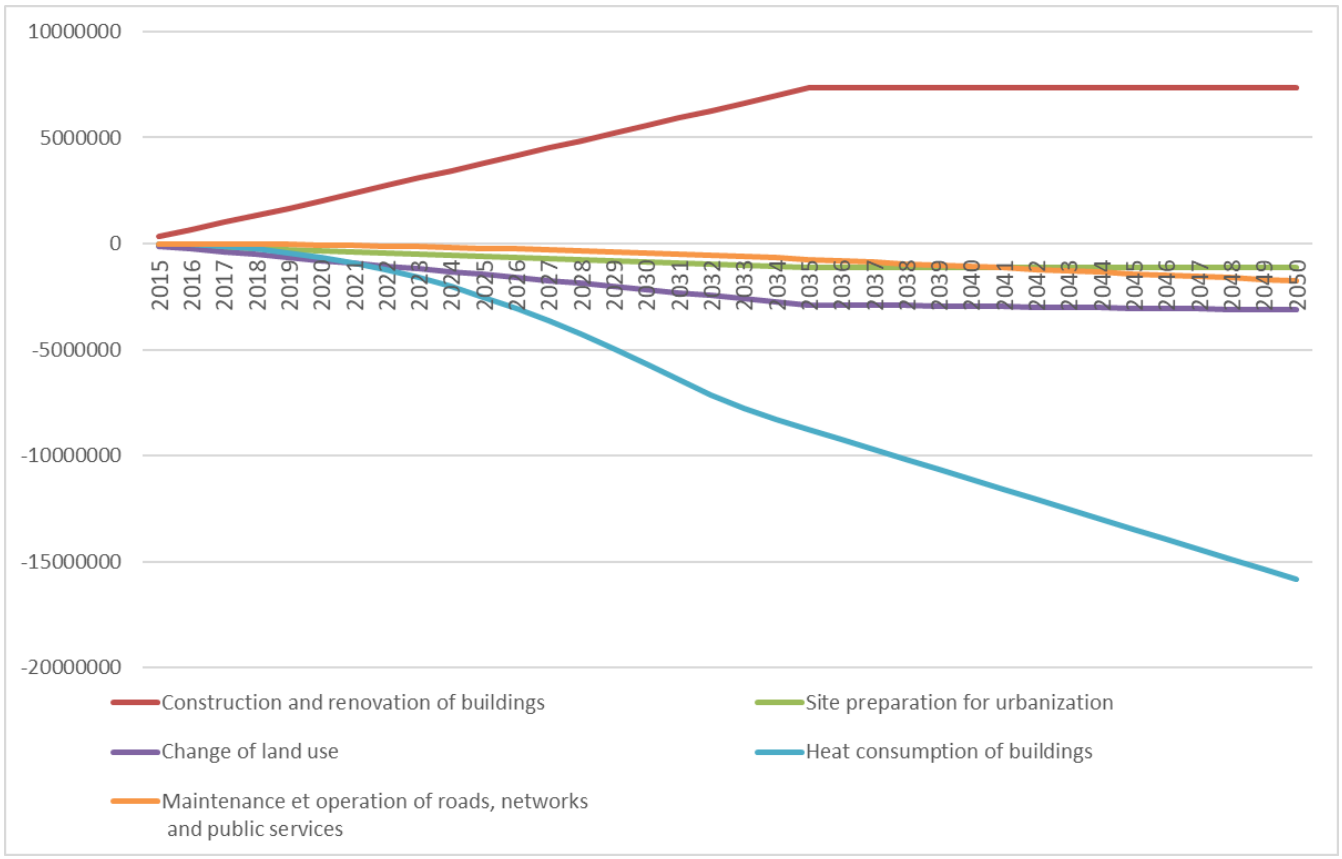

Figure 4: GHG emissions related to territorial development, cumulated throughout time, expressed in t CO_2eq, scenario A (source: CarbOptimum, 2018)

3. GLOBAL BALANCE OF THE GHG EMISSIONS RELATED TO THE GRAND PARIS EXPRESS PROJECT

The general balance of the GHG emissions produced and avoided by the Grand Paris Express, is obtained by adding together the emissions related to the different topics detailed above: pre-construction studies, construction, operation of the GPE, mobility and territorial development.
The table below shows the results of the balance by 2050 and 2070, according to hypotheses that have been retained.

Table 1: Results of the balance by 2050 and 2070, according to the scenarios, expressed in millions of t CO_2eq.

Accumulated emissions in 10^6 of t CO_2eq.	Time horizons	
Scenario	2050	2070
Scenario A	-14.2	-27.4
Scenario B	-28.6	-51.3

The graphs below show the cumulated emissions year per year according to the different items of scenarios A and B.

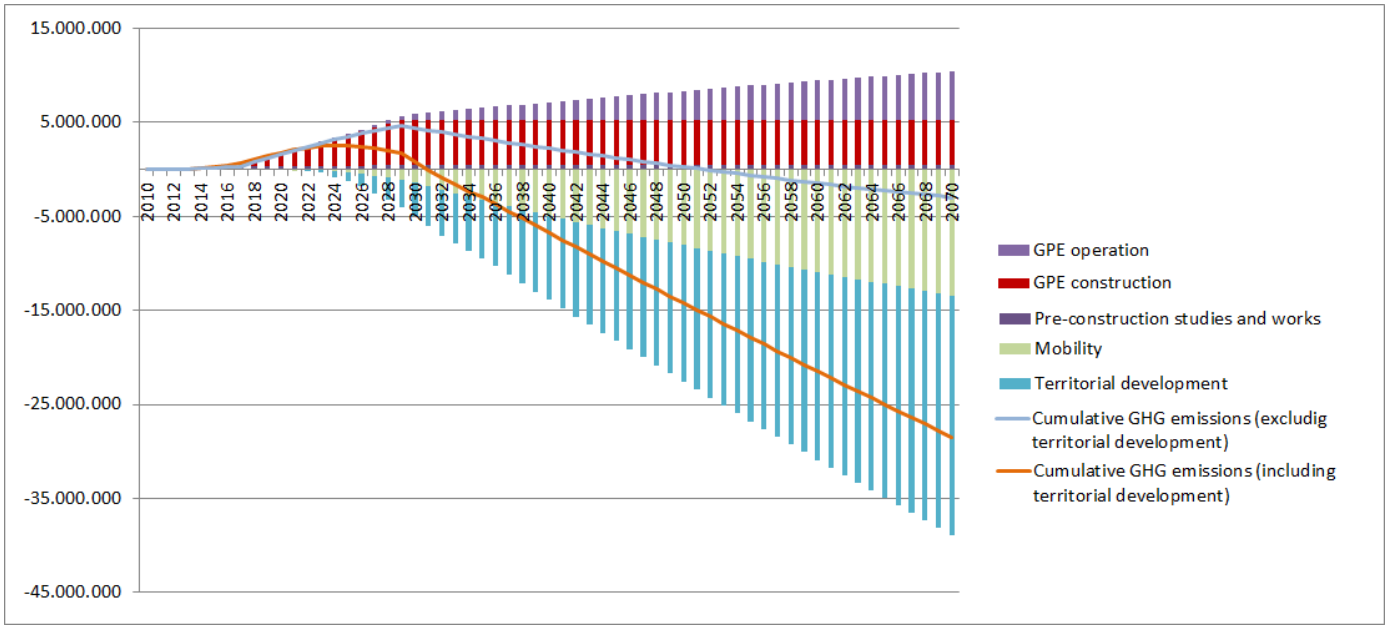

Figure 5: chronological balance of the GHG emissions related to the Grand Paris Express project, according to scenario A, expressed in t CO_2eq (source: CarbOptimum, 2018)

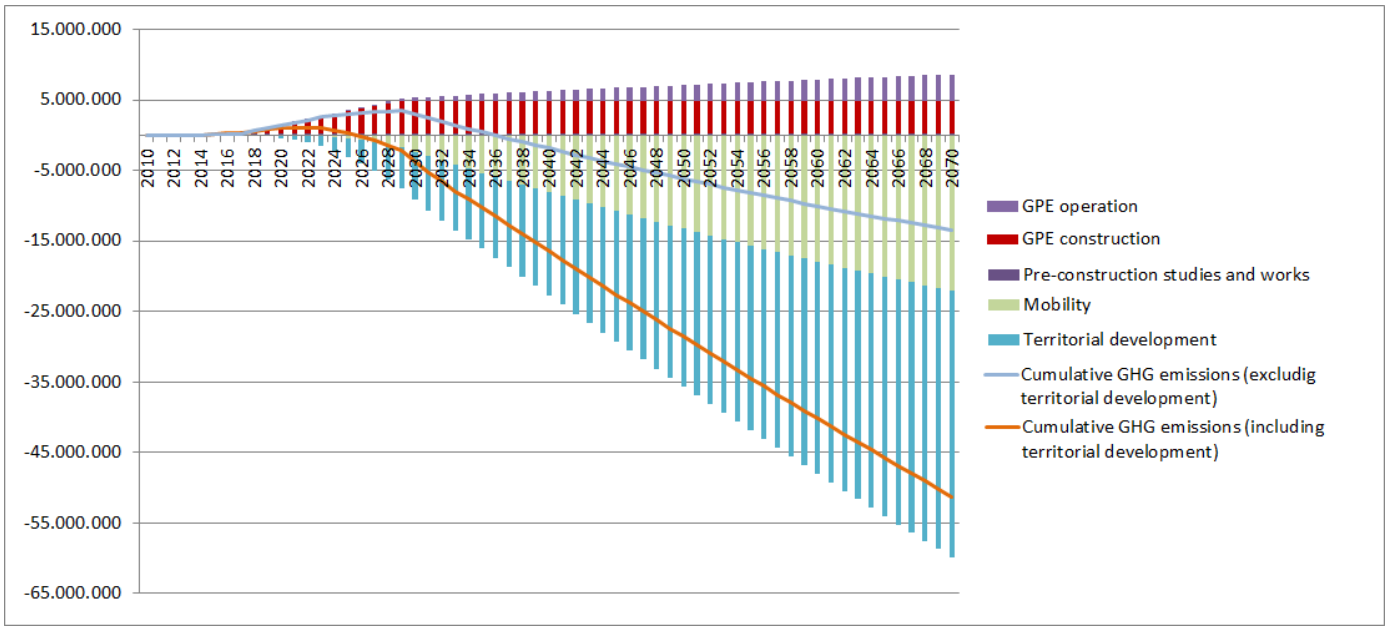

Figure 6: chronological balance of the GHG emissions related to the Grand Paris Express project, according to scenario B, expressed in t CO_2eq (source: CarbOptimum, 2018)

The balance of the GHG emissions becomes positive from 2031 in case of scenario A, and from 2026 in case of scenario B. From then onwards, the annual gains make the balance of the project increasingly positive. Indeed, between 2030 and 2070, **when the infrastructure will be fully operational, the project will allow to avoid about 754,465 t CO_2eq per year according to scenario A, and 1,225,801 t CO_2eq per year according to scenario B.** This reduction must be compared to the annual emissions of the Ile-de-France region, estimated at 40.5 billion t CO_2eq per year[4], i.e. a reduction ranging between -1,8% and -3,0%. Beyond 2050, the balance will continue this positive trend and proofs to be very positive over the life-span of the infrastructure.

In a general way, irrespective of the scenario, the balance is positive by 2050, i.e. only 20 years after the entering into service of the lines of the Grand Paris Express. In this way, **14.2 million of t CO_2eq** can be avoided according to scenario A, and **28.6 million of t CO_2eq** according to scenario B. In 2070, i.e. 40 years after the entering into service of all the lines, the avoided emissions will total **27.4 million of t CO_2eq** according to scenario A and **51.3 million of t CO_2eq** according to scenario B.

Globally, the Grand Paris Express project should allow to drastically reduce the greenhouse gas emissions level. As such, it turns out to be a major lever in the fight against climate warming, represented in France by the “Stratégie Nationale Bas Carbone”.

[4] https://www.airparif.asso.fr/etat-air/air-et-climat-bilan-emissions#ges