NEW RAILWAY LINE LYON TURIN - FRANCO-ITALIAN COMMON PART

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PROJECT MANAGEMENT ASSISTANCE (AMO) FOR THE REALIZATION OF ECONOMIC AND SOCIO-ECONOMIC STUDIES

Connecting Europe Facility – Transport call for proposal - Cost benefit appraisal

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[redacted]

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TABLE OF CONTENTS

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SUMMARY OF ILLUSTRATIONS

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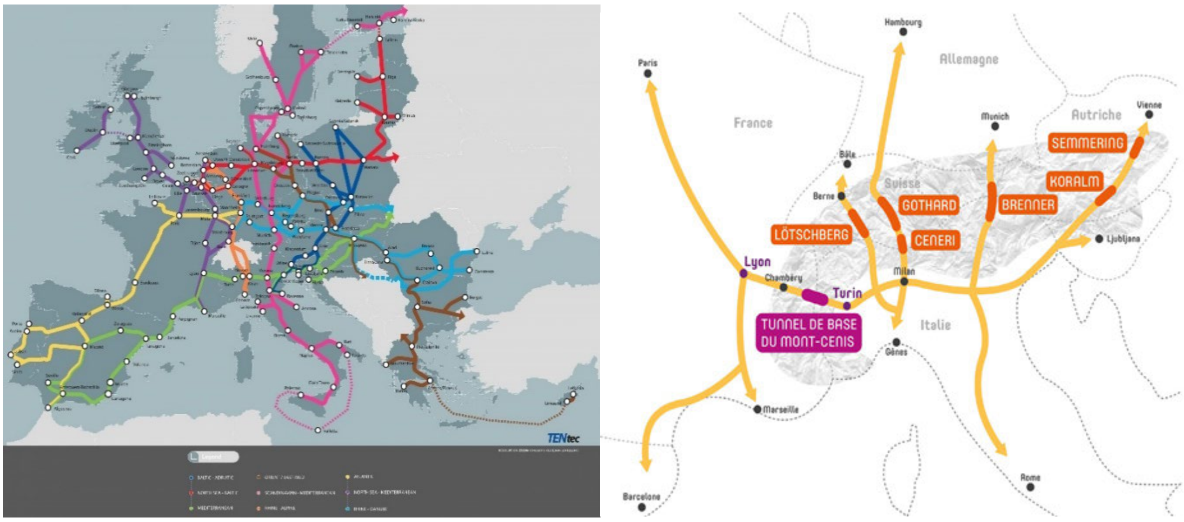
1. INTRODUCTION

The Lyon-Turin Euralpin Tunnel project is one of the essential links in the Mediterranean rail corridor and a major lever for achieving the European Union's ambitious modal shift towards rail objectives. The expected benefits of the project are structured by the internal and external effects of the project, such as production cost savings, time savings and avoidance of environmental impacts during the operational phase.

Like the other existing Alpine crossing points, the Turin-Lyon railway section is a mixed freight/passenger line, located within the "Mediterranean Corridor" of the trans-European TEN-T transport network, as defined in European Regulation No 1315 of 2013. The conditions for the completion of the project for a new rail link between Lyon and Turin and for the operation of the structure were sanctioned by the 2012 International Agreement between the Government of the Italian Republic and the Government of the French Republic

Illustration 1. Positioning of the project on the Mediterranean corridor



The socio-economic and environmental impact of the project depends largely on its , i.e. the forward-looking vision of the functioning of the railway system composed of the historic line and the new line. It is therefore a question of questioning this aspect before addressing the methodological principles of evaluation and its implementation through a set of valuation hypotheses.

The assumptions, as well as the results of the socio-economic and environmental assessment, are presented on the basis of the cost-benefit analysis methodology in force, through the traffic forecasting indicators monitored by socio-economic and financial profitability.

1.1 The project and its context

1.1.1 Foreword

Many years have passed since the first design of the new transalpine railway line Lyon Turin and much has changed since then. The following paragraphs are not intended to reconstruct the history of these changes, but only to highlight how macroeconomic events and changes in the railway sector have gradually changed the context in which the new line is called upon to operate and, consequently, the function it is called upon to perform.

Some of these changes have a direct impact on the parameters that characterise ex-ante assessment tools, in particular transport demand, line capacity, production costs and benefits. The following paragraphs therefore focus on changes that may suggest a revision of the project's ex-ante evaluation tools.

1.1.2 The cross-alpine segment of the Mediterranean corridor

The Mediterranean corridor, the planning axis of the European network

In 1993, on the basis of Articles 170 and 172 of Title XVI TFEU, the[1] European policy on trans-European networks (TENs) for transport, energy and telecommunications was introduced. This policy is reinforced by Regulation (EU) No 1315/2013 which defines the trans-European transport network (TEN-T) and the guidelines, requirements and priorities for its development; Regulation (EU) No 1316/2013 establishes the financial mechanism to connect Europe and defines the trans-European transport corridors (9).

The objective of the TEN-T is the creation of a single European transport area based on a single integrated trans-European network, sustainable, efficient, resilient, innovative, interoperable and multimodal between road, rail, maritime, air and inland waterway transport, between all EU Member States.

The TEN-T transport network is at the heart of European transport development policy, which aims to improve the intramodality, interoperability and economic and environmental performance of transport networks. Among its main objectives, the trans-European transport network must ensure efficient multimodality in order to allow better and more sustainable modal choices for passengers and goods and the consolidation of large volumes for long-distance transfers, in order to make multimodality more economically attractive for passengers, users and carriers.

European funding for the Mediterranean Corridor

The development of the Mediterranean Corridor, as a bridge for international trade between Eastern and Western Europe, is supported by the CEF programme which, between 2014 [2] and 2018, co-financed 147 actions along this Corridor (i.e. 19% of the total number of actions financed by the CEF Transport), for a financing of €2.9 billion (almost 14% of the total funding of the CEF Transport) for a total investment of €6.3 billion. of euros.

[1] Treaty on the Functioning of the European Union
[2] *Connecting Europe Facility*

Most of the funding is allocated to rail (54 actions, €2.4 billion, or 83%), followed by projects to make road transport cleaner and safer (49 actions, €163 million) and maritime projects (33 actions, €248 million).

1.1.3 A new vision on the TELT project

The Western Alpine Arc as a link in the Mediterranean Corridor

The western arc of the Alps forms the border between Italy on the one hand and France and Switzerland on the other: the importance of trade between these nations as well as between Italy and the other nations to the east and north of France and Switzerland explains the reason that pushed the governments of France and Italy, supported by the European Union, to build a new crossing line.
If we consider only direct trade relations with France, the total trade between France and Italy (Import + Export) in 2019 reached the value of 85.3 billion euros ; France is Italy's second customer country with 50.5 billion euros in sales in 2019 and is also the second supplier country with 34.8 billion euros of goods purchased.

The geographical areas with the highest intensity of trade are, for Italy, the regions of Piedmont and Lombardy, for the France the Auvergne-Rhône-Alpes region and the Paris region, and for Spain the region of Catalonia with Barcelona. Lombardy, Veneto, Piedmont and Emilia-Romagna account for 66% of origins and destinations (Liguria only 2%).

The main products exported are motor vehicles, industrial machinery, clothing, metals, plastic articles, medicines and pharmaceutical preparations: products that all travel by road, rail, ship or plane (with their various environmental impacts).

These data explain the strategic importance of the axis for both States but also for the entire Mediterranean Corridor.

The missing link of the Mediterranean Corridor

The insurmountable obstacle for goods to switch from road to rail on the Franco-Italian axis is the historic Cavour tunnel. It is the oldest of the Alps (1871), the highest (1,286 meters above sea level), the most penalizing (gradient of 33 ‰) and the narrowest (distance between the tracks of 341 cm against 355 cm minimum today).

The adaptation works completed in 2011 (after years of alternating one-way operation and shifting traffic to other, more competitive routes) only allow the maintenance of a (penalized) service pending the new base tunnel. Today, a freight train running on this route can have a maximum length of 550 meters and must have, to carry an average of 380 tons, two or even three engines. This is why transporting goods through the historic Fréjus tunnel costs almost 50% more than the Gotthard.

The characteristics of the international section between Italy and France are therefore such that they have gradually made it almost impossible to operate the line for goods and essential to replace it with a European-standard infrastructure.

The alternative mentioned by some to use the Ventimiglia railway line is unfeasible because it is certainly a modern line but deliberately built according to standards adapted only to passenger trains.

1.2 Perimeter and study basis

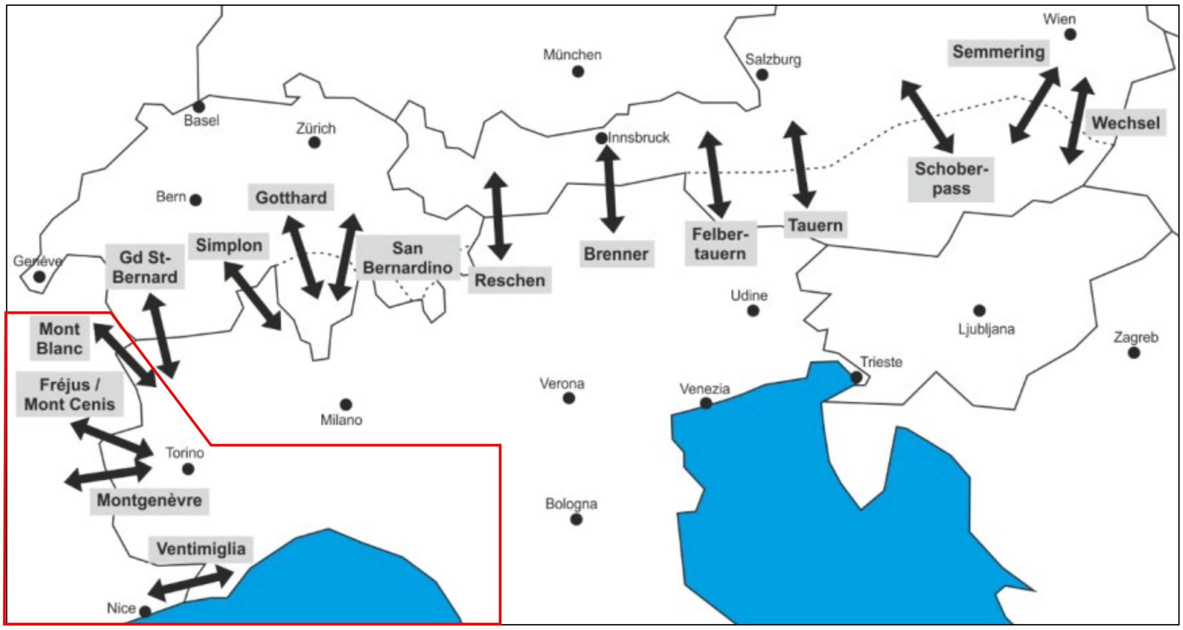
1.2.1 The geographic perimeter and the targeted markets

The cost-benefit analysis focuses on the assessment of the net socio-economic and environmental impacts of the project. In this sense, it is necessary to define the scope of the analysis to indicate the scope of the effects analyzed.

The French, Italian and European recommendations do not specify this point and it is left to the free definition of the evaluator. It seems appropriate to focus on the widest possible perimeter to integrate all potential effects, without however focusing on edge effects.

Thus, the assessment perimeter chosen concerns traffic currently or potentially crossing the western Alpine arc but also competing air and sea services.

Illustration 2. Map of alpine crossings and study perimeter (in red)



Source: [redacted] based on Observation and analysis of transalpine freight traffic flows, Key figures 2019 [redacted]/[redacted]/[redacted]/[redacted] for EC/FOT

Western Alpine Arc

The land crossing points of the Alpine arc considered are as follows:

- Ventimiglia (rail, road)
- Mont-Cenis/Fréjus (rail, road)
- Mont Blanc (road)

[redacted] [redacted]

Crossings at the Gotthard tunnel are not considered as a competing crossing point but only in their possible route combinations with the Mont-Cenis/Fréjus axis according to the approach adopted in the 2006[3] and 2011[4] studies.

Maritime axis

The maritime traffic axis considered concerns only short-distance links between the ports of Barcelona (Spain) and the various Italian ports, mainly Genova and Civitavecchia. The trades considered concern only unitarized goods, i.e. containers and trailers, according to the approach adopted in the 2006 and 2011 studies.

Air axis

The air traffic axis chosen for the benchmarking and potential modal shifts includes connections between the following airports:

- Italy – France
- Barcelona – Italy

These flows were selected so that the scope of analysis includes a volume of flows consistent with the volume considered in the studies conducted in 2006 and 2011.

1.2.2 Perimeter of the cost benefit analysis

In the note called "CBA Guidance Scope of the CBA in the framework of the CEF transport" of March 2022, the European Climate, Infrastructure and Environment Executive Agency gives the following recommendations on the appraisal perimeter for the cost benefit appraisal:

- "The minimum scope of the cost-benefit analysis using the concept of self-sufficient unit of analysis (…) a project to be evaluated constitutes a self-sufficient unit of analysis if it delivers a functionally complete investment"
- "If the components of the project are not self-sufficient, i.e., they cannot function without other components, then you must expand the scope of the cost-benefit analysis to include all other necessary components"
- "if some components of the global project are already operational, already occurred incremental costs (and benefits) related to existing necessary components (category B) must be included in the analysis."
- Page 11: "Very large projects (especially for freight) can have a radical effect on the network they are part of and may, therefore, require extended analysis of the traffic at European level."

[3] File prior to the declaration of public utility, Chapter 8, Socio-economic assessment, April 2006, LTF
[4] Revision of the preliminary project, economic and socio-economic studies, submission n°72, presentation of the socio-economic assessment of the Lyon Turin new rail link project, February 2011, LTF

All these orientations lead to choose a large perimeter of the cost benefit should cover all the investment required for the full project development, i.e. :

- Temporal perimeter: long term timeline from the preliminary and exploratory works to the operation and future upgrade of accesses until [redacted]
- Investment perimeter: all investment components including the Lyon – Turin base tunnel and its national accesses in France and Italy, excepting the works on the Turin and Lyon railway nodes which are supposed to be realized in any case as described below.
- Effect perimeter: Europe-wide network of rail, road, air and short sea shipping services where the effects of the project could be perceived.

1.2.3 A short history of the economic studies of the project

The historical context in which the idea of establishing the rail link between Italy and France has matured is characterised by a constant growth in trade in goods, due to economic development and the gradual opening of national markets (creation of the single European market). This long-term trend is the natural basis on which the Lyon Turin project studies are built: in 2008, rail transport demand was estimated at 16 million tonnes without the project and 32 million tonnes with the construction of the new line. It was therefore considered complementary to the historical line which was quickly to reach saturation. The revision of estimates after the 2008 crisis does not change the vision but simply postpones it (the "lost decade" scenario).

However, the 2011 forecasts were also optimistic: in 2013, the Italian sovereign debt crisis and the resulting austerity policies triggered a recession followed by stagnation. The tonnage of goods transported on the historic railway line, despite complex and costly work to adapt the gauge, must therefore be adapted taking into account the context.

With the entry into force of the 4th "railway package" in June 2016, the European Union is creating the conditions for a strong revival of rail transport at Community level, laying the foundations for a paradigm shift relevant to the Turin-Lyon axis as well. The most important aspects are:

- The introduction of a standard for European connecting lines (core network) capable of guaranteeing the transit of trains with a maximum length of 750 metres, with a towed mass of up to 2,000 tonnes and a gauge suitable for transporting semi-trailers;
- Interoperability of signalling and train control systems including ERTMS systems[5] to enable non-stop transit at borders;
- Full liberalisation of rail transport services.

[5] Regarding the deployment of the ERTMS system, in Italy, the railway network manager ([redacted] has reached the final milestones of the technical projects financed under the Italian Recovery and Recovery Plan (PRR) resulting from the Recovery Plan for Europe. Latest contracts concern the regions of Emilia-Romagna, Tuscany, Piedmont, Lombardy, Liguria, Veneto and Friuli-Venezia Giulia. In France, 40% of LGVs (1000 km) are equipped with the system. The deployment of 5800 km of lines is planned by [redacted] with substantial financing plan within the framework of the investment scenarios proposed by the Infrastructure Orientation Council for the period 2023-[redacted]

A European rail network based on the new operating standards is incompatible with the characteristics of the historic line on the Mont-Cenis axis: for its main functionality, it is therefore necessary to imagine a new scenario, in which the baseline will replace the historic line, both for freight and for long-distance passengers. In addition, freight train payload and changes in environmental policies have changed and will increasingly change the economic competition between rail, road and air. The parameters used in the forecast models therefore need to be revised to account for these exogenous changes.

It is also necessary to examine the role of the historic line, again in the light of the modified scenario: even if some traffic segments can continue to use it to their advantage (repositioning of empty wagons and containers, transport of cars, etc.), it is not obvious to define the usefulness of residual capacity on the baseline, given the high costs of keeping it in service.

This observation may lead to a different classification of the historic line, which would no longer be an essential part of the European core network but a line of historical and tourist interest, which could be managed according to criteria or costs different from those of a line essential for intra-European connections.

1.2.4 The cost benefit appraisal for the European grant submission

Challenges of cost-benefit analysis

After the regulatory studies and the declaration of public utility, a longer-term reflection was implemented by TELT in order to have a follow-up of the socio-economic and environmental impacts of the project, taking into account the economic evolutions and the schedule of realization of the different components of the project taking into account:

- The moderate evolution of economic growth in Western Europe and the revision of the framework macroeconomic forecasts of the European Commission and the OECD;
- The COVID-19 crisis and the sharp slowdown in the global economy or even the recession in 2020 and its consequences in terms of gradual recovery and completion time;
- The evolution of energy and building materials prices and their impact on the construction and transport economy;
- The evolution of the configuration and temporality of access to the base tunnel, particularly on the French side, in order to attribute to the overall project the effects actually expected at each of its stages;

Despite these troubled circumstances, the Euralpine Lyon-Turin Tunnel project is showing great resilience and continues its maturation process that has also made it possible to take into account the political commitments on both sides of the Alps.

Thus, the cost-benefit analysis has the challenge of taking into account changes in the context and definition of the project vis-à-vis cyclical changes, behavioral breaks and changes in the economic paradigm of mobility.

Specific expectations for the European dossier

Initially developed according to the French and Italian standards in force (see the history of the cost benefit analysis of the project in the previous paragraph 1.2.3), this cost-benefit analysis is intended to feed the project grant application file through the Connecting Europe Facility program.

Thus, it will be a question of meeting the specific expectations of evaluations according to European standards in terms of adaptation of standards according to the standards in force and the production of a self-supporting report giving an understanding of the hypotheses applied and the results produced.

The objectives of the cost benefit analysis will therefore be to provide a clear vision to the European evaluators of the economic and financial stakes of the project, its contribution to the community and its respect for political orientations regarding climate change.

In doing so, the cost benefit analysis will be presented through the forms and templates in a consistent way (cashflow) in order to provide updated assumptions and results according to a structure common to all grant files submitted by applicants.

[redacted] [redacted]

2. ASSESSED SCENARIOS

2.1 Introduction

The definition of the scenarios assessed is strategic because of the principles implemented in the cost-benefit analysis. The differential approach will allow for a comparison of the effects of baseline **and project scenarios**. The definition of reference and project scenarios are part of the framework defined subsequently (economic, social, environmental, development) as follows:

- **The reference scenario** shall include operations already initiated or planned in such a way as not to attribute to the evaluated project the benefits of third-party project investments. The reference is the most likely situation in the absence of the developments of the evaluated project;
- **The project scenario** integrates the investments preferred by the contracting authority for the implementation of the project, as well as the necessary investments on the other components of the transport system absolutely necessary for its proper functioning.

2.2 The reference scenario

2.2.1 General description

In a reference scenario, a set of preliminary operations are planned on the French rail network with a view to improving access capacity on the historic line. Recurrent traffic bans for maintenance reasons are scheduled on the Mont Blanc road tunnel.

2.2.2 French rail access

No specific improvements are considered on the French railway accesses in the reference scenario.

2.2.3 Alpine crossing

Historic Montcenis railway tunnel

According to the objective of operating more capacity and safety than the existing one, the doubling of the Montcenis railway tunnel is required in a reference scenario. However, this scenario would imply a degraded level of infrastructure compared to European standards and constitutes a minimum scenario to maintain historical operating conditions.

These investments attributed to the baseline scenario could eventually be avoided in the project scenario where most of the capacity would be deployed on the base tunnel, the historic tunnel being able to operate under the conditions described in the current situation.

Safety improvements to the historical Montcenis railway tunnel are planned among all the investments made by [redacted] on this subject in its 2022-[redacted] program contract. The total amount of this type of investment on the Italian network amounts to €700 million over the period 2023-[redacted] and nearly €5 billion spread after [redacted] over several decades. These safety investment on the historic Montcenis railway tunnel do not depend on the realization of the base tunnel and are not deducible from the project costs.

[redacted] [redacted]

Fréjus road tunnel

The 2004 European directive on tunnel safety led to the need to build a second tube in 2010 in order to have emergency shelters every 500 m minimum. The number of shelters in the tunnel will then be reduced from 11 to 34 through a second tube and regular connection between the two.

The commissioning of the second tube of the Fréjus tunnel has been postponed to autumn 2023. Site interruptions caused by the Covid pandemic and difficulties in sourcing raw materials to complete the work are the main factors explaining this postponement.

Mont Blanc road tunnel

The Mont Blanc tunnel will begin a series of major works from 2023. The vault and the slab that support the roadway must be renovated which will require the total closure of the structure over long periods. A first phase of preliminary work (which will also require the closure of the tunnel for several weeks) is planned for autumn 2023 and [redacted] to determine the duration of closure necessary to restore the vault.

Two scenarios are being studied:
- three to four months of closure each year for 17 to 18 years,
- That is three to four years of total closure of the tunnel. The verdict will be known at the end of [redacted]

In the absence of precision at stage and as a precautionary measure, the operation of the Mont Blanc tunnel will be assumed nominal throughout the evaluation period. A sensitivity test will be presented taking into account a partial closure of 3 months per year over a period of 18 years which will lead to spreading traffic carryovers over a longer period and will constitute a temporarily advantageous situation for the Lyon Turin base rail tunnel project.

2.2.4 Italian rail access

No specific development is taken into account on Italian rail accesses in a reference scenario.

2.2.5 Lyon Railway Node

For the node of Lyon, investments are provisioned before the base tunnel commissioning as follow ([redacted]), independently from the realization of the Lyon Turin project:

- Recutting of blocks around Lyon (Lyon Perrache – Jean Macé, Lyon St-Clair – Sathonay, Lyon Guillotière);
- Lyon Part-Dieu : creation of the track L;
- Track B development in Vénissieux;
- Creation of substations (Miribel, Meximieux, Lyon Saint-Clair, St-Priest);
- Adding a dock – Track 2 in Montluel;
- Part-Dieu – Perrache Tube;
- Recutting of blocks Lyon Part-Dieu – Grenay.

[redacted] [redacted]

Illustration 3. Investments planned at the Lyon railway node in reference -short term

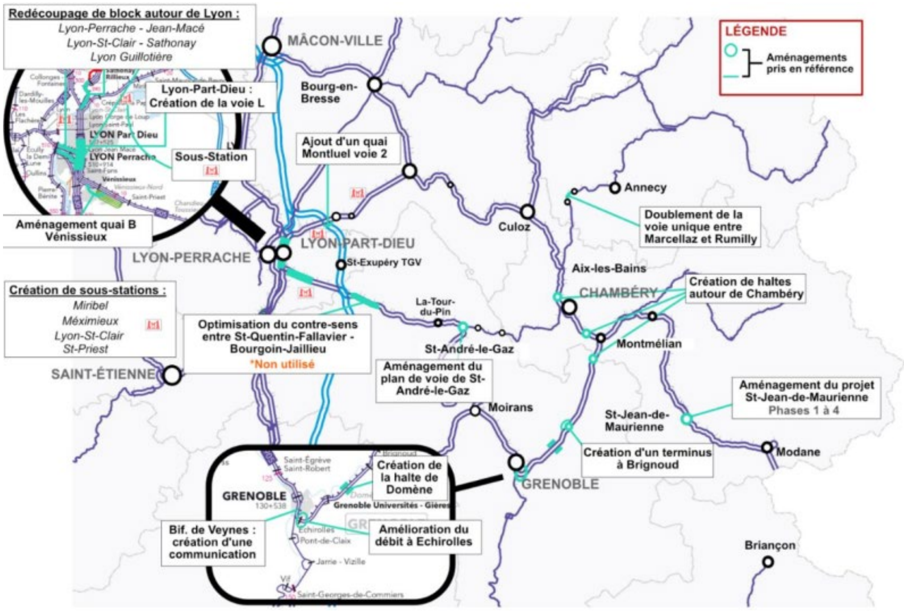
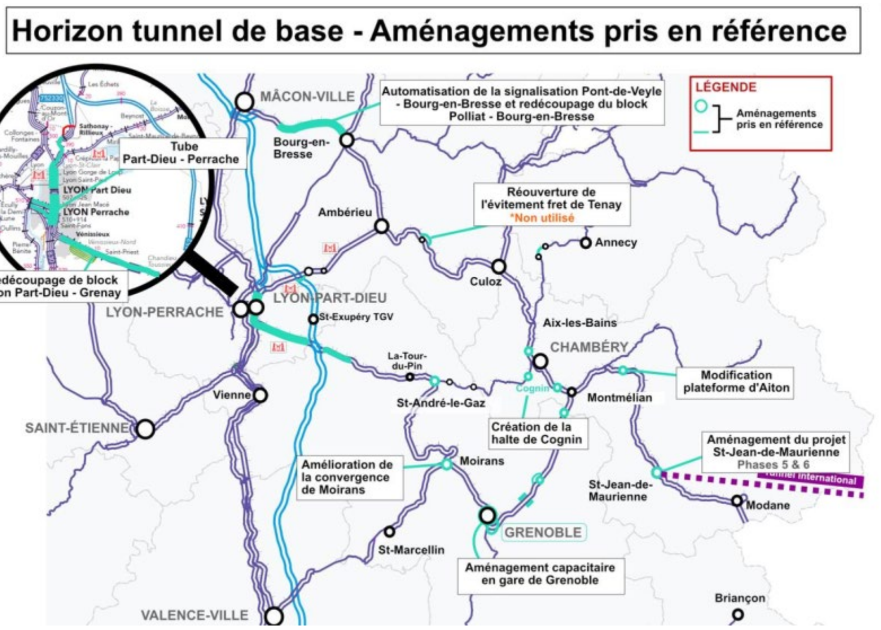


Illustration 4. Investments planned at the Lyon railway node in reference -base tunnel horizon



Source: [redacted], 2021

2.2.6 Turin Railway Node

The developments envisaged for the restructuring of the Turin railway junction are, according to RFI (11/2023) are the following, planned independently from the realization of the Lyon Turin project:

- completion of the Turin railway bypass, Porta Susa - Stura section.
- upgrading of the high-speed line between Porta Susa and Porta Nuova, new 4.5 km independent double-track line, and construction of some new stops in the Turin railway system.
- speeding up the Turin-Genoa line.
- infrastructural and technological upgrading of the Turin railway urban node and related lines, through the adaptation/enhancement of the stations General Regulatory Plan (PRG) and the renewal of the centralized circulation management systems or the insertion of new centralized management systems.
- new railway bypass from Orbassano to Settimo Torinese - phase 1b "Gronda Merci.

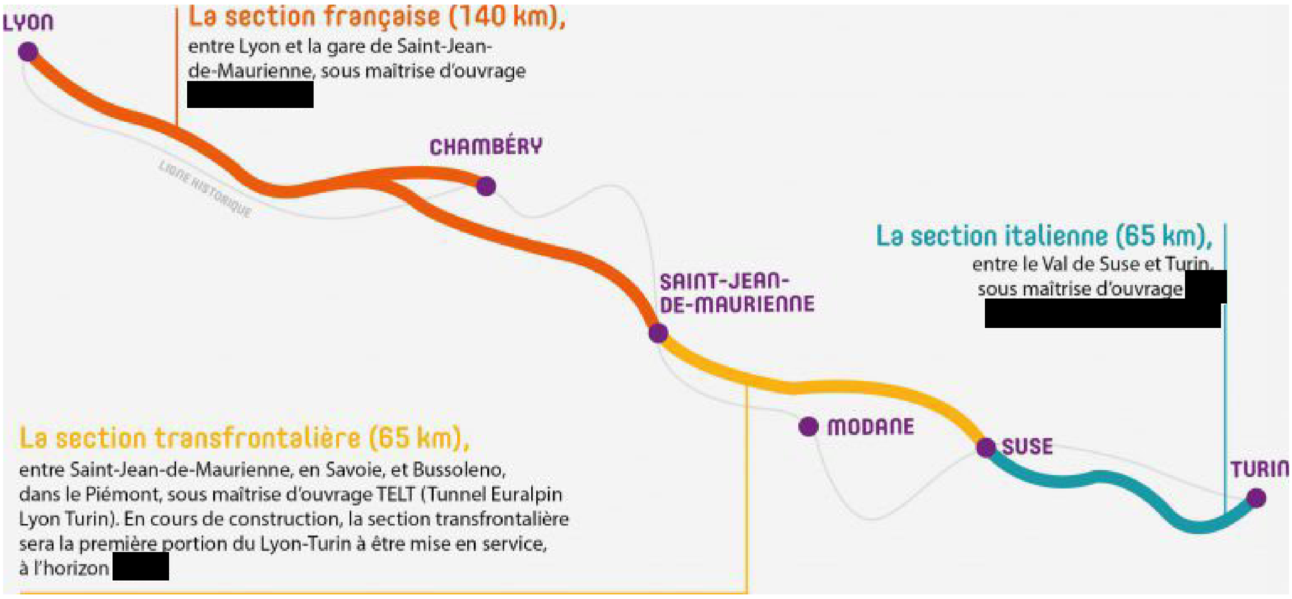
2.3 The project scenario

2.3.1 General description

The project scenario is part of the axis of the Mediterranean corridor consisting of the Susa valleys on the Italian side and the Maurienne valley on the France side with 3 main components:

- The cross-border section under TELT project management between Saint-Jean-de-Maurienne and Susa/Bussoleno.
- The Italian section under [redacted] project management between Bussoleno and Turin.
- The French section under project management [redacted] between Saint-Jean-de-Maurienne and Lyon .

Illustration 5. Main sections of developments in project scenarios



Sourc :e SNCF Réseau https://www.projet-lyonturin.fr/demain-le-lyon-turin/

In terms of structure, the different operations are more precisely distinguished as follows:

- the French part, between the vicinity of Saint-Didier-de-la-Tour (about 60 kilometres from Lyon) and the vicinity of Montmélian.
- the Italian part, from Bussoleno to the Turin pole, including a twin-tube tunnel of almost 19.5 kilometres between Bussoleno and Chiusa San Michele.
- the Italian-French common part, between the vicinity of Montmélian in France and Bussoleno in Italy, which includes:
    - in France, a section of about 33 kilometres through the Belledonne massif, which includes the twin-tube tunnels of Belledonne and Glandon.
    - a "cross-border section" consisting of a twin-tube tunnel of approximately 57 kilometres, between Saint-Jean-de-Maurienne (F) and Susa-Bussoleno (I), dug under the Alps on Italian and French territory and comprising three safety areas in La Praz, Modane and Clarea.
    - an open-air section of about 3 kilometres on Italian territory in Susa.
    - connecting works to the historic line, both in Italy and in France.
    - all ancillary works (stations, electrical installations, etc.) necessary for railway operations and those which the parties subsequently deem should be included in the Italian-French common section.

The provisional dates of commissioning considered in the are the following:

Tableau 1. Provisional dates of commissioning of each project component

Component	Items	Start date	End date
French access	Total		
Doubling of Les Abrest - Pont de Beauvoisin and St Béron - Lépin le lac, long avoidance of Cognin and halt		[redacted]	[redacted]
Mixed line to St-André-Le-Gaz and freight line from St-André-Le-Gaz with single-tube tunnels at the Chartreuse, Belledone and Glandon massifs		[redacted]	[redacted]
Chambéry connection to the conventional railway line		[redacted]	[redacted]
Doubling of the Chartreuse, Belledonne and Glandon tunnels, made mixed between passengers and freight		[redacted]	[redacted]
High-speed line (300 km/h) between Lyon St Exupéry and Chambéry		[redacted]	[redacted]
Italian access	Total		
Turin connection to the Turin-Lyon priority works (first phase of four-tracks-works for Avigliana- Orbassano and upgrade of Orbassano marshalling yard)		[redacted]	[redacted]
Adaptation of the historic Turin-Modane line on the Bussoleno-Avigliana section		2023	[redacted]
Turin connexion to the Turin-Lyon priority works (new line Orbassano - Settimo Torinese, second phase of four-tracks-works for Bussoleno- Avigliana)		[redacted]	[redacted]
TELT	Total		
Exploratory and preliminary works		2002	2019
Base tunnel and international section (certified cost)		2018	[redacted]

Source : [redacted] after TELT, [redacted]/[redacted]/[redacted] [redacted]/MIT and Execution decision project

The following paragraphs present the different components of the project scenario.

[redacted]

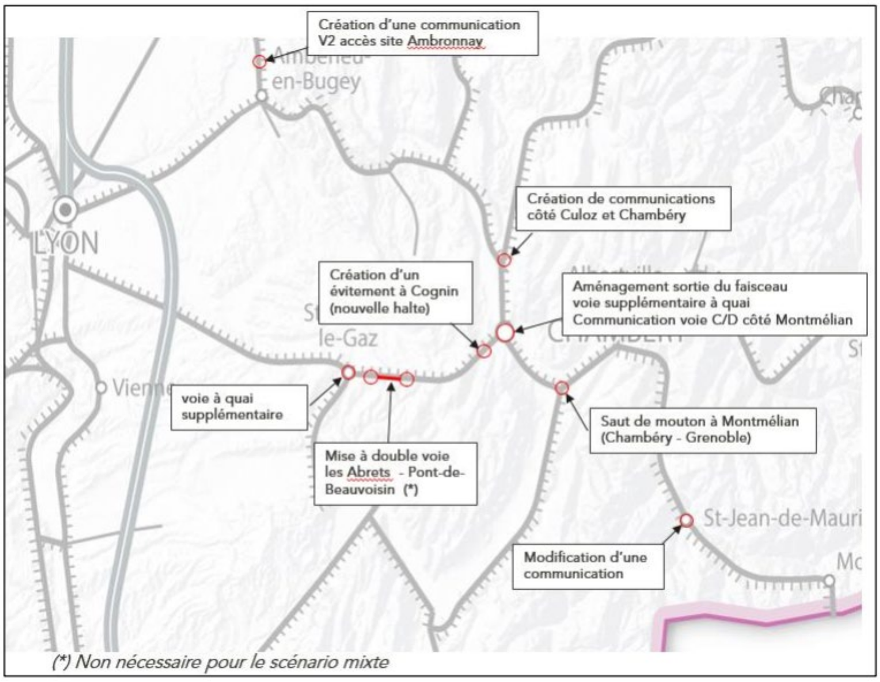
[redacted]

2.3.2 French rail access

2.3.2.1 Preliminary Network Improvement Works

Prior to the commissioning of the base tunnel, a series of operations to improve the French rail network are planned on the various sections between Lyon and Modane as well as on adjacent lines.

Illustration 6. Scheduled operations on French accesses on the base tunnel horizon



Source: [redacted]*, 2021*

Lyon to Montmélian

The planned developments on the Lyon – Chambéry line via Saint-André-le-Gaz include:

- The creation of an additional platform track at Saint-André-le-Gaz to increase platform capacity and allow for increased passenger traffic to Chambéry;
- The two-lane upgrade between Les Abrets and Pont de Beauvoisin to increase traffic capacity between Saint-Angré-le-Gaz and Chambéry;
- The creation of a halt and a siding at Cognin allowing the increase of passenger traffic on the axis;
- The outing of the bundle of additional tracks at the platform and the C/D track communication on the Montmélian side.

Related to this, the following developments are planned:

- Creation of communication and access to the Ambronay site in order to eliminate wrong-way traffic on the line between Dijon and Modane;
- Creation of a communication on the Culoz and Chambéry side;

[redacted]

[redacted]

Montmélian to Modane

On the line from Montmélian to Modane, the following operations are scheduled:

- Bypass of Montmélian on the Chambéry – Grenoble line in order to increase capacity by removing the shear related to the connection of the line from Grenoble;
- Modification of a communication in Saint-Jean-de-Maurienne to increase capacity;

Schedule and commissioning

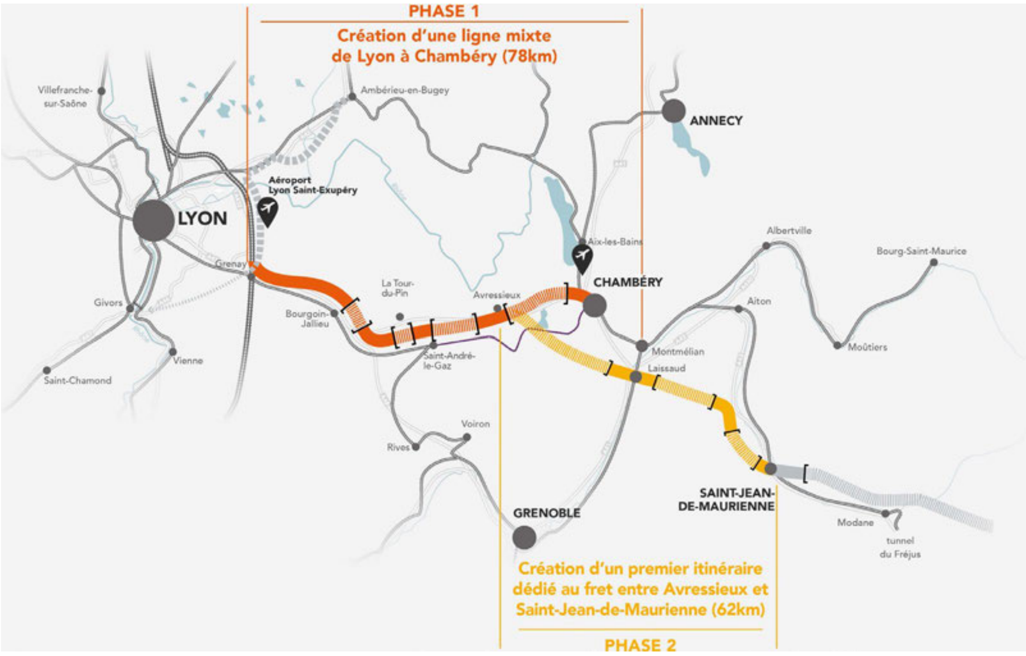
The developments planned in reference scenarios are scheduled to be completed by the time the base tunnel is commissioned, i.e. in [redacted] (see table with dates of commissioning for project scenario above).

Depending on the scenario, for the Auvergne-Rhône-Alpes part, [redacted] estimates the amount of the developments is estimated at €600 million in 2021 value, before any technical study and on the basis of theoretical ratios. These amounts are assumed to be committed in both reference and project scenarios.

2.3.2.2 Development of French access

In France, the complete configuration of the national section (known as the 'access section') was established by ministerial decision of 10 November 2011 and consists of 140 km of link for mixed freight-passenger part and partly only freight and only passengers.

Illustration 7. Programming of French rail access



As shown in the previous figure, this section connects Lyon to Saint-Jean-de-Maurienne and crosses the departments of Rhône, Isère and Savoie. The project was articulated in 2 phases in order to meet the requirements of the territories in terms of daily services and to improve freight traffic more generally. As part of this analysis, it is the "Grand Gabarit" scenario and the Chambéry connection which are studied (maximalist approach).

Lyon to Avressieux

Phase 1 consists of the construction of a new mixed line (passenger/freight) from Lyon to Chambéry to allow:

- a faster service on short distances and to the cities of the Alpine valleys, saving 20 minutes between Lyon and Annecy/Chambéry;
- better traffic management on the existing network by transferring part of the traffic to the new line;
- a competitive alternative to the 43 km of single track between Saint-André-le-Gaz and Chambéry;
- a new high-performance route for the flow of goods from Lyon to Italy.

From Avressieux to Saint-Jean-de-Maurienne

Phase 2 consists of the creation of a first route dedicated to the transport of goods between Avressieux and Saint-Jean-de-Maurienne (62 km) to allow:

- the introduction of an efficient freight route between France and Italy that saves on operating costs;
- the provision of a modal shift tool to modern standards, allowing the direct loading of trucks onto trains (broad gauge motorway);
- a time saving of 45 minutes in the cross-border section compared to existing routes;
- Better management of cargo handling thanks to the shorter length of the mixed line.

From Avressieux to Chambéry

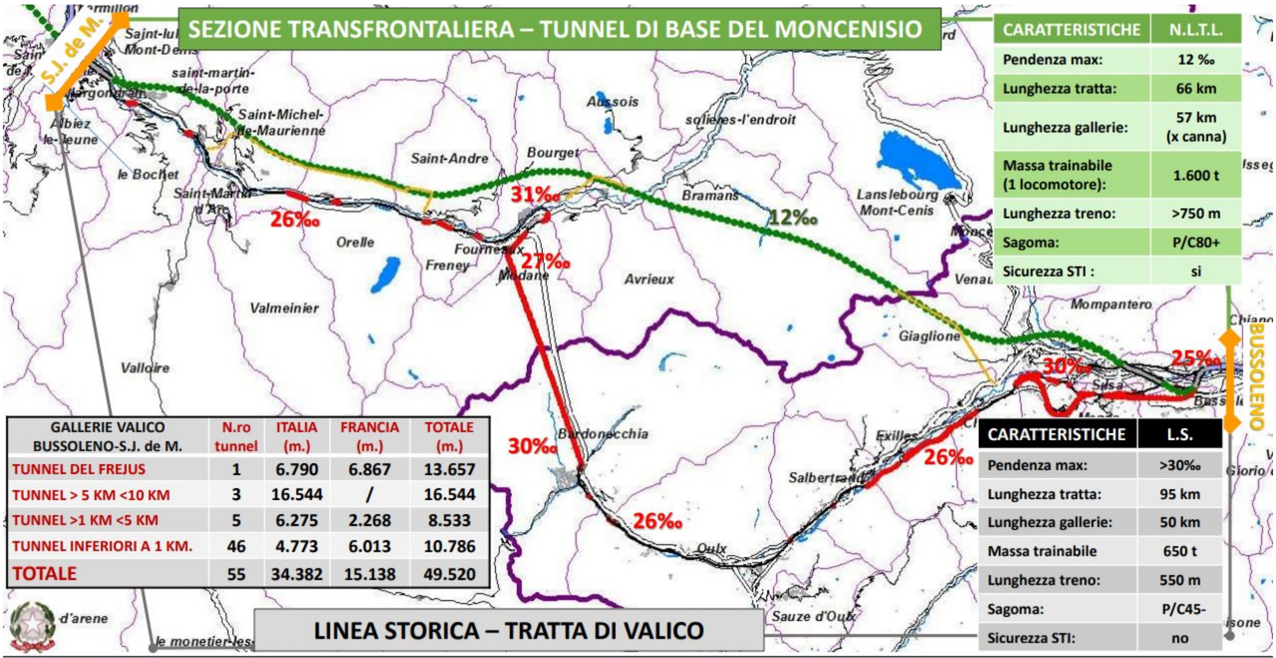
Additionally to the “Grand Gabarit” scenario, the railway connection between Chambéry and the conventional railway line is provisioned and scheduled at the same step as the doubling of Avressieux-St-Jean de Maurienne freight line tunnels.

2.3.3 Alpine crossing

Montcenis base tunnel

Like the other existing Alpine crossing points, the Turin-Lyon railway section is a mixed freight/passenger line, located within the "Mediterranean Corridor" of the trans-European TEN-T transport network, as defined in European Regulation No 1315 of 2013.The conditions for the implementation of the new rail link project between Lyon and Turin and for the operation of the structure were sanctioned by the 2012 International Agreement between the Government of the Italian Republic and the Government of the French Republic, an agreement which lays down its structure.

Illustration 8. Programming of Italian rail access



Source: [redacted] 2019

Historical Montcenis railway tunnel

The safety improvements to the historical Montcenis railway tunnel are planned in the project scenario whereas the doubling would be avoided.

Fréjus road tunnel

No additional development to the baseline scenario was considered in the project scenario for the Fréjus road tunnel.

Mont Blanc road tunnel

No additional development to the baseline scenario was considered in the project scenario for the Mont Blanc road tunnel.

2.3.4 Italian rail access

Bussoleno to Salbertrand

No additional development is planned in a project scenario on this section.

Bussoleno to Avigliana

From Bussoleno to Avigliana, the line has the characteristics of a flat section, with a large residual capacity (max. 280 trains) and an adequate functional level.

While the preliminary project had evaluated the feasibility of all possible interventions capable of guaranteeing in the long term the maximum capacity and the best performances that could be required, ensuring that they could be carried out in the long term, in 2012 the possibility of postponing some of the planned interventions was considered (Orsiera tunnel – Chiusa San Michele safety zone – tunnel between Sant'Ambrogio di Turin and Buttigliera Alta) on the basis of verification, over time, of the effective saturation of the line.

The 2012 binational agreement made the States, as part of the economic component of the cross-border section, bear a contribution to the adaptation interventions of this section of €81 million out of a total amount of €204,68 million divided between [redacted] and [redacted] the rest being borne by [redacted]

From Avigliana to Turin

As part of the in-depth analyses carried out by [redacted] during the "project review", the numerical simulation showed potential critical points on this section on the horizon of the opening of the base tunnel, due to stability margins too small for access to a metropolitan pole.

Therefore, it was planned to build two independent routes between Avigliana and Turin, which the project proposal identified in the Collina Morenica Variant. With this realization, long-distance and freight traffic would be placed on the new route and regional and metropolitan traffic would have a reserved historic line, with the possibility of implementing possible additional services. At the Avigliana site, for the connection of the variant, the optimal positioning of the tracks for the platform of metropolitan trains is planned in the center, between the traffic tracks, to facilitate the exchange between the trains. In Orbassano (freight yard), development work is planned to improve the modal interface.

The cost of the Italian national section, following optimizations, decreased from 4.3 billion to 1.7 billion, including the Orbassano marshalling yard.

2.3.5 Lyon Railway Node

The same investments as provisioned in the reference scenario are accounted at the railway node of Lyon in the project scenario.

2.3.6 Turin Railway Node

The same investments as provisioned in the reference scenario are accounted at the railway node of Turin in the project scenario.

[redacted] [redacted]

2.4 The project scenario impact

2.4.1 General approach of scenario impact

The commissioning of the base tunnel and accesses as described in the above project scenario is based on the principle that the tunnel will preferentially but not exclusively replace the current line route and the historic tunnel. The historic line on the French side will also have to continue to be used in part or in full until the various phases of access development are finalized.

The preceding timelines therefore reveal four main horizons to be considered in the following order to characterize the project scenario:

- Commissioning of the Base Tunnel, Italian accesses and improvements to French accesses (phase 0).
- Commissioning of the new mixed line on the French side to Avressieux and freight line to St-Jean-de-Maurienne (phase 1).
- Commissioning of the second tube of the new line on the French side (phase 2) and realization of the Chambéry connection to the conventional railway.
- Commissioning of the high-speed line on the French side (phase 3).

These different successive project scenarios must therefore be characterised in terms of infrastructure (maximum gradient, maximum gauge) and operating conditions (capacities, journey times). These characteristics are then taken into line in traffic forecasts and cost-benefit assessments.

2.4.2 Infrastructure characteristics

2.4.2.1 Maximum gradient of the line

The maximum gradient of a railway line is a parameter determining the number of traction units to be mobilized according to the maximum mass to be towed. These parameters apply in particular to freight convoys that currently mobilize 2 or even 3 locomotives on the route of the historic line and the Montcenis tunnel. The maximum gradient considered for a high-speed railway line accommodating freight trains is 10 ‰, or 10 meters of vertical drop per 1000 meters of line.

Tableau 2. Gradient of the railway line by section

Scenario	French access	Alpine crossing	Italian access
Current	26 to 33 ‰ on the section between Saint-Jean-de-Maurienne and Modane [a]	30 ‰ [a]	26 ‰ to 30 ‰ on the section between Susa and Bardonecchia [a]
Reference			
Project – base tunnel horizon		12.5 ‰ [a]	10 ‰
Project – horizon ligne nouvelle	10 ‰		
Project – new line horizon with doubling of tunnels	10 ‰		
Project – high-speed line horizon	10 ‰		

[a]: TELT, Workbook [redacted] updated 2023
[b]: Default data on [redacted] and [redacted] flat lines, in the absence of specific information

2.4.2.2 Clearance gauge of the line

The upper gauge of the line (structure/clearance gauge) determines the envelope in which the dynamic gauges of railway convoys must be fit. The high gauge issues concern in particular rail freight convoys for the transport of containers, swap bodies and trailers. The following compatibilities are established between infrastructure gauges (G) and convoy gauges of container trains (C) or trailers (P):

- GA: P/C22 and below
- GB: P/C45 and lower, compatible with high cube containers
- GB1: compatible 4m trailers with low-loaders, high cube and lower containers
- GC: compatible with 4m trailers and high cube containers and lower, higher than P/C80

Tableau 3. Table 1 Clearance gauge of the railway line by section

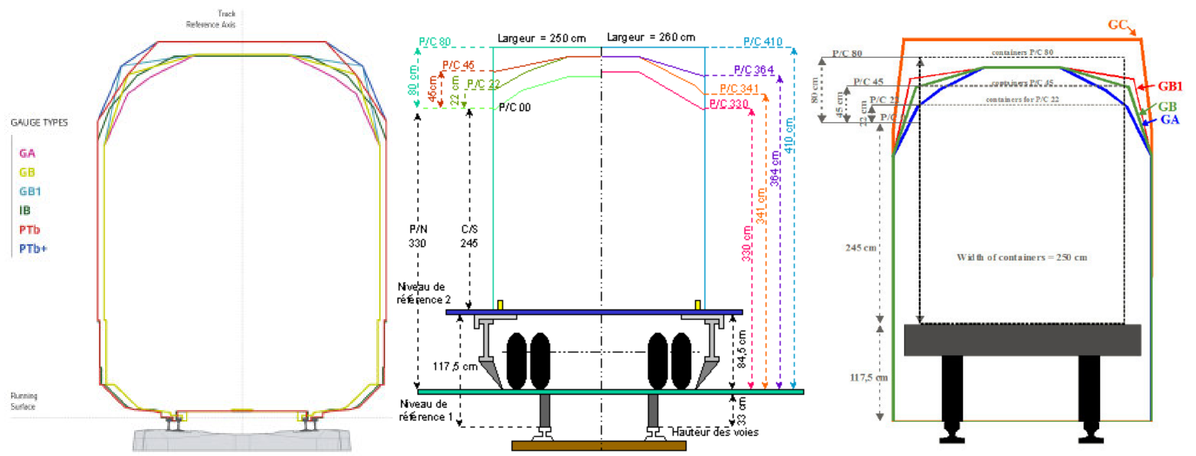
Scenario	French access	Alpine crossing	Italian access
Current	GB1 [a]	GB1 [b]	P/C45 = GBc
Reference	GB1 [a]	GB1 [b]	P/C45 = GB[c]
Project – base tunnel horizon	GB1 [a]	GC [b]	P/C80 ~GC [c]
Project – new line horizon	GC [a]	GC [b]	P/C80 ~GC [c]
Project – new line horizon with doubling of tunnels	GC [a]	GC [b]	P/C80 ~GC [c]
Project – high-speed line horizon	GC [a]	GC [b]	P/C80 ~GC [c]

[a]: Map of the limit gauges of high obstacles, January 2023, [redacted], https://www.[redacted].com/sites/default/files/2023-03/11_2023_A3_Gabarit_Fret_3500ke_l93_v03.pdf

[b]: gauge obtained by lowering the running surface and taking over the vault of the tunnel and bringing the two tracks closer together (reduction of the centre distance, refocusing in the structure) for more than €100 million from 2006 to 2008

[c]: according to TELT/[redacted] the current Italian wagon gauge is P/C45, equivalent to the GB infrastructure gauge. These car gauges will be raised to P/C80 gauge almost equivalent to GC infrastructure gauge.

Illustration 9. Equivalence between wagon gauge and infrastructure gauge



Source: Union Internationale des Chemins de Fer (UIC)

2.4.3 Railway passenger time savings

The journey times of long-distance rail services represent an average of the journey times per section of the historic line or the new line when in service. The time savings are broken down by section concerned between Lyon Saint Exupéry and Milan at the different stages of the development program.

Tableau 4. Journey time of long-distance services per section

(minutes) Scenario	French access Lyon St Ex - SJDM	Alpine crossing SJDM – Bussoleno	Italian access Bussoleno - Turin	Line GV Italy Turin - Milano	Total Lyon St Ex - Milano
Current	96b (1h36)	73b (1h13)	36b (0:36)	90b (1h30)	**295b** **(4:55 a.m.)**
Reference	96b (1h36)	73b (1h13)	36b (0:36)	90b (1h30)	**295b** **(4:55 a.m.)**
Project – base tunnel horizon	96b (1h36)	47 *(-26a)* (0:47)	25 *(-11 [b])* (0:25)	45b *(-45)* (0:45)	**213 *(-82)*** **(3h33)**
Project – new line horizon	91 *(-5c)* (1h31)	47 *(-26a)* (0:47)	25 *(-11 [b])* (0:25)	45b *(-45)* (0:45)	**208 *(-87)*** **(3h27)**
Project – new line horizon with doubling of tunnels	91 *(-5c)* (1h31)	47 *(-26a)* (0:47)	25 *(-11 [b])* (0:25)	45b *(-45)* (0:45)	**208 *(-87)*** **(3h27)**
Project – high-speed line horizon	68 *(-28a)* (1h08)	47 *(-26a)* (0:47)	25 *(-11 [b])* (0:25)	45b *(-45)* (0:45)	**185 *(-110)*** ***(3:05)***

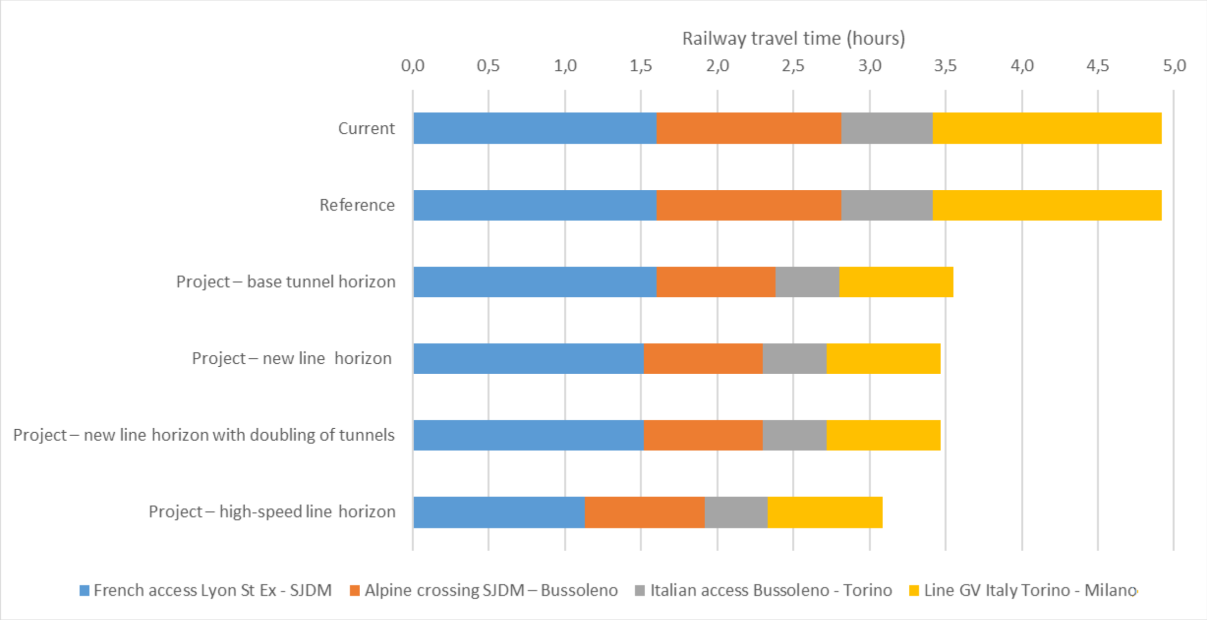
[a]: PRELIMINARY PROJECT REVISION, SUBMISSION NO. 41, PASSENGER TRAFFIC STUDIES, LTF, 20/12/2010
[b] : Asse Ferroviario Turin – Lyon TAPPA 1 – [redacted] Turin, 12 Ottobre 2018, [redacted]
[c]: Alpine access, Summary note of the exploitation study, V2 of 27/11/2021, [redacted]

The passenger time savings assumptions are summarized in the graph below:

[redacted]

[redacted]

Illustration 10. Passenger time savings assumptions



Source: as in the table above

2.4.4 Railway freight load factor

The maximum carrying of freight trains corresponds to the average net mass of goods transported by convoy transiting the Montcenis axis via the Montcenis tunnel or the base tunnel when it is put into service.

This payload is determined both by the gradient of the line (maximum net tonnage, average number of locomotives) and by the expected commercial performance of the operators (payload rate, load factor).

The average net tonnage for mountain lines is between 300 and 750 tonnes per train, those for base tunnels may exceed more than 1000 tonnes per train for base tunnels (see comparison in Annex 1).

This average tonnage indicator takes into account the partial filling of wagons (filling ratio) as well as the empty return of convoys (payload rate).

[redacted]

[redacted]

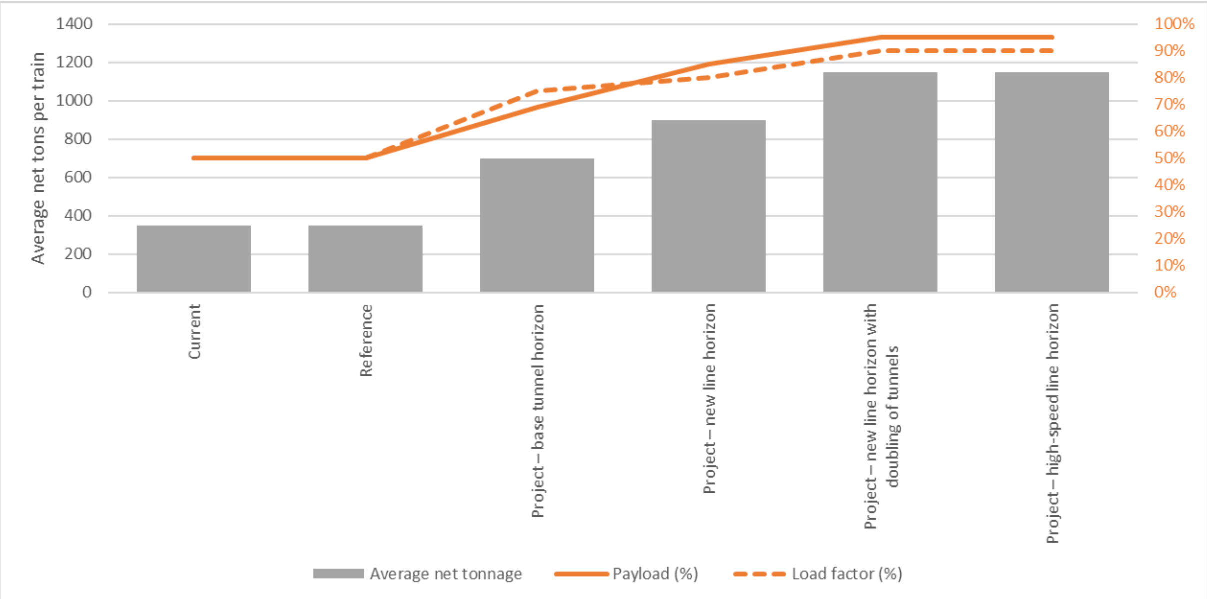
Tableau 5. Maximum load of freight trains on the Lyon-Turin project axis

Scenario	Payload	Load factor	Average net tonnage	Maximum net tonnage	Average number of loco
Current	50%*	50%*	350th	1350d	2,1
Reference	50%*	50%*	350th	1350d	2,1
Project – base tunnel horizon	69%[d]	75%[d]	700 [d]	1350d	2,1
Project – new line horizon	85%*	80%*	900*	1350 [d]	1,0
Project – new line horizon with doubling of tunnels	95%*	90%*	1150*	1350 [d]	1,0
Project – high-speed line horizon	95%*	90%*	1150*	1350 [d]	1,0

[d]: French access scenario "Grand Gabarit" defined in Alpine access - Summary note of the operating study, [redacted]*, 16/09/2022*
e: Statistics of tonnages related to traffic according to Observation and analysis of transalpine freight transport flows, EC, 2019 and [redacted]*,* [redacted] *2020 and* [redacted]
* : [redacted] estimation

The railway freight load factors assumptions are summarized in the graph below:

Illustration 11. Railway freight load factor assumptions



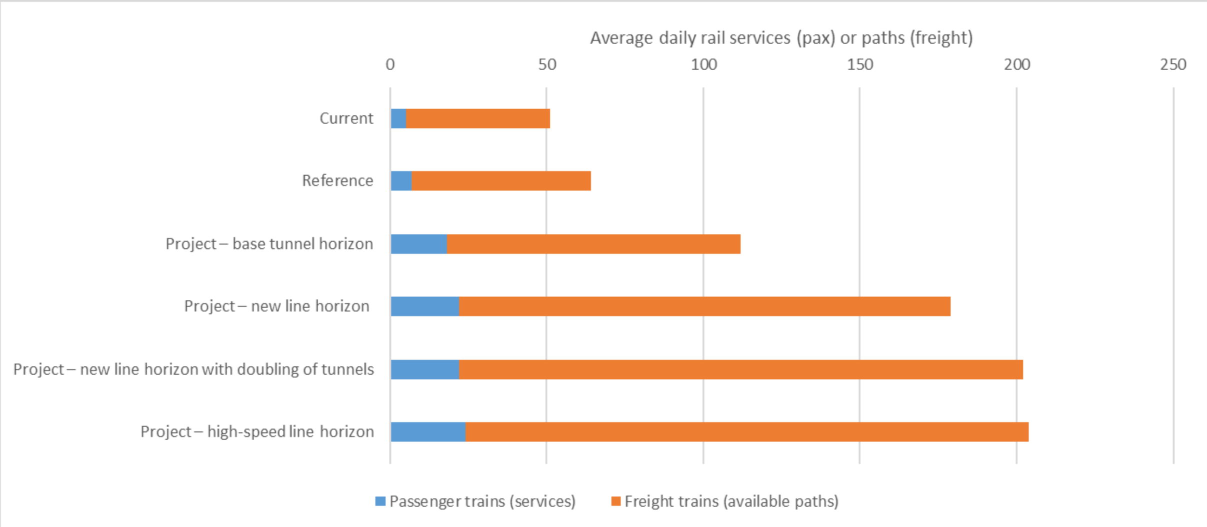
Source: as in the table above

2.4.5 Railway capacity

2.4.5.1 Total capacity

The total railway capacity assumptions for freight and passengers are summarized in the graph below:

Illustration 12. Railway capacity assumptions for freight and passengers



Source: as in the table above

2.4.5.2 Number of daily long-distance services

The capacity for passenger services are defined in daily long distance services as follow:

Tableau 6. Number of daily high-speed services per crossing point

Scenario	Historic tunnel	Base tunnel	Total
Current*	5a	-	5a
Reference	7c	-	7c
Project – base tunnel horizon	-	18b	18b
Project – new line horizon	-	22b	22b
Project – new line horizon with doubling of tunnels	-	22b	22b
Project – high-speed line horizon	-	24b	24b

[a]: [redacted] and [redacted] access restriction scenario as part of the 2018 security audit
[b]: Revision of the preliminary draft reference, Functional submissions to the IGC, Submission 36 (Vol. B) Project traffic, LTF, 15/06/2012;
[c] : Alpine access - Summary note of the operating study, [redacted], 16/09/2022

2.4.5.3 *Maximum capacity for freight trains*

The maximum capacity of freight trains shall be counted as the average number of train paths that can be traced for those convoys on the route using the historic tunnel or base tunnel. These train paths do not presume their actual use, unlike high-speed passenger services for which a service plan is determined in advance.

Tableau 7. Freight Train Capacity per Annual Average Day – Broad Gauge Scenario (number of trains per day)

Scenario	Historic tunnel	Base tunnel	Total
Current	46b	-	46 [b]
Reference	57a	-	57a
Project – base tunnel horizon	18a	76*	94d
Project – new line horizon	18a	139*	157d
Project – new line horizon with doubling of tunnels	18a	162*	180c
Project – high-speed line horizon	18a	162*	180c

[a]: Revision of the preliminary draft reference, Functional submissions to the IGC, Submission 36 (Vol. B) Project traffic, LTF, 15/06/2012
[b]: [redacted] and [redacted] access restriction scenario as part of the 2018 security audit
[c]: Verification report of the operating model for the national section on the Italian side, phase 1 [redacted] 10/11/2017
[d]: French access scenario "Grand Gabarit" defined in Alpine access - Summary note of the operating study, [redacted], 16/09/2022
* : [redacted] estimation by deduction

3. ASSUMPTIONS AND FRAMEWORK

3.1 Macroeconomic framework

In the context of cyclical developments described in the introduction, the macroeconomic data considered for the framework reflect these dynamics and feed into the projections presented below. These macroeconomic data are restricted to Franco-Italian gross domestic products and average annual populations. These data are collected from national statistical agencies for historical series and as prospective assumptions after 2021.

3.1.1 Macro-economic projections

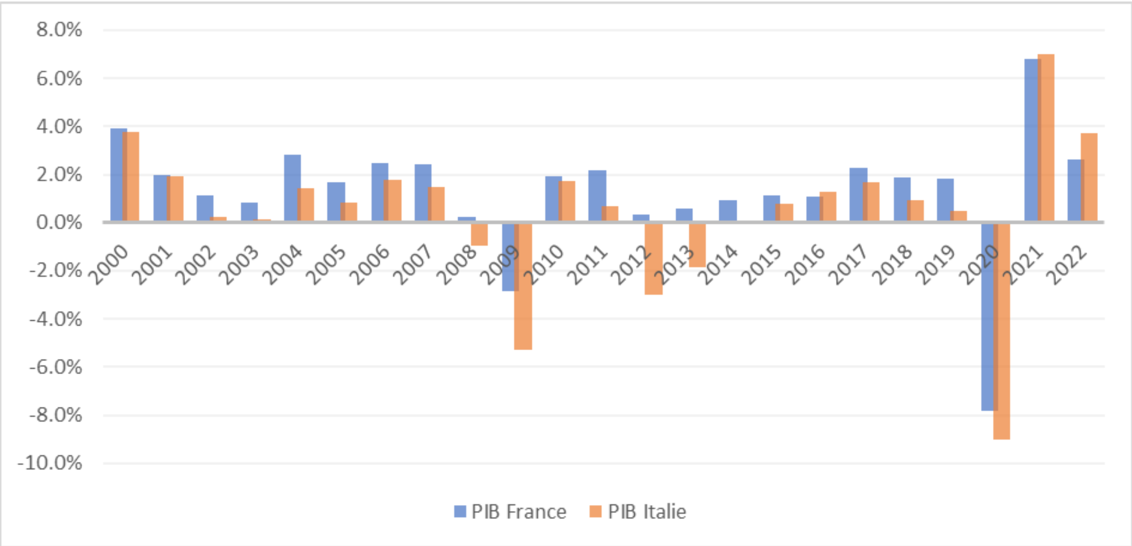
3.1.1.1 Gross domestic product

Historical developments 2000-2022

Over the past decade, economic growth in France and Italy has been on a slight slope since 2014, when Italy emerged from two years of recession. Since 2015, France and Italy have experienced a stabilisation of the pace of growth with rates above 0.9%/year for Italy, and 1.1%/year in France. The years 2017, 2018 and 2019 show a certain recovery in growth before the crisis of 2020 and the impact of COVID-19 on economies.

The impact of the health crisis in 2020 was reflected in the two transalpine economies by a year of recession and a decline in GDP around 8%, with Italy being slightly more affected than France. The years 2021 and 2022 are marked by a significant recovery in economic activity and a catch-up effect compared to 2020. In 2021, despite the maintenance of restrictions related to the health situation, particularly at the beginning of the year, growth in France and Italy is around 8%. In 2022, it is lower than in 2021 but it reaches 2.6% in France and 3.7% in Italy, despite the geopolitical context between Ukraine and Russia.

Illustration 13. Average annual real GDP growth (%/year)



Source Italy: Istat; Source France: INSEE

[redacted] [redacted]

Projections 2022-[redacted]

To take account of macroeconomic developments (gross domestic product and population), different forecasts are analysed. The sources are distinguished according to whether it is short and medium / long term in order to ensure the greatest possible homogeneity throughout the perimeter as follows:

- Short term (2022-[redacted]
  - Italy: Banca d'Italia[6]
  - France: Pensions Orientation Council[7], Short-term

- Medium/long term ([redacted]
  - Italy: Pension expenses[8], Scenario Nazionale Base
  - France : Pensions Advisory Council[9], Scenario 1.3%

The short-term real gross domestic product forecasts are as follows:

Tableau 8. Short-term GDP forecasts

AAGR Real GDP	2022	2023	[redacted]	[redacted]	2022-[redacted]
France (COR/CT)	2,5%	1,4%	1,6%	1,7%	1,8%
Italy (BI)	3,9%	0,6%	1,2%	1,2%	2,3%

Source: France – COR, September 2022 (Short-term); Italy – Banca d'Italia, January 2023

The long-term real gross domestic product forecasts are as follows:

Tableau 9. Medium/long-term GDP forecasts

AAGR Real GDP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
France (COR/1.3%)	1,7%	0,9%	1,1%	1,2%	1,2%	1,2%
Italy (MEF/SNB)	1,1%	1,1%	0,8%	0,8%	1,1%	1,1%

Source: France – COR, September 2022 (scenario 1.3%); Italy – MEF, Spesa pensionistica, June 2022

3.1.1.2 Demography

In terms of demography, the strong trend is a slowdown, without a change, with very small variations for the France (between 0.3 and 0.7% depending on the year) and a decrease in population in Italy with rates of up to -0.3%. The year 2021 is marked by an accentuation of the decrease in the population in Italy compared to previous years (-0.7%) while the France sees a slightly more significant increase in its population compared to the previous 7 years (+0.5%). The year 2022, meanwhile, marks a return to the trend values observed during the 2010s (-0.3% in Italy and +0.3% in France).

[6] See: Banca d'Italia, Bolletino Economico, January 2023

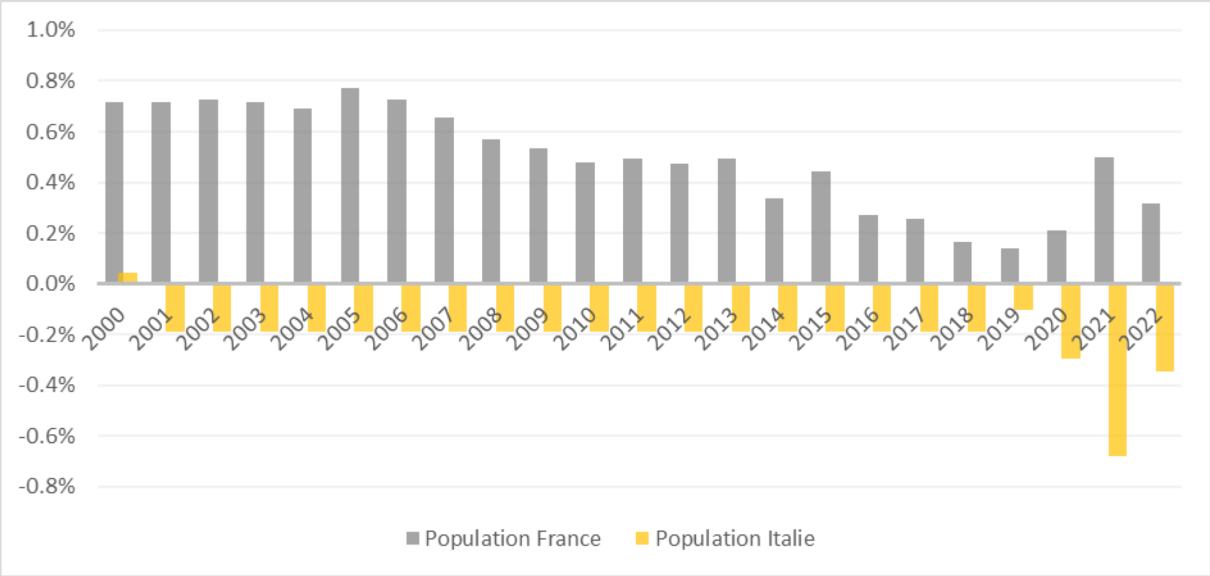
[7] See: Pensions Orientation Council, Annual Report, Developments and prospects of pensions in France, September 2022

[8] See: Ministry of Economy and Finance of Italy, The medium-long term trends of the pension and social-health system, rapporto n°23, Giugno 2022

[9] See: Pensions Advisory Council, Annual Report, Developments and prospects of pensions in France, September 2022

[redacted] [redacted]

Illustration 14. Average annual population growth (%/year)



Source Italy: Istat; Source France: INSEE

The long-term population forecasts used are as follows:

Tableau 10. Medium/long-term population forecasts

CAGR Population	**2020-**[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
France (COR/1.3%)	0,2%	0,1%	0,0%	-0,1%	-0,1%
Italy (MEF/SNB)	-0,1%	-0,3%	-0,4%	-0,6%	-0,7%

Source: France – COR, September 2022 (scenario 1.3%); Italy – MEF, Spesa pensionistica, June 2022

3.1.2 Micro-economic projections

Microeconomic data characterize the production and consumption costs of passenger and freight transport. They derive from a set of factors relating to:

- Average load and vehicle occupancy rates
- Engines and energy sources used
- Taxation and energy prices
- Public aid and subsidies
- Trend drift and the resulting price

These different aspects are described in the following paragraphs to analyse both historical trends and prospective trajectories retained in a coherent scenario built on the basis of national strategies for energy and ecological transition.

3.1.2.1 Vehicle and train load factors

Average loads and occupancy rates are an indicator of transport performance necessary in traffic forecasts, but also a factor for adjusting forecasts.

Indeed, the number of passengers per private vehicle remains poorly known due to the lack of recent survey: it therefore derives from the volume of traffic and other hypotheses explained below. Gains in average load or occupancy rate induce a decrease in the cost per unit transported and thus a strengthening of the competitiveness of the service.

Light vehicles

Occupancy rates for light vehicles are generally measured for the entire national territory through annual or multi-year surveys. However, the resulting occupancy rates are largely weighted by daily commutes, which have particularly low values. These rates include:

- Between 1.14 (2001) and 1.33 (2019) for Italy (Audimob, 17° Rapporto sulla mobilità degli italiani)
- Between 1.61 (2008) and 1.57 (2016) for France (Twenty-five years of inland passenger transport, CGDD)

The analysis of various European and Anglo-Saxon studies[10] leads to the finding of occupancy rates for tourism/leisure reasons (EU 1997, UK 2002-2004, CH 2002, FR 2015) or for tourism abroad (FR 1994, FR 2008, FR 2015) which are significantly higher, between 1.8 and 2.5. Similarly, DGITM notes a rate in 2015 of 2.2 passengers per vehicle for long-distance trips (Reference Scenario, May 2019).

In line with these analyses and the DGITM[11] 's forecast, which indicates a stable rate over time, the following assumptions are used. National values (France-Italy average) are given for comparison.

Tableau 11. Passenger car occupancy rate (pax/veh)

Passenger cars (pax/veh)	2000	2010	2020	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
International	2,30	2,08	2,03	2,03	2,03	2,03	2,03	2,03
National	*1,61*	*1,50*	*1,45*	*1,54*	*1,66*	*1,78*	*1,78*	*1,78*

Source: [redacted] *2021 according to CGDD, AUDIMOB, DGITM, INRETS, EEA*

Heavy vehicles

The occupancy rates of heavy goods vehicles are estimated relatively reliably by the managers of the Mont-Blanc and Fréjus tunnels, and in a manner consistent with the statistics of the historical "Cross alpine Freight Transit" surveys of 1994, 2000, 2004 and 2010.

Looking ahead, the DGITM reference scenario indicates a growth in loading rates to 12 tonnes per vehicle, stabilized from [redacted] This rate is already largely achieved on the Fréjus and Mont-Blanc axis and is therefore not subject to change beyond 2020. An alignment of the different axes is retained in order to homogenize the hypotheses.

[10] See: European Environment Agency, Occupancy rates of passenger vehicles, 2015; Analysis of the load factor and the empty running rate for road transport, INRETS, 2004;
[11] DGITM, Reference Case Framing, May 2019

[redacted] [redacted]

Tableau 12. Load rate of heavy goods vehicles (tonnes/hgv)

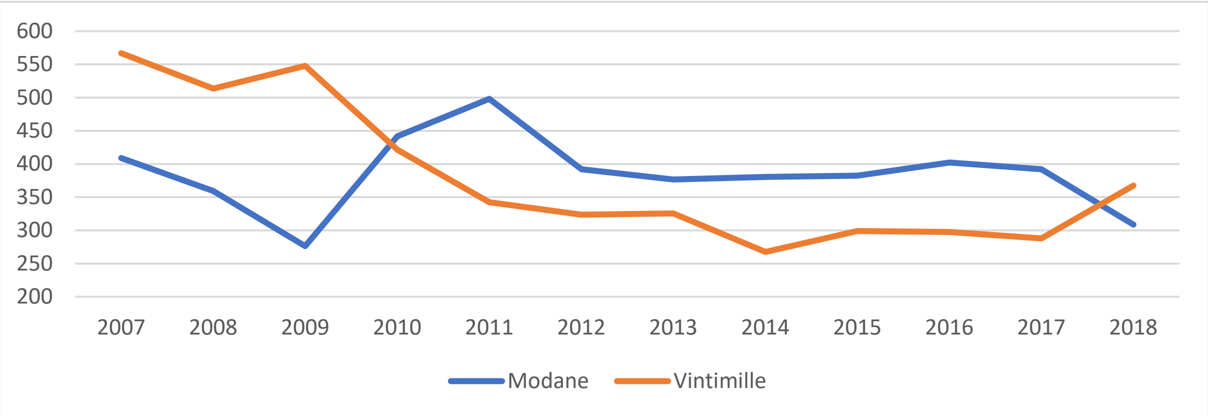
Heavy Goods Vehicles (tonnes/hgv)	2000	2010	2020	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Vintimille	12,91	13,68	13,57	15,00	15,00	15,00	15,00	15,00
Fréjus	16,50	15,03	15,03	15,00	15,00	15,00	15,00	15,00
Mont Blanc	N/A	15,21	15,19	15,00	15,00	15,00	15,00	15,00
Average	*14,71*	*14,35*	*14,30*	*15,00*	*15,00*	*15,00*	*15,00*	*15,00*

Source: [redacted] 2021 based on Alpinfo 2000-2014; Alpine Traffic Observatory / EC 2015-2020; DGITM 2019

Freight trains

The reconstruction of historical load rates of freight trains is a complex exercise that involves data that is sometimes difficult to access. The work carried out on [redacted] and [redacted] data has made it possible to produce estimates that include both partial loading rates of so-called "loaded" trains but also empty or high-foot traffic, known as "empty". These estimates differ from time to time from those already published elsewhere by the Osservatorio (Workbook/ Quaderno 10: 426 T/train in 2015) for reasons difficult to explain without having all the data, however, the orders of magnitude remain substantially the same. These average loadings are particularly low compared to good practice at European level in lowland lines and show the potential progression to move to a lowland line, with a possible almost doubling of average loadings.

Illustration 15. Average load of freight trains in Modane and Ventimiglia (tonnes/train)



Source: [redacted] based on [redacted] and [redacted] data

The analysis of the maximum tonnages transportable in a lowland line shows that the gain could be achieved both in train length and average load factor. In addition, an increase in volumes leads to a greater probability of reloading and the probable decrease in empty circulations. Part of these empty runs currently allows the repositioning of locomotives when 2 or 3 machines are mobilized in one direction but not necessarily in the other, which leads to overcrowding of train paths and a reduction in capacity for the effective movement of goods.

The following calculation assumptions are used to establish the average load variations of freight trains with the Lyon Turin Base Tunnel project:

Tableau 13. Assumptions for calculating rail freight loads in lowland lines

	Max net tonnage per loaded train	Loading rate per loaded train or UTI			Empty return rate per loaded train			Share of traffic
	Horizon	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Conventional freight	1500	70%	90%	95%	50%	40%	20%	50%
Combined freight (containers)	1200	70%	80%	95%	0%	0%	0%	25%
Combined freight (trailers)	1200	70%	80%	95%	0%	0%	0%	25%
Average	*1350*	*70%*	*85%*	*95%*	*25%*	*20%*	*10%*	*100%*

Source: [redacted]/[redacted] 2021 estimates based on maximum tonnages from [redacted]

The resulting assumptions are as follows:

Tableau 14. Freight train load rate (Net tonnes per train)

Freight trains (tonnes/train)	2005	2010	2020	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Mont-Cenis	384	405	368	380	380	380	380	380
New line	N	N	N	680	890	785	890	1140
Ventimiglia	540	437	318	380	380	380	380	380

Source: [redacted] based on [redacted] and [redacted]

3.1.2.2 Engines and energy use

The motorization of road vehicles is a component that draws both the impact of the sector on the environment and its competitiveness in the future. To address this aspect, current parks and different possible prospects are explored.

Light vehicle fleet

The composition and evolution of the light vehicle fleet is the subject of different prospective scenarios, all of which include an assumption of growth in e-mobility (electric or hybrid vehicles) in varying proportions:

- France:
  - 94% of electric vehicles in [redacted] according to the DGITM's "AMS"12 scenario (reference scenario, May 2019) from the national low-carbon strategy, without the mobilization of gas engines

[12] AMS: with additional measures, is the "main scenario of the SNBC, whose assumptions make it possible to achieve the political objective of carbon neutrality by [redacted] and to reduce energy consumption in a significant and sustainable way through energy efficiency or more sober behavior" (DGITM, Reference scenario framework, 2019)

- 29% of electric vehicles in [redacted] according to the DGITM's "AME" scenario[13]

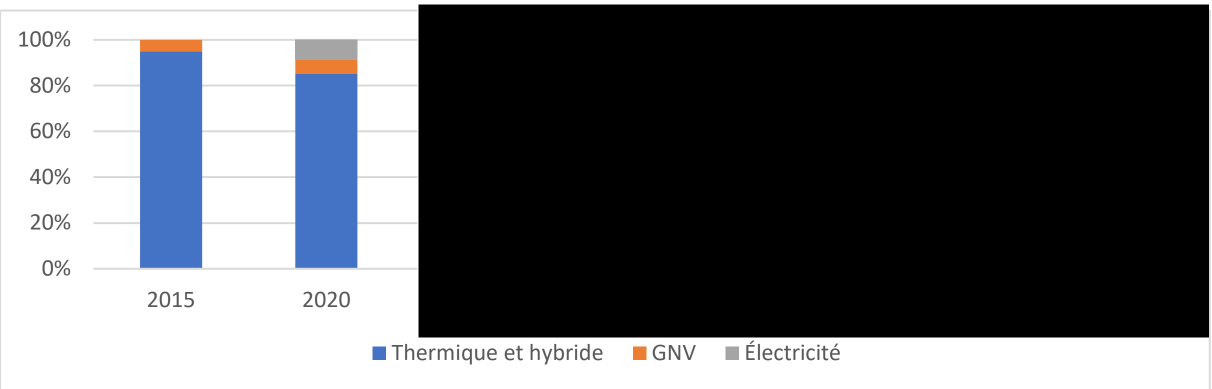
- Italy: 37% electric in [redacted] with 21% gas engines (LPG, hydrogen and CNG) according to the MIT "Referimento" scenario (Strategia italiana di lungo termine sulla riduzione delle emissioni dei gas a effetto serra, 2021);

- Europe: 38% electric in [redacted] and 10% hydrogen in medium scenario (Europe's Clean Mobility Outlook: Scenarios for the EU light-duty vehicle fleet, associated energy needs and emissions, RICARDO)

The Italian reference trajectory is selected, as an intermediary between the high (AMS) and low (AME) trajectories of the France, and in coherence with the available European forecasts, as follows:

Tableau 15. Light vehicle fleet by motorization (%hve)

VL rolling stock	2015	2020	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Thermal and hybrid	95%	85%	75%	59%	42%	32%	21%
CNG	5%	6%	8%	15%	21%	21%	21%
Electricity	0%	9%	17%	27%	37%	47%	58%



Source: [redacted] 2021, based on MIT, DGITM, RICARDO

Heavy goods vehicles fleet

The composition and evolution of the heavy-duty vehicle fleet has different levels of detail depending on prospective sources. In particular, the Italian strategy does not present any numerical details on this subject, but various studies make it possible to frame the prospective. The proposals considered are as follows:

- France:
  - 50% CNG by [redacted] and 25% electric according to the DGITM's "AMS" scenario (reference scenario, May 2019) from the national low-carbon strategy
  - 100% diesel in [redacted] according to the DGITM's "AME" scenario
- Italy:

[13] AME: with existing measures, is the scenario "qualified as trend and which integrates all the measures decided before 1 July 2017", (DGITM, Framework of the reference scenario, 2019)

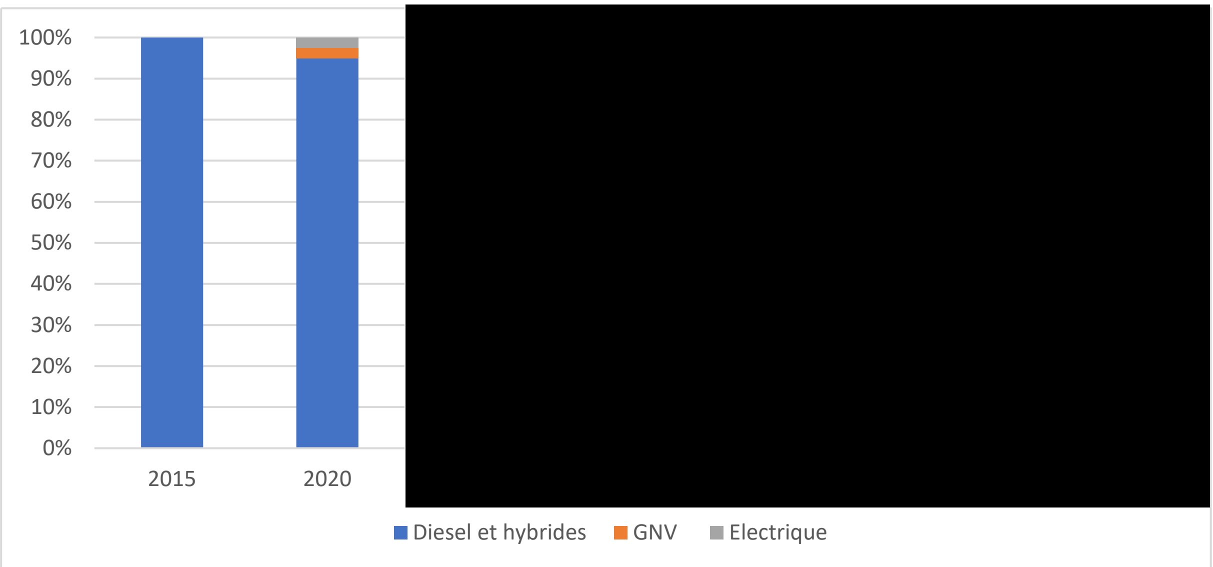
- 10% electric by [redacted] according to the intermediate scenario of The European House / Ambrosetti (Electrification, industrial value chains and opportunities for a sustainable future in Europe and Italy)

- Europe:
  - 70% of electric trucks in sales in [redacted] according to European Climate Foundation (Trucking in a greener future, 2019)
  - 37% of the electric fleet in [redacted] and 4% in CNG according to [redacted]/[redacted] (Commercial Vehicle of the Future, 2017)

The combination of these different sources makes it possible to trace an intermediate trajectory with a balanced development between electric and gas engines as follows:

Tableau 16. Fleet of heavy vehicles by motorization (%veh)

PL Rolling Stock	2015	2020	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Diesel and hybrids	100%	95%	90%	66%	42%	33%	24%
CNG	0%	3%	5%	12%	18%	25%	32%
Electric	0%	3%	5%	23%	40%	42%	45%



Source: [redacted] 2021, based on [redacted] DGITM, [redacted]/[redacted]

Vehicle consumption

In line with the assumptions of engine evolution, the analysis of the average consumption of vehicles by type of engine, integrating future performance gains, makes it possible to draw a basis for the calculation of energy expenditure that follows.

In the absence of an equivalent national forecast in Italy, the assumptions used are those of the DGITM AME reference scenario for petroleum fuels, and AMS for electricity and gas fuels.

Tableau 17. Fuel consumption (unit/100km)

Fuel consumption		2015	2020	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	Unit
Light vehicles	Diesel & hybrids	6,20	5,75	5,30	5,05	4,80	4,05	3,30	L/100km
	Gasoline & hybrids	7,40	6,75	6,1	5,80	5,5	4,45	3,4	L/100km
	Electricity	17,80	17,45	17,1	16,65	16,2	14,85	13,5	kWh/100km
	CNG	3,80	3,48	3,15	2,64	2,13	2,06	2,00	kg/100km
Trucks	Diesel	33,90	32,65	31,40	29,20	27,00	24,00	21,00	L/100km
	CNG	27,00	24,70	22,40	18,75	15,10	14,65	14,20	kg/100km
	Electricity	197,00	182,50	168,00	147,00	126,00	122,00	118,00	kWh/100km

Source: IMTD, Reference Case, May 2019, AME (Diesel/Petrol) and AMS (NGV/Electricity) Scenarios

3.1.2.3 Energy price and taxes

Energy prices and energy taxation are one of the key parameters for the competitiveness of different modes of transport. Combined with the evolution of engines and consumption defined above, they make it possible to assess the potential impact on cost balance.

Energy taxation

The domestic consumption tax on energy products or TICPE is the tax applied to energy products, including fuel in France. It is fixed by product (motor fuels or fuel), the determination of its rate is voted each year in the draft Finance Law. Excise duties are the equivalent taxes in Italy.

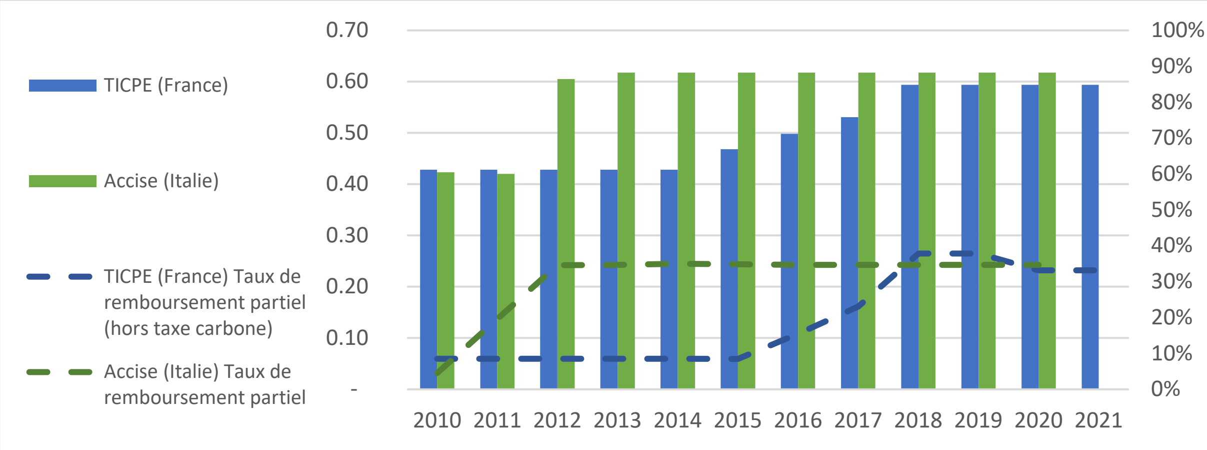
Currently, road hauliers benefit from a partial refund of energy taxation in France as in Italy on road diesel in order to support competitiveness in the face of foreign competition.

In France, the government committed to stabilizing its reduced tariff until 2022, then to abolish this reimbursement mechanism by [redacted] (Finance Bill - Article 30). The TICPE applied to road diesel remains stable at €59.40/hl on 1 January 2023.

In Italy, road freight transport has been subject to a temporary reduction in excise duty at the pump to limit the pass-through of higher energy products to consumer prices. This measure was extended until October 5, 2022 to maintain the 0.25 cents per litre reduction in the pump purchase price for gasoline, diesel and LPG. At the same time, VAT on LPG was deducted from 22% to 5% to limit the pass-through of higher gas prices. In terms of reimbursement rates on commercial diesel, a tax credit is introduced for goods vehicles weighing more than 7.5 tonnes of category Euro 5 and over. These temporary measures are supposed to be abolished at a later date.

The historical rates and reimbursement rates are shown in the table below:

Illustration 16. Taxes on energy products between 2010 and 2020 (€current/litre diesel)



Source: [redacted] according to the Ministry of Ecological Transition; [redacted] / [redacted] /Agenzia delle Dogane/Banca d'Italia

For a decade, partial reimbursement rates have tripled to stabilize at just over 35% since 2018 (if we exclude the carbon tax on the French side). Energy taxation on diesel is therefore currently similar on both sides of the Alps.

Looking ahead, we take up the hypotheses for the evolution of energy taxation (excluding carbon tax) proposed by the DGITM. This trajectory is complemented by an assumption on the reduction of partial repayments following the principle initiated in France but at a slower pace, with a cancellation at binational level in [redacted] (and not in [redacted] as planned in France).

Tableau 18. Energy taxation between 2020 and [redacted]

Energy taxation	**2010**	**2020**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Energy tax (excluding carbon tax) (€2015/l)	0,43	0,54	1,10	1,10	1,10	1,10	1,10
Partial refund rate (excluding carbon tax)	7%	34%	17%	9%	0%	0%	0%

Source: [redacted] 2021, based on DGITM
Source: https://www.economie.gouv.fr/entreprises/taxe-interieure-consommation-sur-produits-energetiques-ticpe and https://www.cnr.fr/trm-actualite-ticpe-janvier-2023; https://www.confetra.com/wp-content/uploads/circ216-2022.pdf

Fuel prices

The evolution of fuel prices remains a delicate subject as the price level can be volatile and depend on geopolitical conditions that influence the market. In October 2021, price levels for superfuel and diesel are around €1.6/l in France or even €1.7/l in Italy depending on national supply channels. However, it is necessary to adopt a forward-looking trajectory, even if its fragility remains in view of the fluctuations of recent months. This is precisely the purpose of the observatory of energy and materials prices set up by TELT, one of the objectives of which is to present estimates on the possible future evolution of these prices on the basis of prospective institutional benchmarks.

When estimating gas and oil prices, it is essential to take into account the high political and economic uncertainty that implies high volatility in energy prices, as well as the continuation of energy transition policies towards renewable and sustainable sources. To account for this uncertainty, different price estimation scenarios have been established:

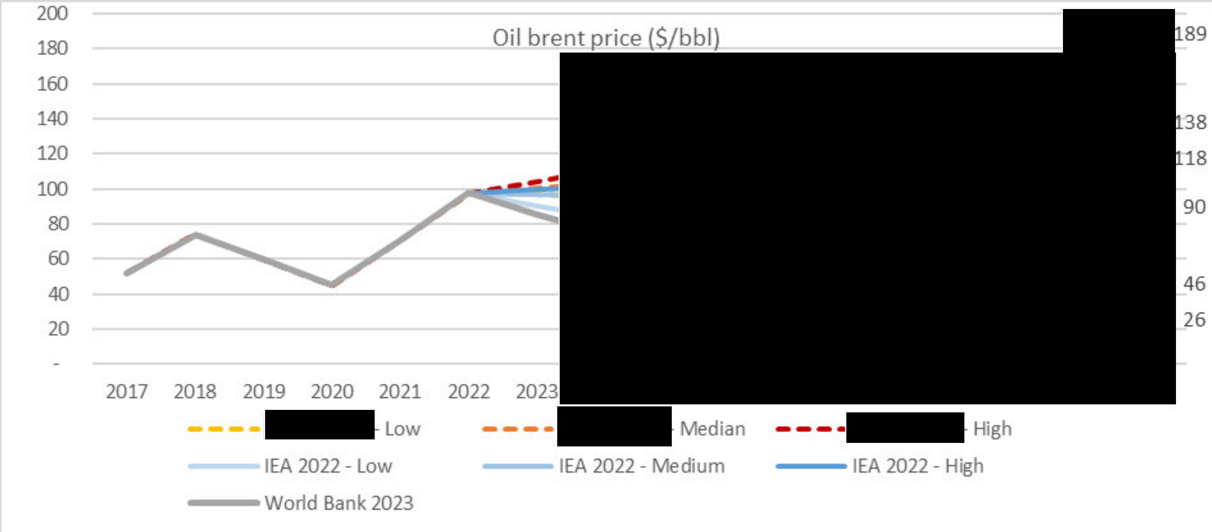
- The scenarios called "External Source" are based on estimates provided by the World Bank and the IEA, 3 of which outline different growth rates. The four scenarios lead to very similar price estimates, assuming a slightly downward trend;
- The choice of these sources provides an overview of trends in the prices of energy products and allows us to have a baseline for our analysis;
- The so-called "high" scenario is a scenario developed by the consultant that uses historical growth rates, including the "crisis" phase. This scenario offers an optimistic view of the future, taking into account long-term growth and historical trends in the energy sector;
- A "low" scenario is proposed, it represents a forecast of low price growth based on growth rates before the "crisis" phase. This scenario provides us with a more conservative assessment of future forecasts for the energy sector;
- Finally, a median scenario is determined that represents the intermediate value between the "low" and "high" scenarios.

Tableau 19. Evolution of fuel and energy prices

Nominal value excluding taxes (current euros)	2015	2020	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Petrol (€/L)	0,51	0,47	1,00	1,07	1,14	1,14	1,14
Diesel (€/L)	0,48	0,44	0,94	1,01	1,07	1,07	1,07
CNG (€/kg)	0,71	0,27	1,96	3,83	2,02	2,02	2,02
Electricity (€/kwh)	0,10	0,11	0,24	0,27	0,30	0,30	0,30

Source: DGITM, Reference Scenario, May 2019, AME Scenario; [redacted] Energy Price Observatory, March 2023

Illustration 17. Projection of Brent oil prices per barrel



Source: [redacted] processing according to World Bank, IEA and historical data

Beyond [redacted] fuel prices are assumed to be insensitive to the price per barrel due to the majority incorporation of biofuels.

Carbon tax

Since 2014, on the French side, energy taxation has included a carbon component according to each tonne of CO2 emitted by the extraction and combustion of each type of fuel, starting from €44.6/tCO2 in 2019 with a planned increase to €100/t CO2 in [redacted] Stabilized in 2018 because of the national popular movement, called the yellow vests movement, the revival of the carbon tax in 2022 is now proposed by various think tanks. This proposal would include compensation for low-income households and could be left to the discretion of the Regions (and not national).

The trajectory we propose to adopt is as follows, with a significant time lag compared to the trajectory initially planned in France, to take into account the complexity of implementing this taxation.

The level of carbon tax remains much slower than the value of carbon climate action advocated at European or national level[14]. This tax would only be eligible on diesel and petrol fuels as follows:

Tableau 20. Carbon tax on diesel

Carbon tax	**2020**	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
€2015/teqCO2	22	48	74	100	175	250
€2015/liter	0,06	0,12	0,17	0,21	0,33	0,41

Source: [redacted] 2021, based on initial French carbon tax trajectory for 2019-[redacted] and emission factors for diesel and petrol fuels (see incorporation of biofuels)

[14] *See: France Strategy, The Value of Climate Action: A Carbon Guardianship Value for Assessing Investments and Public Policy, February 2019*

3.1.2.4 Public subsidies

On both sides of the Alpine arc, several measures exist or are planned to provide financial support for rail freight transport.

Italy: Ferrobonus

In Italy, Decreto n. 125 del 14 luglio 17 (2012-2018) allowing the implementation of a contribution and incentive to intermodality entitled "Ferrobonus".

This measure represents a reduction in the cost of rail transport production assumed to be fully reflected in the price of €2.5/train.km on a Milano – Bardonecchia type section (230 km) on a total Milano – Paris route (1000 km) with a basic transport price of €3.5/tonne.km, i.e. a reduction of 14.3% in the rail transport price taking into account the average load.

The European Commission has issued a positive opinion on the activation from 2023 to [redacted] of ferrobonus, the Italian measure whose objective is to promote the modal shift from road to rail for intermodal transport. This incentive, in its latest version, has a budget of €22 million per year, guaranteeing aid of €2.5 per train-km. The European Commission also presented a report on this subject, pointing out that over the years, the measure had made it possible to subsidize an ever-increasing number of train-km, from 25.9 million train-km in the first year (2017/2018) to 33.8 million train-km in the year 2020/2021. During the same period, the number of beneficiaries of the measure increased from 56 in 2017 to 70 in 2021. Finally, the amounts granted since 2017 have increased from €17.7 million to €46.4 million over the 2021/2022 period.

In 2022, each railway undertaking received a contribution based on the train-km travelled during the twelve months, up to a maximum of EUR 2.5 for each intermodal or transhipped train-km carried out. The actual contribution paid to the beneficiary companies for each train-km turned out to be just over one euro (€1.15).

The ferrobonus is taken into account in the long-term modeling which is aligned at the maximum level of 2.5 euros per train.km considering a reduction in non-use with the development of services and transalpine capacity.

Source: Supply Chain Italy, "Ok della Commissione Europea al Ferrobonus italiano 2023-2027", March 2023

Italy: Regional Ferrobonus of Piedmont, Lombardy and Liguria

In terms of funding, support for the ferrobonus has been provided by the regions of Piedmont, Lombardy and Liguria since 2018, with amounts that amounted to €600,000 cumulated over 2018-2019 for Piedmont, €1.8 million for the Lombardy region for 2018-2020.

This contribution is included in the overall amount of ferrobonuses announced by the State and does not constitute additional aid to the amounts indicated above.

Source: Region Piemonte, Il Ferrobonus regionale, 2019; Regione Lombardia, Dote merci ferroviaria, 2018; [redacted], Regione Liguria introdurra ferrobonus per merci su rotaia, 2017

Italy : Fund for Investment and Development of Freight Terminals

The country's Infrastructure Investment and Development Fund for the completion of the national network of freight ports, particularly in the south of the country, amounted to €45 million in 2022 and amounts to €15 million in 2023.

The investment fund on freight terminals is considered to be recorded as a reference as a project and will not be specifically attributed to the project, assuming that the development of intermodal traffic will be unconstrained at the level of handling areas.

Italy : Aid for modal shift in Friuli Venezia Giulia

The European Commission has authorised from 2022 an aid scheme in Italy to promote the modal shift of goods from road to rail and inland waterways in the Friuli-Venezia Giulia region. The scheme has a total budget of €30 million and will run until 31 [redacted]. It would be based on the reduction of external costs as well as the distance travelled and would be achieved through direct subsidies to multimodal transport operators.

Subsidized services will include a departure and/or arrival terminal in the regions. In addition to covering external cost savings, the aid will cover the additional costs of using infrastructure between road and rail modes, as well as additional costs resulting from sectoral specificities, physical or border barriers of different Member States and non-Member States, traction exchange, lack of interoperability of railway equipment used, constraints on the use of rolling stock and unequal in the costs of railway infrastructure, access to railway infrastructure between countries.

This regional aid could supplement the aid for combined transport already financed by the State and the regions of north-west Italy, with the specific feature of covering only traffic with an origin or destination in the region. However, the amounts are not specified at the stage and for a limited part of the potential demand for the Lyon Turin tunnel. In this sense, this aid will not be explicitly integrated but may contribute to reaching a ceiling level equivalent to the maximum ferrobonus defined above.

Source: European Commission, Aiuti di Stato: the Commissione approva un regime italiano da 30 milioni di € che promuove il trasporto merci intermodale nella regione Friuli Venezia Giulia, March 2022; Regione Autonoma Friulu Venezia Giulia, Nuovo sistemi di transporto delle merci, 2013

Italy : Aid for modal shift on short sea shipping

The European Commission has approved an Italian aid scheme of €125 million in factor form for combined short-sea road-sea transport. The aim is to promote modal shift and reduce the environmental, health and social impact of road traffic and road congestion. The aid is programmed until the end of [redacted] in the form of direct grants, so as to cover a maximum of €0.30 per vehicle-kilometre transferred from road to short sea shipping (i.e. about 3ct/tkm covering about 20% of maritime transport costs).

As this aid must stop before the commissioning of the base tunnel, the measure is not included in the evolution of shortsea shipping prices and the calculation of surplus after [redacted]

Source: Ferpress, EU Commission: ok a regime italiano da 125 mln a sostegno del transport merci intermodale, 2023

France: Rail Freight Support Plan

In September 2021, the government set up a €170 million rail freight support plan paid each year until 2024. Included in the 2021 Finance Bill, these 170 million euros of operating aid relate to:

- 50% of the tolls owed by freight operators to [redacted] (€38 million);
- €70 million for single wagons;
- €47 million for the operation of services;
- €15 million for rail motorways.

Source: French Government, Rail freight: aid of €170 million per year until [redacted] September 2021

The subsidy rate of rail tolls for freight by the French State is assumed to be stable over time in the reference and project scenario.

France: Assistance for the operation of single car services

The objective of the aid set up is to enable rail transport operators providing services for the carriage of single wagons to offer competitive services in order to promote the development of this system of direct service to economic activities by rail.

The total amount including VAT of all public operating subsidies (local, national, international, Community) received by the beneficiary for its assisted single wagon transport services is limited to **30% of the transport costs including VAT**. For import/export services, the government subsidies considered include those received by the beneficiary in other States. The total annual amount of this aid is equivalent to €70 million.

Support for the operation of single wagon services is not taken into account in the traffic model as service patterns are not defined at this stage. Traffic is supposed to be divided mainly between whole trains, rail motorways and combined container or swap body transport.

Source: MTE, Aid for the operation of single wagon services: call for expressions of interest to identify traffic in 2023, 2023

France: Support for the creation and modernization of ITE

The French authorities have obtained an agreement from the European Commission for the establishment of a general aid scheme to support the financing of investments contributing to the creation, reactivation, renovation or extension of the second part of an ITE, belonging to a private entity. This aid will be provided on a case-by-case basis directly by local authorities, in particular the regions to which successive decentralisation laws have conferred the competence to aid economic development.

This help is not explicitly integrated into the modeling. It will be assumed that there are no obstacles to the creation and operation of ITES for private companies and this will not constitute a limit to the development of rail traffic. These budgets will be assumed to be committed in both baseline and project scenarios.

Source: MTE, Technical Note on Support for the Creation and Modernization of Branch Terminal Installations (ITE), October 2018

France: Rail freight subsidy

In order to encourage companies to use freight transport by train, the government has decided to contribute to the compensation of the cost between rail freight and road transport. It announces the opening of the Energy Savings Certificates (CEE) scheme to support the modal shift from road freight to conventional rail freight.

The standardized operation sheet was published by decree on 28 October 2022 for rail freight. It plans to increase the aid provided so that the support is equivalent to about 13% of the average cost. Substantial support, likely to encourage companies to use rail freight.

In the absence of a well-defined temporality and assurance on its durability and amount, this mechanism is not carried over into the model.

Sources: MTE, Rail Freight Bonus, March 2023; MTE, The Government accelerates the transition of modes of freight transport by opening the system of energy savings certificates to the transfer of road freight to rail freight

France: Economic aid DGITM

In July 2022, the French rail freight sector benefited from economic aid amounting to €26 million paid by the DGITM (Direction Générale des Infrastructures, des Transports et des Mobilités), in addition to the €170 million in annual aid allocated by the government until [redacted]

DGITM's cyclical aid is not integrated into the model, nor is it intended to be, as it is not long-term structural aid. In addition, this aid is considered to be recorded and recorded in both a baseline and project scenario.

Source: Téma transport & logistics, A welcome help for rail freight, July 2022

France: Help for the intermodal units handling / combined rail-road transport:

In France, the "pincer" aid represents a flat-rate operating subsidy per Intermodal Transport Unit (UTI) provided that the transhipment is integrated into a transport chain in post and road pre-routing carried out at a terminal in metropolitan France. It is implemented according to Law No. 2009-967 of 3 August 2009 allowing the implementation of an aid scheme for the operation of regular combined goods transport services for the period 2013 - 2017, approved by the European Commission on 19 June 2014, more commonly entitled "aid to the clamp".

This subsidy is intended for any combined transport operator between road transport and other modes, including rail transport. This strategy aims to partially compensate for the additional cost of combined transport, due to the inherent load disruption of this mode, in order to make it competitive and contribute to the objectives of the ecological transition.

Aid for the operation of combined freight transport services aims to reduce the external cost differential between mass modes (rail, waterway, short sea shipping) and road, induced by the break in load inherent in this mode of transport.

The subsidy is defined as a fixed annual allowance to be distributed among all services. Thus, by taking the annual amounts allocated, it is possible to estimate the average unit amount per tkm realized as follows:

Tableau 21. Aid for combined transport

Aid for combined transport	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual subsidy (M€)	19,5	25,5	24,3	25,8	25,9	27,0	27,0	27,0	27,0	27,0
Combined transport (M.Tkm)	8399	9114	9010	7515	6976	6803	7400	N	N	N
Unit subsidy (ct€tkm)	0,232	0,280	0,270	0,343	0,371	0,397	0,365	-	-	-

Source: Ministry of Ecological Transition and SDES

The subsidy level for 2019, compared to the average price level defined subsequently, is equivalent to a price decrease of about 7% until [redacted] raised to 10% from [redacted] taking into account the lower cost of production via the base tunnel.

The clamp aid is integrated into the traffic forecasting model using the following assumptions: it is equivalent to about 80€ for a 400km journey. This value was translated into a discount on the transport price at the rate of €5 per train-km.

Source: https://www.ecologie.gouv.fr/transport-combine#scroll-nav__4

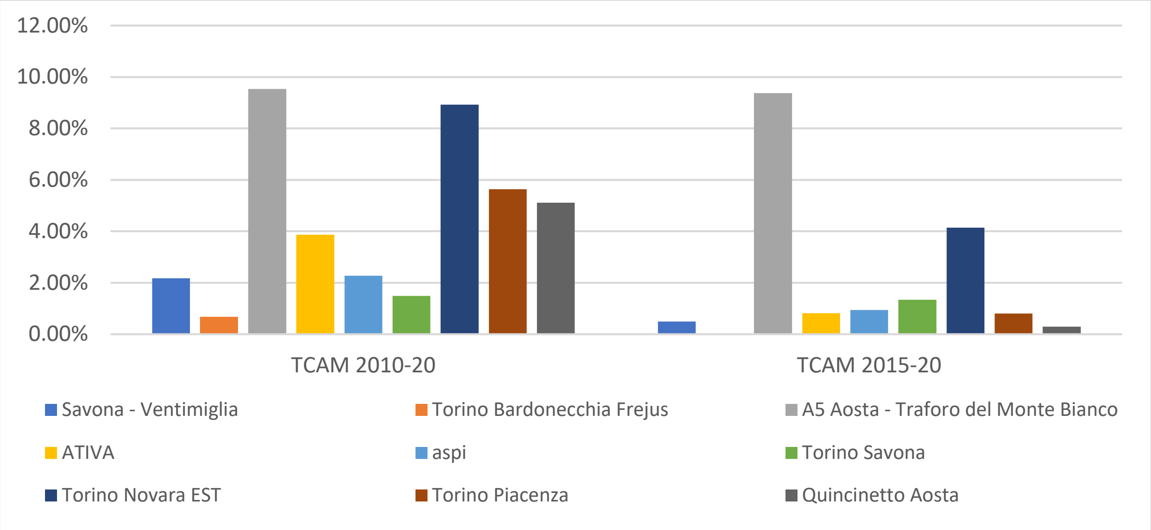
3.1.2.5 Road tolls

Road tolls are used in the composition of the total transport cost and its passing-on in the transport price charged to final customers. Its integration is made on the basis of flat-rate utilization rates as defined below.

Road tolls are established on the basis of average levels related to all kilometres travelled on the networks and recorded in official statistics. The underlying assumption is that the burden of tolls in transport costs on crossings of the western Alpine arc is similar to those of national average journeys. These tolls implicitly include tunnel crossing tariffs.

By way of comparison, the average annual growth rates have been recorded on different sections of the Italian network, they are expressed over the periods 2010-2020 or 2015-2020 and include inflation. Over the last decade, inflation in Italy has averaged 0.9%/year, and 0.6%/year over 2015-2020. Over this last period, it appears that the rates of evolution of tolls were mainly between 0 and 1% / year in current value, around -0.5 and +0.5% / year in real value.

Illustration 18. Average evolution of road tolls in Italy



The levels of road tolls chosen are therefore as follows, in line with the French forecast and the average evolutions in Italy over the last 5 years:

Tableau 22. Average road tolls on all routes

Average road tolls	Toll Level	Evolution
Passenger car (€2015/vl.km*)	0,076	-0.5%/year in constant euros
Heavy goods vehicles (€2015/pl.km*)	0,089	stable in constant euros

* : on the whole route including roads with or without concession and tunnels, the difference between passenger vehicles and heavy goods vehicles includes in particular the difference between journeys on toll roads or not.

Source: DGITM, Reference Case, May 2019 for passenger vehicles; National Road Committee, 2021 for heavy goods vehicles (long-distance articulated assembly)

For the purposes of the socio-economic balance, tunnel tolls are reconstituted independently: they are assumed to be included in the road production costs defined with the previous assumptions, and are charged to infrastructure managers on the following basis:

Tableau 23. Tunnel tolls

Tunnel tolls	€2016/VP TTC	€2016/PL HT	Evolution
Fréjus	18	212	Stable in constant euros
Mont Blanc	28	218	Stable in constant euros

Source: statements on SFTRF websites; ATMB

3.1.2.6 Transport costs

The evolution of transport prices results from the various assumptions on production conditions and costs described above (average load, motorization, taxation, aid, tolls), as well as from a hypothesis of pure and perfect competition: this last hypothesis establishes the fact that operators transfer all of their production surplus into surplus consumption, i.e. in prices without changing their margin.[15]

Cost of passenger transport

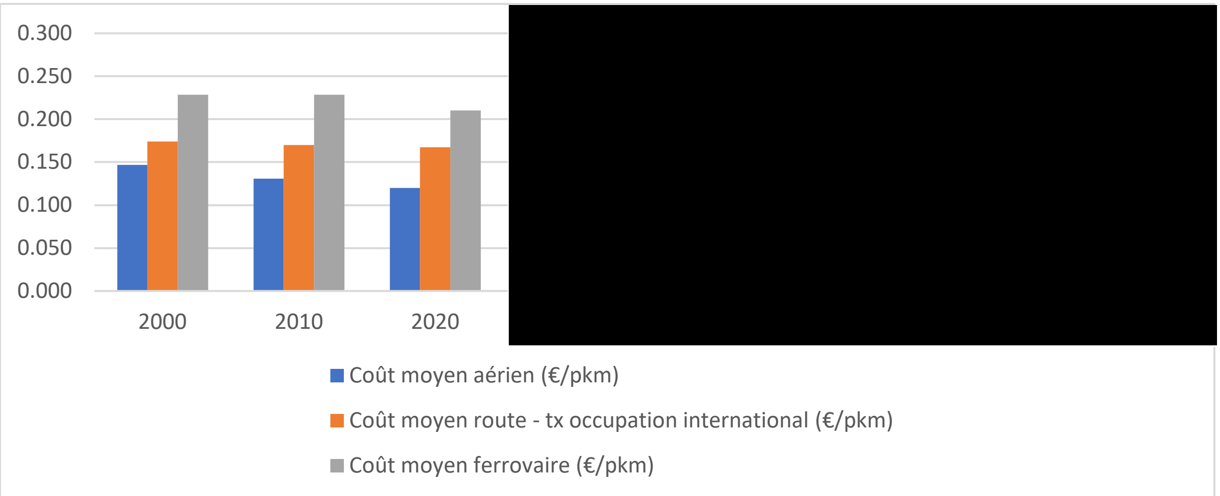
In parallel with the evolution of the components previously described in **the cost of road passenger transport**, we retain a trend evolution of vehicle maintenance/depreciation components from DGITM estimates (reference scenario, May 2019) for an overall price level calibrated on the national estimates of the CGDD (CGDD, Query of the international multimodal model MODEV, 2015). The DGITM considers in the AME scenario an increase in these costs (excluding tolls and energy) of +0.56%/year between 2015 and [redacted] and 0.61%/year until [redacted] with a stabilization in constant euros over the long term.

The price level of **air transport** is also derived from these same CGDD estimates. In the AME scenario, DGITM considers a price increase of +1%/year between 2015 and [redacted] followed by a stabilisation of these costs in constant euros over the long term.

The price level of **rail passenger transport** is established on the basis of the surveys carried out by [redacted] for Western Europe (Study on the prices and quality of rail passenger services, April 2016, [redacted]). In the AME scenario, the DGITM assumes a decrease in the price at a rate of -1%/year between 2015 and [redacted] then a stabilization of these prices.

The resulting price levels according to the modes and time horizons considered are as follows:

Illustration 19. Prospective passenger transport prices (€/pax.km)



Source: [redacted] based on CGDD, DGITM, [redacted]

[15] *This usual assumption makes it possible to simplify the distribution of benefits by actors and limits the need to use the estimation of so-called "wider economic benefits", the approach of which is not currently standardized at national or European level.*

[redacted] [redacted]

Cost of freight transport

For **road freight transport**, in addition to the evolution of the cost components described above, the overall price is assumed to derive from a trend evolution of the wage and depreciation components of vehicles resulting from an analysis of the historical trends of the Bank of Italy indices (Indagine sui trasporti internazionali di merci, Banca d'Italia, 14/07/2021). This analysis leads to consider a trend growth of 0.05% / year after 2020 over the long term, in constant euros. The reference price level for road freight transport is defined according to the case study of Paris-Milan and Marseille-Milan routes for road transport loaded at 15T. (Alpine Traffic Observatory 2019).

The price level of **maritime transport** derives from requests for freight rates on the Barcelona – Genoa routes (worldfreightrates.com, 2018) and the analysis of rate developments over a long series (UNCTAD, Review of maritime transport, 2020) with a certain stability around rather low values since 2015, and the assumption of a stable level in constant euros over the long term.

The price level of **rail freight** transport comes from the same source used for the road transport price level (Alpine Traffic Observatory 2019) for Paris-Milan and Marseille-Milan routes and a load of 15T per UTI as a base value. This price is modulated by the average load specifically constrained on the historic line (reference) and adjusted to European standards on the new line (planned). In addition, the following assumptions are made on the components of maintenance costs and traction energy on a typical route:

- Traction is achieved with an average of 2.11 locomotives per train on the Mont-Cenis axis currently (Source: [redacted] statistics 2019/2020);
- The differential in energy cost is assumed to be proportional to the differential of gross tons circulated in single units (plain) and multiple units (mountain);
- The locomotive maintenance cost differential is assumed to be doubled in the mountains (with at least 2 locomotives in traction, not counting the empty returns at the top of the foot for repositioning of surplus locomotives)

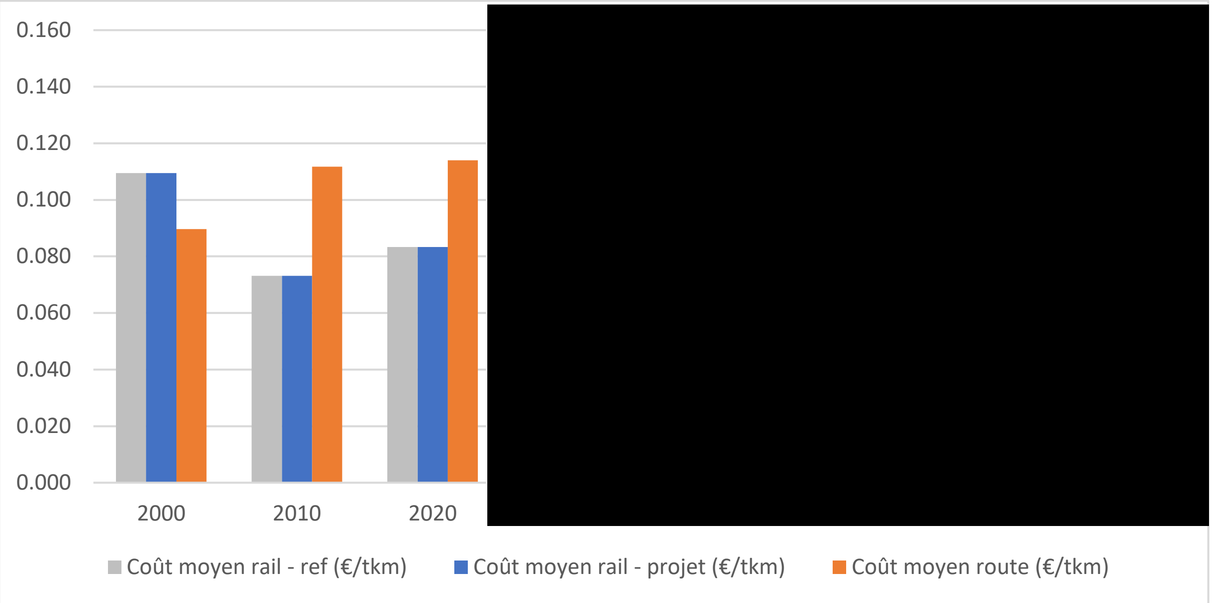
Tableau 24. Rail freight costs - energy and maintenance in plains and mountains

€2012 / train.km	Project (plain)				Reference (mountain)
	Combined transport	Car carrier	Entire trains	Average	Average
Traction energy	1,250	0,740	1,820	1,270	2,19
Locomotive maintenance	1,220	1,350	1,220	1,263	2,53

Source: [redacted] according to [redacted] socio-economic assessment framework, 04/2021

The resulting price levels according to the modes and time horizons considered are as follows:

Illustration 20. Prospective freight transport prices (€2015/tkm)



Source: [redacted] *based on CGDD, DGITM, SDG*

3.2 Project economics

3.2.1 Capital expenditure

3.2.1.1 Reference investments, avoided in project scenario

The developments planned in a reference scenario to maintain the capacity of the base tunnel and the safety conditions of its operation are provided by the Contracting Authority in 2018 to the tunnel of €975 million in 2018 including:

- the creation of a second tube at the Montcenis railway tunnel
- the deployment of 34 shelters and 11 technical stations, as well as 11 by-passes

These developments are assumed to be carried out in a reference scenario and not in the project scenario, on the horizon of commissioning of the base tunnel.

3.2.1.2 Project investment on French access

The costs of the project submitted for public debate (phases 1 and 2) amount to 7.7 billion euros (Euro January 2011 – source [redacted] – updated in 2020 to 8.6 billion euros). By decree of 23 August 2013, the project (phase 1 + phase 2) was declared of public utility.

The detailed project approach of the access lines on the French side is still being studied; in 2020, the Steering Committee for French access to the cross-border line took office in Lyon, with the main objective of overseeing the launch of studies for access; the French local authorities and [redacted] are associated with the Committee and TELT participates as head of the cross-border section. [redacted] has studied three project scenarios for the new line between Lyon and Saint-Jean-de-Maurienne: (1) "Dominante fret"; (2) "Grand Gabarit"; (3) "Mixte". The French government's decision on the chosen scenario is also part of the selection process of national priorities under the competence of the IOC (Infrastructure Steering Committee).

The IOC report of February 2023 entitled "Investing more and better in mobility for a successful transition" presents different scenarios for public spending on infrastructure. In her speech on February 24, 2023, Premier Elisabeth Borne indicated that "it is from the "ecological planning" scenario of the Infrastructure Advisory Council that (she intends to conduct) exchanges with communities. "[16]tag.

This scenario is therefore selected as the central scenario for the cost-benefit assessment. It retains the so-called "Grand Gabarit" development scenario comprising the following operations. The railway connection of Chambéry to the conventional railway, only considered in the “Mixte” scenario but already provisioned in the “Déclaration d’Utilité Publique” is nonetheless accounted at the horizon of the doubling of the freight tunnels.

[16] https://www.gouvernement.fr/discours/discours-de-la-premiere-ministre-elisabeth-borne-remise-du-rapport-du-conseil-dorientation-des-infrastructures-coi-et-presentation-dun-plan-davenir-pour-les-transports

Tableau 25. Investment amounts for French rail access

CODE	Entitled	Perimeter	Amount (K€$_{2020}$)
GGP1	Complete doubling of the sections Les Abrest - Pont de Beauvoisin and St Béron - Lépin le lac, long avoidance of Cognin and halt	France	600 000
GGP2	Creation of a mixed line to St-André-Le-Gaz and a freight line from St-André-Le-Gaz with single-tube tunnels at the Chartreuse, Belledone and Glandon massifs	France	6 700 000
GGP3	Doubling of the Chartreuse, Belledonne and Glandon tunnels, made mixed between passengers and freight	France	2 260 000
GGP4	Creation of a high-speed line (300 km/h) between Lyon St Exupéry and Chambéry	France	1 580 000
RLNC	Connexion of the conventional railway line to Chambéry	France	1 900 000
		French rail accesses Total in €$_{2021}$	**13 040 000**
		French rail accesses Total in €$_{2023}$	**15 274 946**

Source: [redacted], French access to Lyon-Turin: technical committee, July 2022; Infrastructure Advisory Council, Investing more and better in mobility for a successful transition: annex report, January 2023; [redacted] elaborations for €$_{2023}$ values, based on NLTL index

The above table also presents the total costs in 2023 values, because, in order to provide consistency throughout the analysis, all amounts computed into the CBA have been converted into constant €$_{2023}$ values.

The temporal and projected distribution according to the Report of the Infrastructure Steering Committee and Cost Allocation Hypothesis would be as follows:

[redacted] [redacted]

Illustration 21. Capital expenditure on French Alpine accesses – Large gauge scenario / Ecological planning (M€ 2021)

Source: [redacted] according to [redacted], Accès français du Lyon-Turin: technical committee, July 2022; Infrastructure Advisory Council, Investing more and better in mobility for a successful transition: annex report, January 2023

The COI report specifies that, in the "green planning" investment scenario, the "Grand Gabarit" access scenario would be commissioned in [redacted] in phase 1 and [redacted] in phase 2, [redacted] in phase 3 and after for phase 4 (defined as [redacted]

3.2.1.3 Alpine crossing project investments

Preliminary and exploratory works have been led by the promoter TELT SAS (previously LTF) which are up to 1 492 $M€_{2010}$ (equal to 1 986 $M€_{2023}$ after the conversion for CBA purposes), spread over 5 main galleries as follow:

- France
  - Saint-Martin-la-Porte 2003 – 2010 (2350 m) and 2015-2016 (1808 m)
  - La Praz, 2005 – 2009 (2665 m)
  - Villarodin-Bourget/Modane 2002 – 2007 (4036 m)
- Italy: La Maddalena 2012 – 2019 / 7020 m

The costs of the following investments carried by the promoter TELT SAS for the different Italian, French and common parts of the international section are structured in 12 operational projects, accompanied by transversal expenses as follows. The amounts presented below correspond to the certified cost agreed by the member states:

Tableau 26. Investment amounts of Tunnel Euralpin Lyon-Turin

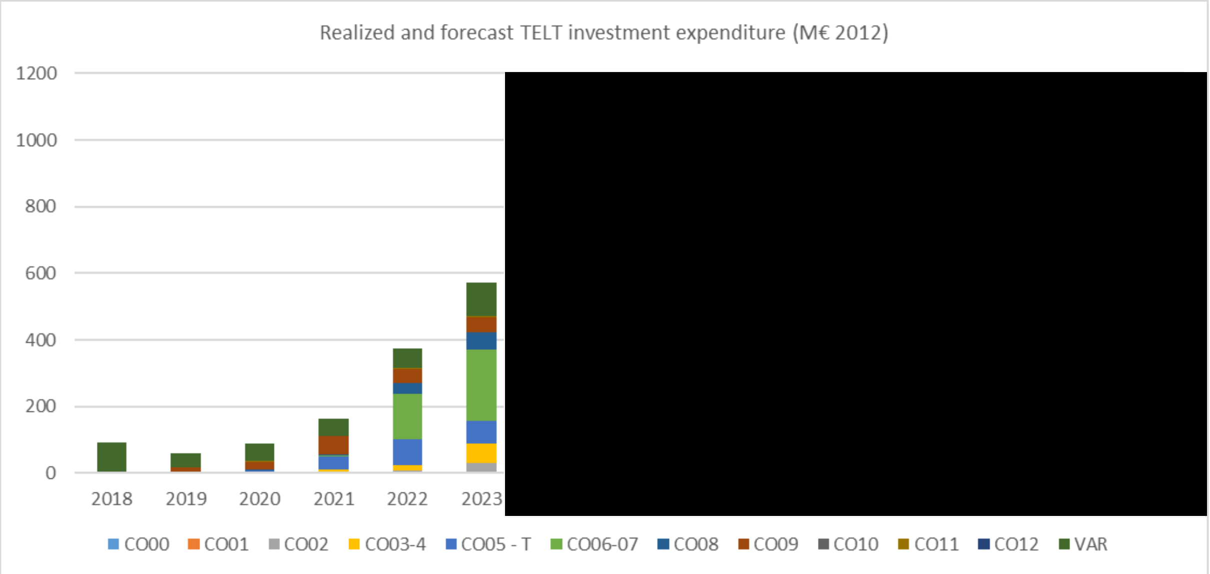
CODE	Entitled	Perimeter	Amount ($M€_{2012}$)
CO00	General	Total	45,54
CO01	Bussoleno Interconnection	Italy	134,57
CO02	Open-air work Susa	Italy	345,82

CODE	Entitled	Perimeter	Amount (M€$_{2012}$)
CO03-04	Base tunnel from the entrance on Chiomonte	Italy	961,59
CO05	Base tunnel from VBM	Italy	1432,18
CO06-07	Base tunnel from SMLP and La Praz attacks	France	1213,88
CO08	West portal base tunnel	France	204,39
CO09	Open air work SJDM	France	614,90
CO10	Management works and valorization of excavation materials on the Italian side	Italy	265,52
CO11	Management work and valorization of excavation materials on the French side	France	492,47
CO12	Equipment installation work	Total	1537,58
VAR	Various (insurance, expropriations, engineering, operation, etc.)	Total	1361,26
TOT	**TOTAL base tunnel (certified cost)**	**Total**	**8609,69**
		Base tunnel Total (certified cost) in €$_{2023}$	**10787,95**

Source: TELT SAS, Rapporto di avanzamento economico: quarto quarto 2022 (Totale Progetto), December 2022; [redacted] *elaborations for €$_{2023}$ values, based on NLTL index*

The temporal and forecast breakdown according to the Progress Report of 31/12/2022 is as follows:

Illustration 22. Investment schedule of Tunnel Euralpin Lyon-Turin



Source: [redacted] based on TELT, Progress report as of 31/12/2022

In line with the schedule presented above, the commissioning of the base tunnel is scheduled for early [redacted] with the settlement of the sums to value during the year.

3.2.1.4 Project investments on Italian accesses

The investment costs for Italian rail access are structured as follows:

Tableau 27. Investment amounts for Italian rail access

CODE	Entitled	Perimeter	Amount (K€$_{2021}$)
CTO2	Turin belt connection to the Turin-Lyon line (priority works), Orbassano Avigliana phase 1 and Orbassano yard	Italy	1 700 150
BSA	Adaptation of the historic Turin-Modane line on the Bussoleno-Avigliana section	Italy	204 680
CTO2	Turin belt connection to the Turin Lyon line (new line Orbassano-Settimo Torinese; Orbassano Avigliana phase 2)	Italy	2 692 850
		Italian rail accesses Total in €$_{2021}$	**4 597 680**
		Italian rail accesses Total in €$_{2023}$	**5 317 757**

[redacted] [redacted]

Source: RFI e MIT, Contratto di programma 2022-2026: Parte investimenti, December 2022; SYSTRA elaborations for €$_{2023}$ values based on NLTL index

Illustration 23. Investment schedule for Italian rail access

Source: [redacted] *after* [redacted] *Contratto di Programma, Dicembre 2022*

3.2.1.5 *Total investments recorded*

Accounting for all capital expenditures in a project scenario, including baseline investments that would be evaded, the amounts involved are as follows:

Tableau 28. Summary of total investments recorded (K€2023)

Component	Items	Source values	Various Unit	Converted values M€$_{2023}$
French access	Total	13040	M€$_{2020}$	15275
Doubling of Les Abrest - Pont de Beauvoisin and St Béron - Lépin le lac, long avoidance of Cognin and halt		600	M€$_{2020}$	702
Mixed line to St-André-Le-Gaz and freight line from St-André-Le-Gaz with single-tube tunnels at the Chartreuse, Belledone and Glandon massifs		6700	M€$_{2020}$	7848
Chambéry connection to the conventional railway line		1900	M€$_{2020}$	2226
Doubling of the Chartreuse, Belledonne and Glandon tunnels, made mixed between passengers and freight		2260	M€$_{2020}$	2647
High-speed line (300 km/h) between Lyon St Exupéry and Chambéry		1580	M€$_{2020}$	1851
Italian access	Total	4592	M€$_{2021}$	5318
Turin connection to the Turin-Lyon priority works (first phase of four-tracks-works for Avigliana- Orbassano and upgrade of Orbassano marshalling yard)		1700	M€$_{2021}$	1966
Adaptation of the historic Turin-Modane line on the Bussoleno-Avigliana section		205	M€$_{2021}$	237
Turin connexion to the Turin-Lyon priority works (new line Orbassano - Settimo Torinese, second phase of four-tracks-works for Bussoleno- Avigliana)		2692	M€$_{2021}$	3115
TELT	Total	N/C	-	11587
Exploratory and preliminary works		1492	M€$_{2010}$	1986
Base tunnel and international section (certified cost)		8609	M€$_{2012}$	10788
Historical railway tunnel doubling		- 975	M€$_{2018}$	-1187
TOTAL		N/C	N/C	**32180**

Source: [redacted] based on sources previously indicated for each operation

The cumulated investment commissioned at the date of the base tunnel ([redacted] accounts for 15 679 M€2023 excluding the avoided costs, broken down into:

- Italian accesses 2 203 (41% of the provisioned works)
- French accesses: 702 (5%)
- Base tunnel exploratory works: 1986 (100%)
- Base tunnel works: 10 788 (100%)

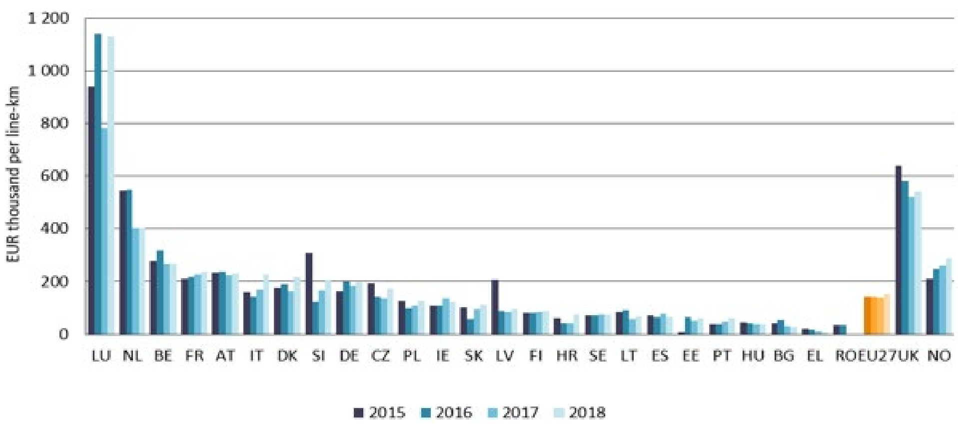
3.2.2 Operating expenditure

European comparison

The methodology for calculating railway maintenance and renewal costs applied in the cost-benefit assessment is based, first of all, on comparative data from the "Rail Market Monitoring 2020 (RMMS)" published by the European Commission, which detail the levels of investment devoted to the maintenance, renewal and improvement of the rail network by line-km by EU State.

This indicator makes it possible to establish a European average of expenditure on maintenance/renewal/improvement of railway infrastructure, as well as conversion factors between European States. This basis is compared with the reference values for the relative fixed and variable costs of rail maintenance indicated in the [redacted] standard.

Tableau 29. Fixed rail maintenance/renewal expenses (K€)



Source: RMMS 2020, Figure 14, European Commission, January 2021

Tableau 30. Fixed and average rail maintenance/renewal costs

Pays	Unité	2015	2016	2017	2018	MOYENNE	Ratio FR
France	Dépenses (maintenance, renouvellement, renforcement) par ligne-km par pays	209	216	228	238	*222.75*	100.0%
Autriche		233	236	223	231	*230.75*	103.6%
Italie		161	143	169	226	*174.75*	78.5%
Allemagne		163	200	183	195	*185.25*	83.2%
Espagne		70	64	79	66	*69.75*	31.3%
					Moyenne UE	***176.65***	**79.3%**
					Moyenne FR-IT	***198.75***	**89.2%**

Source: [redacted] *based on RMMS 2020, Figure 14, European Commission, January 2021*

[redacted] socio-economic assessment reference system provides fixed and variable components of maintenance and regeneration costs. These values are therefore adjusted as follows:

[redacted] [redacted]

- For the international TELT section: 89.2% compared to [redacted] reference values (average level of expenditure between France and Italy),
- For French rail access: 100% compared to [redacted] reference values,
- For Italian rail access: 78.5% compared to [redacted] reference values (level of expenditure devoted by Italy compared to the level of expenditure devoted by France).

Applicable reference system

As mentioned above, the assumptions for calculating rail maintenance and renewal costs for the TELT project are based on the methodology set out in the reference framework published by [redacted] on the framing of socio-economic and financial studies (April 2021). In this document, infrastructure maintenance costs are broken down into two types:

- Maintenance costs (including monitoring);
- Regeneration (or renewal) costs.

According to this framework, the annual infrastructure maintenance costs are the result of a linear function of the form a*l+b*t with:

- a*l the annual fixed cost, where l is the track line (in km)
- b*t is the annual variable cost, where t is traffic (train x km).

Annual fixed railway maintenance and renewal costs

The [redacted] standard includes 5 cost items to be taken into account in the calculation of annual fixed costs, namely:

- Fixed maintenance costs (excluding electrical installations),
- Fixed maintenance costs of electrical installations,
- Fixed operating costs,
- Fixed renewal costs (excluding electrical installations),
- Fixed costs of renewing electrical installations.

The table below summarizes the values mentioned in the [redacted] reference system for each fixed cost item, as well as the values adjusted to the economic conditions of the project.

Tableau 31. Annual fixed railway maintenance costs for UIC lines 2-6 (€2013)

		Réf. SNCFR	**Moy. FR-IT**	**Moy. UE**	**Ratio IT**
Coût fixe annuel	**Unité**	***UIC 2-6***	***UIC 2-6***	***UIC 2-6***	***UIC 2-6***
Entretien (hors inst. Élec.)	€2013/km voie	43 167	38 516	34 233	33 865
Entretien des inst. Élec.	€2013/km voie élec.	5 647	5 039	4 478	4 430
Exploitation	€2013/km ligne	27 479	24 518	21 792	21 558
Renouvellement (hors IE)	€2013/km voie	54 734	48 837	43 406	42 939
Renouvellement des IE	€2013/km voie élec.	6 200	5 532	4 917	4 864

Source: [redacted] based on [redacted] (2021) and RMMS (2020)

Annual variable costs of maintenance and railway renewal

The [redacted] standard includes 6 cost items to be taken into account in the calculation of annual variable costs, namely:

- variable costs of track and switches and crossings maintenance,
- variable costs of maintaining signalling installations,
- variable maintenance costs of electrical installations,
- variable operational operating costs,
- variable costs of renewal of track and switches and crossings,
- variable costs of renewing electrical installations.

The table below summarizes the values mentioned in the [redacted] reference system for each variable cost item, as well as the values adjusted to the economic conditions of the project.

Tableau 32. Annual variable railway maintenance costs for UIC lines 2-4 (€2013)

Coût variable annuel	€ 2 013	Réf. [redacted]		Moy. FR-IT		Moy. UE		Ratio IT	
Coûts marginaux d'entretien	**Unité**	***LGV***	***Fret (UIC 2-4)***	***LGV***	***Fret (UIC 2-4)***	***LGV***	***Fret (UIC 2-4)***	***LGV***	***Fret (UIC 2-4)***
Entretien (Voie+ADV)	€KTBC-km	0.617	0.343	0.551	0.306	0.489	0.272	0.484	0.269
Entretien (signalisation)	€/train-km	0.105	0.198	0.094	0.177	0.083	0.157	0.082	0.155
Entretien (caténaire+EALE)	€/train-km	0.096	0.161	0.086	0.144	0.076	0.128	0.075	0.126
Coûts marginaux d'exploitation									
Exploitation	€/train-km	0.058	0.203	0.052	0.181	0.046	0.161	0.046	0.159
Coûts marginaux de renouvellement									
Renouvellement (Voie+ADV)	€KTBC-km	4.566	1.184	4.074	1.056	3.621	0.939	3.582	0.929
Renouvellement (caténaire+EALE)	€/train-km	0.117	0.117	0.104	0.104	0.093	0.093	0.092	0.092

Source: [redacted] based on [redacted] (2021) and RMMS (2020)

For the calculation of the gross tonnage of freight and passenger trains, we considered the following assumptions of tare weight of rolling stock:

- For passenger traffic, a TGV train weighs 420 tonnes,
- For freight traffic, the tare weight of wagons and locomotives represents 33% of the gross tons circulated.

3.2.3 Revenues

Rail access charges and passenger train traffic

The fee schedule applicable to the Lyon-Turin Euralpin Tunnel project is not yet defined at this stage. A valuation of tolls is prepared as a synthesis of the Italian and French scales, consistent with the economic studies carried out previously.

On the French side, the calculation of passenger rail charges in France can be based on the 2010 scale[17] reduced to current values. For this, from 2010, the changes in the scale defined in the document "Socio-economic reference framework: fees and costs of the GI" published by RFF in March 2009. The scale category that may be used for the base tunnel is that of New High Traffic Lines (N1). This fee was broken down as follows:

- Reservation fee
- Road charge
- Electric supply and traction charge

[17] 2010 scale, minimum benefits, (December 2008 edition), [redacted]/[redacted]

[redacted] [redacted]

On the Italian side, the applicable scale is that of Rete ferroviario Italiano ([redacted] from which it is possible to reconstitute the tariffs of the different sections of the Italian network which includes 3 main terms, the lines of type "Alta Velocità / Alta Capacità" have been retained for the calculation:

- An access fee;
- A circulation fee;
- An electric traction fee.

The cumulative average values for these different components selected for the resulting international section are €20.3/train.km with a long-term evolution of 0.5%/year in constant euros.

Rail access charges and freight train traffic

In the same way as for passenger trains, the level of charge applicable for freight trains on the cross-border section is not defined at this stage. A medium hypothesis, established in coherence with previous studies is proposed.

The French scales broken down by mass hauled train on the different lines and the Italian scale used in previous studies, based on updated 2004 tariffs, lead to establish an average rate of €6.2 2020/train.km, with a long-term drift of 1.1%/year in constant euros.

Evolution of short-term rail access and traffic tolls

In the network's reference document for the 2024 service timetable, [redacted] has made public the proposed rail infrastructure usage charges for the [redacted]-[redacted] fare cycle. The latter are notably marked by a dynamic evolution over the period, based, in particular, on an average increase of around 8% between 2023 and 2024, which aims to respond to the inflationary context and the objective of improving the coverage of the full costs of infrastructure management by rail tolls, set by the performance contract between the State and [redacted] for the period 2021-[redacted]

At the end of its analyses, it is considered that the changes in the structure of the tariff increases applicable to passenger transport services, which respond to the recommendations it had made in the past, in particular in its study on the opening up of domestic rail passenger services to competition in February 2022, significantly improve the relevance of the economic signals sent to users of the rail network and will thus make it possible to ensure a more effective and optimal use of the network, in accordance with the applicable legal framework.

In 2024, the fee paid by carriers will increase by 8% for TER and 7.6% for TGV and Intercity, before increasing by another 4% in [redacted] and [redacted]

The translation of this increase in tolls into the overall price of rail transport remains questionable as it is difficult to determine a long-term trajectory and an impact on the final transport price. However, these short-term adjustments make it possible to adjust the infrastructure manager's balance sheet in order to align increases in revenue and maintenance-operation costs.

Sources: ART, L'ART publishes its opinions on the network's reference document for the 2024 working timetable, February 2023; Le Messager, [redacted] why could ticket prices still increase soon?, March 2023

[redacted] [redacted]

3.2.4 Funding plan

For the Euralpine Tunnel Lyon Turin, ; the distribution of funding between the French and Italian States is established according to the Additional Protocol of 8 March 2016 to the Agreement of 24 February 2015 for the initiation of final works on the cross-border section of the new Lyon Turin railway line: this protocol establishes the certified cost of the project which serves as a key benchmark for the distribution of investment amounts between the two countries.

The Additional Protocol details the breakdown of the amounts by country but also by item of expenditure, as well as the total amount of investment estimated for the implementation of the cross-border section. These elements have no impact on the current socio-economic assessment.

We will note that the funding for developments other than the amounts eligible for the current grant application is borne by the public authorities, whether at the European or national level, without the application of a specific conversion factor.

The eligible amounts for the period [redacted]-[redacted] in this grant application are assumed to be financed at a rate of 50% by the European Commission and 50% by the Member States, with the application of an appropriate conversion factor on this latter portion (see §6.1.2.2). It should be mentioned that the Italian and French Governments together with European Commission are working for the definition of an Implementing Decision ensuring the financing to the project from the node of Turin and Lyon on a shared investment programme on the long term. According to the Decision "it is important to identify the remaining actions necessary for the full completion of the project, so that European resources can be exploited at the maximum level, in line with respective planning and applicable co-financing rates, together with the available financial resources at national and regional level. According to the Regulation of the European Parliament and of the Council establishing the Connecting Europe Facility (CEF Regulation), all of the sections of the Lyon-Turin project are eligible for EU funding, (up to maximum 55% for the base tunnel and 50% for access lines). They must demonstrate a high degree of integration in the planning and implementation of the action and be in line with the article 14 of the CEF Regulation. Financial resources should be, therefore, fully optimised with the maximum efforts of all parties involved".

For the present calculation the following assumptions are thus used:

- The European Funding presented only accounts for the present subsidy request, and does not take into account previous or future requests, or other stakeholders request for the present call for proposal;
- The other public contribution corresponds to the rest of the funding plan, including the other contribution of the European Union and the Member States, where some cost savings transferred to public budget could contribute, such as the road maintenance and operating costs avoidance.

3.3 Valuation assumptions

3.3.1 Social valuation

3.3.1.1 Time value for passengers

Time lost or gained, depending on the case, whether modal shift or congestion, can be valued according to the two most recent national benchmarks.

Italy breaks down these values by reason and distance of travel for passengers: a median value of 20 € / voy.h is retained between business (20-35 € / voy.h) and other reasons (10-25 € / voy.h) for long distance.

Source: Linee guida per la valutazione degli investimenti in opere publicche, MIT, 2016

The France proposes time values by mode and distance of transport, among which we will retain an average value of 28 € 2015/voy.h corresponding to long-distance rail transport for all reasons, significantly higher than that proposed for Italy.

3.3.1.2 Time value for goods

Time lost or gained, depending on the case, whether modal shift or congestion, can be valued according to the two most recent national benchmarks.

In Italy, for freight, the values are between 0.5 and 4.0 € 2016/tonne.h depending on the value of the goods, a conservative value of 0.5 € 2016/tonne.h is retained.

Source: Linee guida per la valutazione degli investimenti in opere publicche, MIT, 2016

In France, for the transport of goods, the cost of immobilization of goods is estimated at 0.6 € 2015/tonne.h, to which must be added the cost of immobilization of drivers and rolling stock at 39 € 2015/pl.hour when it is not already included in the cost of production of transport.

The time saved in decongestion was valued only through the immobilization of goods in the 2019 evaluation, this evaluation was supplemented by the cost of immobilization of drivers and rolling stock.

3.3.2 Environmental valuation

The main integrated environmental data concern the estimation of greenhouse gases, which must be produced in coherence with micro-economic prospective hypotheses (motorization, etc.). The other externality hypotheses are taken from the European and French standards in force in May 2019 without change compared to the previous assessment.

3.3.2.1 Biofuels incorporation

The assumptions of incorporation of biofuels remain decisive for the calculation of fuel emission factors insofar as the extraction phase of these energy products is very dimensional for their

[redacted] [redacted]

greenhouse gas emissions. ADEME estimates that biofuel emits about 2.5 times less greenhouse gases in the life cycle than conventional diesel.[18]

The various national policies show more or less rapid trajectories of incorporation which can be summarized as follows:

- France: 7% biofuels in road diesel in 2015 (0% CNG), 12% in [redacted] (10% CNG), 100% in [redacted] (100% CNG) according to the National Carbon Strategy (Summary of the reference scenario of the French strategy for energy and climate National Low Carbon Strategy (SNBC) and Multiannual Energy Programming (PPE), DGEC, January 2020)
- Italy: 7% of biofuels in road diesel in 2015, 50% in [redacted] according to the Long-term Italian Strategy on reducing greenhouse gas emissions (MIT, 2021)

None of these documents mentions the aviation sector for which the International Energy Agency estimates that the share of biofuel in kerosene could be 5% in [redacted] 20% in [redacted] (Are aviation biofuels ready for take off?, International Energy Agency, 18 March 2019).

Based on these various trajectories, an average hypothesis is proposed for the assessment as follows, taking into account a common incorporation factor for all biofuels:

Tableau 33. Share of biofuel blend

Share in fuel	2015	2020	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Land-based biofuels	7%	7%	31%	41%	50%	63%	75%
Aviation biofuel	0%	0%	10%	20%	30%	40%	50%

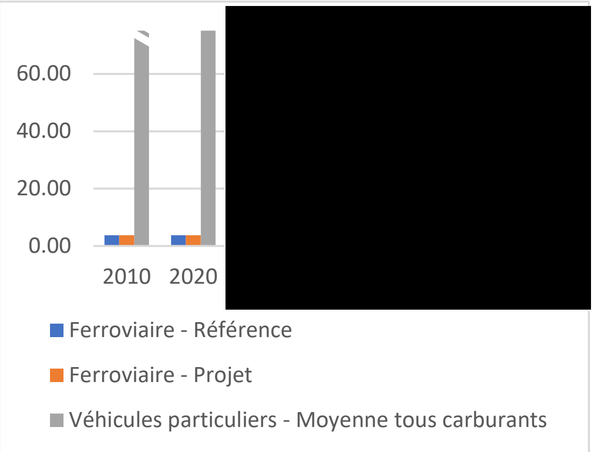
Source: [redacted] based on MTE, MIT, IEA

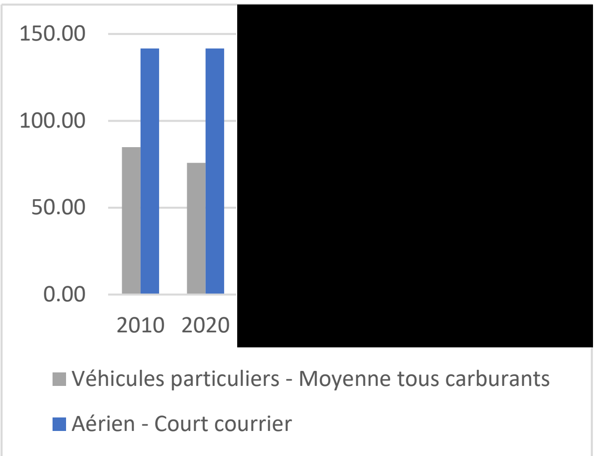
[18] See: Energy balance and GHG emissions of conventional fuels and biofuels (2016, ADEME)

3.3.2.2 GHG emission factors

Based on the previously defined engine, average load, average consumption, and biofuel incorporation assumptions, the resulting greenhouse gas emission factors for passenger transport are as follows:

Illustration 24. GHG emission factors for passenger transport (geqCO2/pax.km)

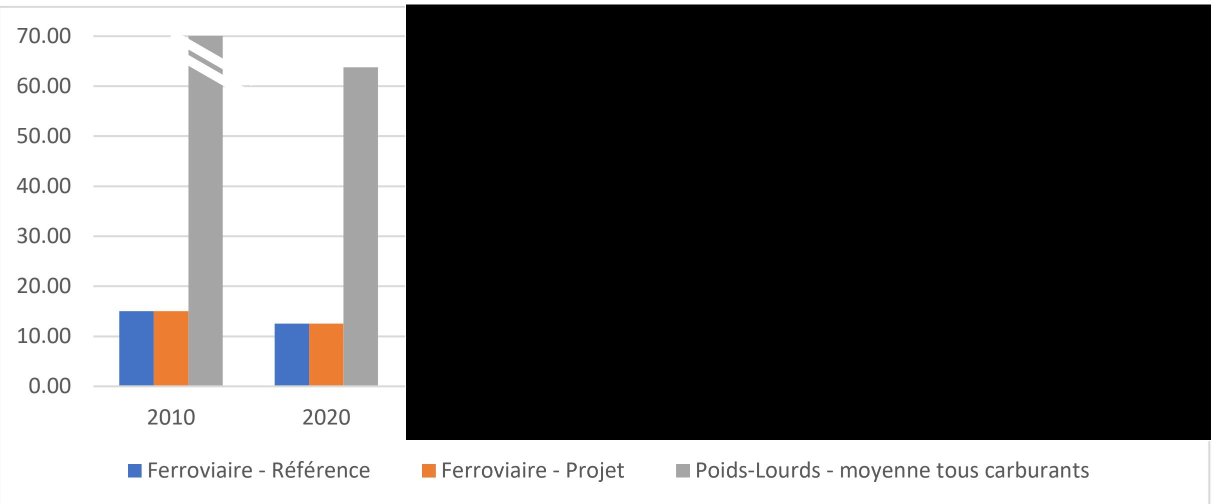




Source: SYSTRA 2021, based on previously indicated sources

These emission factors are as follows for the carriage of goods:

Illustration 25. GHG emission factors for freight transportation (CO2geq/tkm)



Source: [redacted] *2021, based on previously indicated sources*

3.3.2.3 Carbon value

The carbon value is the parameter for prioritizing and prioritizing different development scenarios and selecting sustainable developments. Different values are given according to the perimeters and principals. In particular, the following European and French values are noted:

Tableau 34. Carbon values for France and Europe

Carbon value	2018	2020	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
France €2015/TeqCO2	53	-	-	246	-	491	-	763	1184	1184
Europe €2016/TeqCO2	-	80	165	250	390	525	660	800	-	-

Source: France: Prescribed reference values for socio-economic calculation, Version of 03 May 2019; Europe: Technical guidance for integrating climate issues into infrastructure projects for the period 2021-2027

The value of European carbon was significantly raised in 2021 compared to the values published in the DELFT 2019 report, with a trajectory that now joins French values in [redacted] Beyond that, the latter continue to grow while European values are not defined.

3.3.3 External costs

The European Commission has published an update of the Handbook on the external costs of transport, produced by a consortium led by CE DELFT. The new values expressed in 2016 euros are presented in the table below.

Tableau 35. Tutelary values of externalities France

Legend: VP: passenger vehicle, PL: heavy goods vehicles, TV: passenger train, TF: freight train, AR: air, SS: short sea shipping			EC/DELFT 2019	
			[redacted]	[redacted]
Accident valuations	VP	€2016/vkm	0.0029	0.0037
	.PL	€2016/vkm	0.0123	0.0155
Valuations Local pollution	VP	€2016/vkm	0.0032	0.0025
	.PL	€2016/vkm	0.0158	0.0199
	TV	€2016/trkm	0.0070	0.0089
	TF	€2016/trkm	0.0374	0.0472
Greenhouse gas valuations	VP	€2016/vkm	0.0141	0.0380
	.PL	€2016/vkm	0.0630	0.1695
	AR	€2016/pkm	0.0153	0.0412
	SS	€2016/tkm	0.0003	0.0009
	VP	KgeqCO2/vkm	0.1412	0.1412
	.PL	KgeqCO2/vkm	0.6300	0.6300
	AR	KgeqCO2/pkm	0.1700	0.1700
	SS	KgeqCO2/tkm	0.0034	0.0034
Valuations Upstream downstream effects	VP	€2016/vkm	0.0043	0.0116
	.PL	€2016/vkm	0.0150	0.0404
	TV	€2016/trkm	1.1740	3.1581
	TF	€2016/trkm	1.5130	4.0700
Noise valuations	VP	€2016/vkm	0.0001	0.0002
	.PL	€2016/vkm	0.0018	0.0022
	TV	€2016/trkm	0.0701	0.0885
	TF	€2016/trkm	0.0935	0.1180

Source: [redacted] from Handbook on the External Costs of Transport, CE DELFT, 2019

The values recorded in the latest benchmark show a decrease in greenhouse gas values and upstream-downstream effects in the short term but a long-term revaluation linked to the carbon price scenario (instead of a simple indexation to the evolution of GDP).

The local pollution values are generally lower than those used previously, while the noise recovery has been marginally increased for passenger trains compared to the previous values.

4. TRAFFIC FORECAST

4.1 Principles and structure

4.1.1 Modelling methodology

The purpose of this chapter is to present the methodology used for the development of a tool for monitoring the socio-economic and environmental impact of the Lyon-Turin Euralpin Tunnel project. The following paragraphs detail successively:

- The architecture of the tool and its methodological principles
- The traffic forecasting method and its results
- The socio-economic and environmental assessment method

Principles and architecture

The tool for monitoring the impact of the Lyon-Turin Euralpin Tunnel project and calculating the cost-benefit analysis is based on several guiding principles, which are as follows:

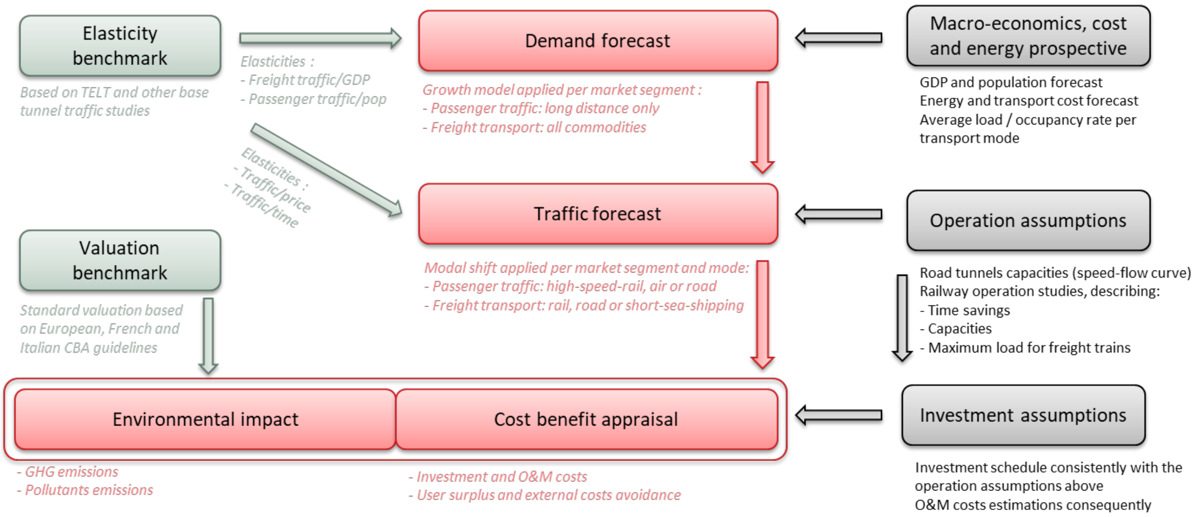
- **Continuity**: the calculations implemented reflect as much as possible the underlying mechanisms of the previous studies carried out by the Contracting Authority;
- **Transparency**: the calculations made are exposed in an open manner both in the methodology below and in the spreadsheet communicated to the Client;
- **Acceptability**: the estimates reproduce as much as possible assumptions commonly used in economic studies of transport infrastructure projects at European, French or Italian level;
- **Determinism**: the models formed follow the principle that the same set of hypotheses provide the same results;

In addition, the constitution of the impact monitoring tool is intended to be a simplified approach (in comparison with the studies previously carried out by the Project Owner and its service providers over more than a decade). In this sense, certain assumptions of "causation" or at least "correlation" were taken in order to link the effects with the different components of the project.

Tool architecture

The tool developed on behalf of the Contracting Authority is structured in such a way as to group common hypotheses and results in well-identified spreadsheets and to show input/output links. The architecture implemented is as follows:

Illustration 26. Architecture of the tracking tool



Source: [redacted] 2017

In summary, the tool is structured in 3 main steps that are:

- Demand projection all modes / all Alpine crossings
- Distribution of traffic by crossing (carryovers, induction)
- Environmental and socio-economic impact assessment

As one of the main objectives is to carry out a cost-benefit analysis, a differential approach has been chosen in accordance with the methodologies in force at European, French or Italian level: a reference scenario without a project is compared to a project scenario with progressive development of the tunnel and its accesses.

The main input data of the calculations are;

- Macroeconomic assumptions (GDP, population)
- Operating assumptions (cost, time, capacity)
- Investment assumptions (amounts, schedule)

The mechanisms for compiling both traffic forecasting, distribution and valuation are fed by the elasticity and valuation assumptions as detailed below.

Traffic forecasting method

The determination of traffic volumes is done sequentially in terms of demand projection (mobility evolution) and traffic distribution per Alpine crossing (postponements and induction). As detailed in the table below, these steps are applied separately to the baseline scenario and project variants.

[redacted] [redacted]

Tableau 36. Mechanisms and formalization by scenario

Location / Variants		Mechanism	Formalization
Waterflow (analytical framework)		Evolution of mobility	Elasticities traffic all modes / GDP France + Italy
	+	Reports to the Mont Cenis axis linked to road price variations	Direct road traffic / road price elasticity
	+	Reports to the Mont Cenis axis linked to road time variations	Direct traffic / road time elasticity based on time lost to congestion in year n-1
	+	Reports to the Mont Cenis axis linked to variations in air weather	Direct air traffic / air time elasticity
Reference (non-project)		Fil de l'eau (analytical framework)	See above
	+	Rail price change carry-overs	Direct elasticity rail traffic / rail prices
	+	Rail capacity carry-overs	Carry over to the road in proportion to the capacity overrun of year n-1
Project (development program)		Fil de l'eau (analytical framework)	See above
	+	Rail time variations carry-overs	Direct elasticity between rail traffic and rail time
	+	Rail price change carry-overs	Direct elasticity rail traffic / rail prices
	+	Rail capacity carry-overs	Carry over to the road in proportion to the overtaking of year n-1
	+	Induction related to the passenger rail frequency effect	Direct rail traffic / rail frequency elasticity
	+	Induction related to the rail freight capacity effect	Cross-elasticity traffic Short Sea Barcelona-Italy + Gotthard-Brenner iron / rail freight capacity axis Mont Cenis
	+	Rail capacity carry-overs	Carry over to the road in proportion to the capacity overrun of year n-1

Source: [redacted] 2018

The principles and assumptions used in the calculations of the different traffic mechanisms are detailed in the following paragraphs.

4.1.2 Market mechanisms integrated in the model

Trend in mobility

The calculation of the evolution of mobility is based on the assumption of a linear statistical link between the change in real GDP (constant euro) of France and Italy, and that of passenger and freight transport volumes. This evolution of mobility is expressed in average annual growth rate and applies from the base year 2015.

The corresponding elasticities are derived from the analysis of previous traffic forecasts for all modes of passengers and freight carried out by TELT from the documents below:

- PRELIMINARY DRAFT REVISION, SUBMISSION N 41, Passenger traffic study, TELT, 20/12/2010
- PRELIMINARY PROJECT REVISION, SUBMISSION N 46, Freight traffic forecasts, TELT, 21/01/2011

By way of comparison, similar elasticities have been recalculated from the studies of various European base tunnel projects in the note cited above.

Traffic reports by mode and route

Time- or price-related traffic carryovers are based on the assumption of a punctually linear statistical link (arc elasticity):

- between the price/time variation of a mode and its traffic variation: this is then a so-called "direct" elasticity;
- between the price/time variation of a mode and the traffic variation of a concurrent mode: in this case, this is a so-called "cross" elasticity;

The corresponding elasticities are noted in the previous forecasts of all modes of passenger and freight traffic carried out by TELT mentioned above.

In the absence of an explicit value, the direct price and time elasticities of rail freight transport were recalculated on the basis of a typical origin-destination, modal choice formulations provided by Nomisma and reported in the above documents as well as an additive pivot application based on rail volumes on the Ventimiglia - Mont Blanc arc (2015).

Capacity constraints of road tunnels and urban motorways

Congestion in road tunnels is taken into account on the basis of the speed flow curves used in TELT's freight transport studies (see previous references).

The formulation of the evolution of the journey time, as a function of the ratio between daily traffic and theoretical capacity, is as follows:

$$T = T_0 \left[1 + \alpha \left(\frac{V}{C} \right)^{\beta} \right]$$

The corresponding assumptions are as follows:

Tableau 37. Assumption for calculating traffic congestion

Parameter	Urban highway	Tunnel
Theoretical capacity (C) (Million.PL+VL)	A6 Paris (Viry) : 61.2 A43 Lyon (St Priest): 48.2 A4 Turin Milano: 38.7 A8 Nice (Grasse) : 42.8 AP-7 Barcelona (Montmelo) : 40.1	Fréjus : 2.1 Mont Blanc : 1.9
Unladen travel time (T0) (min)	A6 Paris (Viry) : 20 A43 Lyon (St Priest): 10 A4 Turin Milano: 20 A8 Nice (Grasse) : 10 AP-7 Barcelona (Montmelo) : 10	Fréjus : 30 Mont Blanc: 30
Alpha	0.06	0.06
Beta	6	15

Source: PRELIMINARY PROJECT REVISION, SUBMISSION NO. 46, Freight traffic forecasts, TELT, 21/01/2011

In addition, for urban motorways, it was considered that 25% of traffic was affected by saturation (2 hours of morning peak period + 2 hours of evening peak period reported at 16 hours of service from 6 am to 10 pm) on the linear concerned.

On these same motorways, only the busiest section was selected, on the basis of a reference traffic[19] recorded in the literature with a drift of 0.25% / year according to the guidelines given by the CGDD.

Source: Long-term transportation demand projections, CGSD, 2014.

The overtime on these various sections makes it possible to estimate the carryovers to the rail mode through the traffic / time elasticities defined above. The corresponding relative time variations are established on the basis of a typical Paris – Milan route.

Moreover, in a conservative approach, the nominal capacities of Alpine tunnels are assumed to have room for growth, for example through platooning technologies: a hypothesis of gains of 30% compared to nominal capacities is applied gradually between [redacted] and [redacted] (1.3%/year).

Source: Platooning, Toward sustainable road freight transport, 2023. https://www.sia-partners.com/en/insights/publications/platooning-toward-sustainable-road-freight-transport

Capacity constraints of passenger rolling stock

Rail passenger traffic is limited by the capacity of the rolling stock (seats available per service) multiplied by the number of services offered. The capacity of the rolling stock is defined according to

[19] http://www.dir.ile-de-france.developpement-durable.gouv.fr/les-comptages-a174.html
http://www.rhone.gouv.fr/Politiques-publiques/Transport-deplacements-et-securite-routiere/Transports-et-deplacements/Trafics-et-comptages-sur-les-voiries-departementales-et-nationales-du-Rhone/Cartes-des-trafics-routiers
http://www.aiscat.it/pubblicazioni/downloads/%20trim_3-4_2016.pdf
http://www.paca.developpement-durable.gouv.fr/IMG/pdf/traf_rout_cle0e87d4.pdf
http://www.fomento.gob.es/NR/rdonlyres/88D0DC19-4E58-4F25-A875-B6FA58271907/140861/2_Peaje17.pdf

[redacted] [redacted]

the document REVISION OF THE PRELIMINARY DRAFT REFERENCE, FUNCTIONAL SUBMISSIONS TO THE IGC, Submission 36 (Vol. B) Project traffic, LTF, 15/06/2012 and Annexes.

In addition, the service scheme resulting from TELT's previous traffic studies has been taken up (see document cited).

The rolling stock capacity assumptions taken from the documents cited, adjusted to this scenario and extrapolated for step 3 are as follows (NB: Pax = Passenger):

Tableau 38. Capacity of passenger rolling stock

Rolling stock			Reference			Project		
Pax/train	Step:	0	1	2	3	1	2	3
Single TGV	377	100%	100%	100%	100%	56%	22%	10%
TGV Double	754	0%	0%	0%	0%	33%	45%	60%
ETR (11 cars)	590	0%	0%	0%	0%	11%	23%	10%
ETR (12 cars)	656	0%	0%	0%	0%	0%	10%	20%
Average	↘	**377**	**377**	**377**	**377**	**526**	**624**	**680**

Source: [redacted] according to REVISION OF THE PRELIMINARY PROJECT, SUBMISSION N 41, Passenger traffic study, TELT, 20/12/2010

The assumptions for the number of long-distance passenger services for the different stages are also detailed in the description of the scenarios considered on the Alpine crossing and its access.

A transfer of traffic from rail to road is applied for each year, corresponding to the new traffic of the year that cannot be supported within the limits of the combined capacity of the rolling stock (places available) and the number of services (daily round trip).

Capacity constraint of freight train paths

Rail freight traffic is limited by the number of train paths available for freight (converted into possible traffic). These are defined on the basis of the document entitled REVISION OF THE PRELIMINARY DRAFT REFERENCE, FUNCTIONAL SUBMISSIONS TO THE IGC, Submission 36 (Vol. B) Project traffic, LTF, 15/06/2012.

The freight capacity assumptions for the various stages are also detailed in the description of the scenarios considered on the Alpine crossing and its access.

A transfer of traffic from rail to road shall be applied for each year, corresponding to the new traffic of the year which cannot be traced within the limit of capacity expressed in number of paths.

Induction of passenger traffic: mobility gains

The phenomenon of induction of passenger transport on the rail mode is based on the mechanism described in previous studies carried out by TELT (see cited document). Its transcription into the simplified model is carried out in the form of the application of an elasticity of demand to the frequency of high-speed services. The estimated volume of induction will therefore depend on:

- The basic railway volume (excluding induction) of the Mont Cenis railway on which the induction applies (run-of-river traffic);
- The frequency gain of high-speed services on this axis vis-à-vis the reference scenario;

Induction of freight traffic: carry-overs from outside the perimeter

The phenomenon of freight transport induction covers traffic transfers from outside the perimeter of the simplified model, based on previous studies carried out by TELT (see cited document). In particular, we consider:

- The transfer of traffic from the Gotthard and Brenner railway axes to the Mont Cenis railway axis;
- The transfer of traffic from the maritime motorway services between Barcelona and Italy to the Mont Cenis rail axis;

These two mechanisms are the subject of a similar transcription in the simplified model, the volume of induction will depend on:

- The basic railway volume (excluding induction) of the Mont Cenis railway on which the induction applies (run-of-river traffic);
- The gain in freight path capacity on this axis vis-à-vis the reference scenario;

If we analyse the rail routes on different origins – typical destinations with a passage through the Gotthard, the Brenner or a passage through the Euralpin Tunnel Lyon Turin, we see that the routes are indeed competitive, whether for the exclusive use of an Alpine tunnel, or for a composite route through two tunnels instead of using the Ventimiglia passage.

Tableau 39. Rail distances on exclusive routes (km)

Origin – Destination	Via St Gotthard	Via Brenner	Via TELT
Dourges – Milano	947	1316	1110
Paris – Milano	875	1288	904
Dourges – Turin	1048	1477	957
Paris – Turin	976	1449	751

Tableau 40. Rail distances on composite routes (kms)

Origin – Destination	Via St Gotthard and Ventimiglia	Via Brenner and Ventimiglia	Via St Gotthard and TELT	Via Brenner and TELT
Madrid – München	2401	2287	2374	2321
Madrid – Stuttgart	2295	2475	2268	2509

Source: [redacted] 2018 based on http://dium.dbcargo.com/dium/index.jsp

4.1.3 Elasticities per market segment

To establish traffic forecasts, an elasticity set was extracted from the comprehensive studies conducted between 2006 and 2011 in order to represent the price and supply sensitivities of demand by mode at levels estimated by previous statistical analyses. The elasticities used are as follows:

Tableau 41. Elasticities used for traffic forecasting

Seg.	Market	Unit	<[redacted]	[redacted]	>[redacted]
Pax	All modes - total	Var(Pax)/Var(GDP)	0,79	0,74	0,74
Freight	All modes - total	Var(Ton)/Var(GDP)	1,52	1,10	1,10
Pax	Route - Mont Blanc-Fréjus	Var(Pax RTE)/Var(PRIX_RTE)	-0,75	-0,75	-1,10
	Route - Ventimiglia	Var(Pax RTE)/Var(PRIX_RTE)	-0,25	-0,25	-0,37
	Total rail	Var(Pax FER)/Var(PRIX_FER)	-0,88	-0,88	-1,10
Freight	Route Mont Blanc-Fréjus	Var(Ton RTE)/Var(PRIX_RTE)	-0,50	-0,39	-0,39
	Route - Ventimiglia	Var(Ton RTE)/Var(PRIX_RTE)	-0,17	-0,13	-0,13
	Iron - total	Var(Ton FER)/Var(PRIX_FER)	-2,05	-1,59	-1,59
Pax	Road - total	Var(Pax RTE)/Var(TPS_RTE)	-0,45	-0,45	-0,45
	Iron - total	Var(Pax FER)/Var(TPS_FER)	-2,02	-2,02	-2,02
	Air - total	Var(Pax AIR)/Var(TPS_AIR)	-0,59	-0,59	-0,59
Freight	Road – total	Var(Ton RTE)/Var(TPS_RTE)	-1,70	-1,32	-1,32
	Iron - total	Var(Ton FER)/Var(TPS_FER)	-1,13	-0,88	-0,88
Pax	Iron - total	Var(Pax FER)/Var(FREQ_FER)	0,00	0,55	0,55
Freight	Iron - total	Var(Ton TM)/Var(CAPA_FER)	0,00	0,16	0,16
	Short Sea - total	Var(Ton SSS)/Var(CAPA_FER)	0,04	0,04	0,04

Source: [redacted] 2021 based on LTF traffic studies 2006 / 2011

Various adjustments have been made to the elasticity estimates used in the 2019 evaluations in order to take into account more precisely the effects of the project:

- Distinction of freight and passenger modal shift elasticities vis-à-vis the road price on the Mont Blanc/Fréjus axis on the one hand and on Ventimiglia on the other. The elasticity on Ventimiglia is aligned with the estimates of the CGDD in the plain (Projection of transport demand over the long term, 2016)

- Hypothesis of gradual amplification of passenger modal shift elasticities vis-à-vis road or rail prices after [redacted] according to the trajectories given by DELFT (Modal choice criteria in rail transport, DELFT, 2018)

- Change of basis for the calculation of the induction of rail passenger transport in a project scenario, based on the traffic of the reference scenario and not from the total unconstrained run-of-river potential, consistent with the link between service differential and traffic gain

4.2 Traffic and transport demand in the past years

The **data published annually** that we have identified at this stage and that need to be updated for the updating of the socio-economic assessment are the so-called observed data and the forecasts produced for the most recent years. The main producers are the national statistical institutes (INSEE, ISTAT), national institutions (Treasury France, Bank of Italy), the European Commission (EUROSTAT, ALPIFRET) and infrastructure managers ([redacted]

4.2.1 Passenger traffic and transport demand across the alps

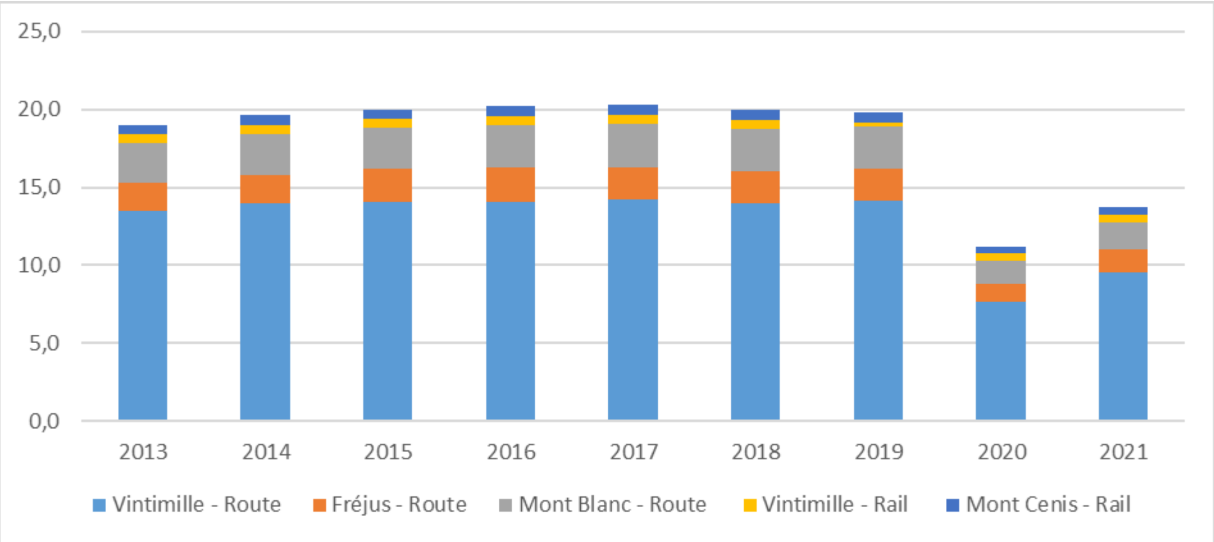
The various transport observatories on the French and Italian side and at European level generally do not cover passenger demand but rather focus on road traffic aspects. Mobility data can be consolidated from Eurostat, national or regional vehicle traffic databases as well as through assumptions on vehicle occupancy rates (see §**Errore. L'origine riferimento non è stata trovata.**). The demand for passenger transport in the perimeter can be broken down into two axes as follows:

- Demand for rail and road (passenger) journeys by axis of the Alpine arc;
- Demand for air travel (passengers) on the France/Spain-Italy route.

Traffic is reconstructed over a shorter period than for freight transport because of the difficulty of consolidating these data on the oldest dates.

The analysis of the evolution of passenger transport on the chosen perimeter shows air transport on the perimeter continues to develop until 2019 with sustained growth (+30% over the last 5 years): its price attractiveness and its range of offers is however strongly subject to evolution over the year 2020 with the restrictions of the health crisis and subsequently with the necessary reorganization of the sector. Road transport remains on the axis with a slow progression (+4% in 5 years). The year 2021 is reflected in a gradual recovery of overall traffic on the Alpine arc compared to 2020 (+38%), but which remains significantly below the levels reached at the end of the 2010s.

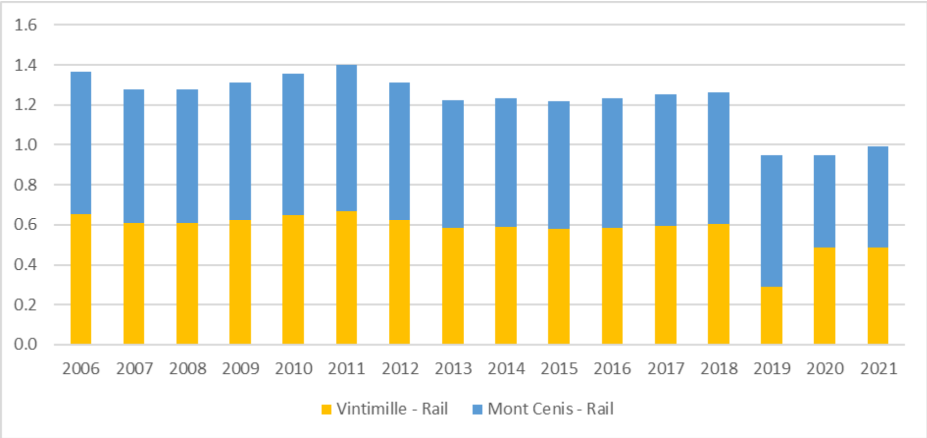
Illustration 27. Total passenger transport demand on the western Alpine arc (MPax/year)



Source: Transport statistics in France: facts and figures 2022, 2020, 2017, 2015, 2014 and Eurostat

Rail passenger transport has been maintained for a decade with a balance between the markets served by Mont-Cenis and Ventimiglia. Market developments in 2020 and 2021 are estimated on the basis of the overall evolution of road and air mobility on the axis and has the impact of dividing traffic by about half due to health restrictions and the inertia of Alpine tourism in the post-lockdown period (gradual relaxation of measures and vaccination).

Illustration 28. Rail demand for passenger transport on the Alpine arc (MPax / year)



Source: Transport statistics in France: facts and figures 2022, 2021, 2020, 2017, 2015, 2014
Eurostat : https://ec.europa.eu/eurostat/fr/data/database

4.2.2 Freight traffic and transport demand across the alps

From the various transport observatories on the French and Italian side and at European level, the demand for goods transport in the perimeter can be broken down into two axes as follows:

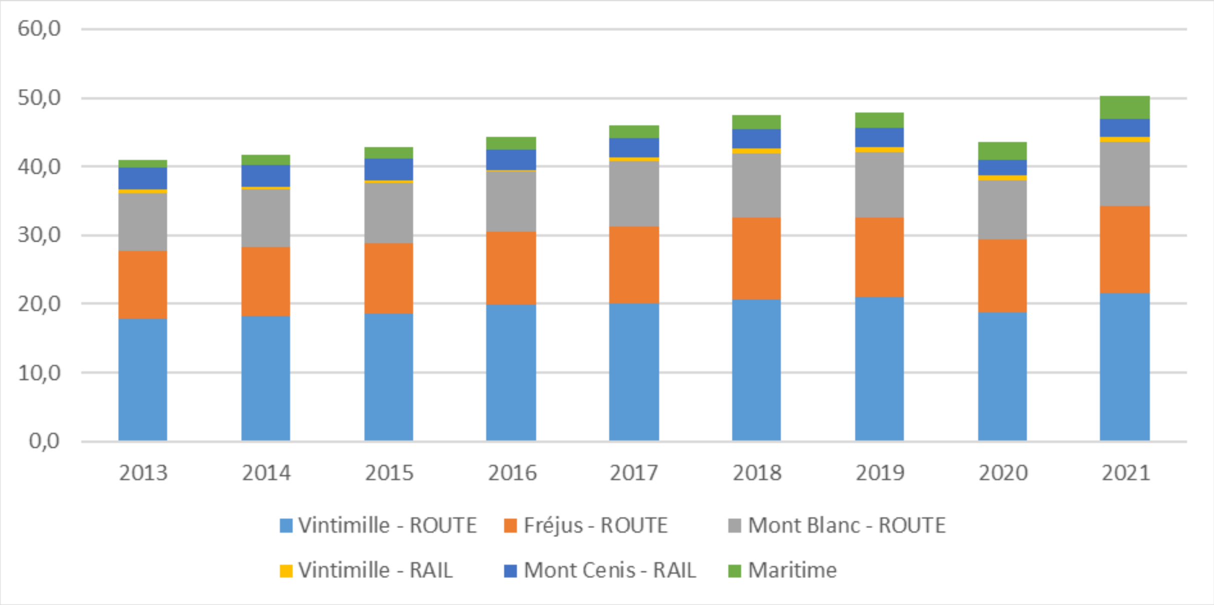
- Demand for rail and road freight (tonnes) by axis of the Western Alpine Arc;
- Demand for short sea sea freight (tonnes) on the Spain-Italy axis.

In the Alpine arc and the short sea shipping corridor, road transport remains by far the dominant mode for freight transport, although its share has fallen by 10% over the last decade. Rail transport has been maintained for the last ten years after the historic decline preceding the crisis of 2008/2009, this sector has progressed slowly over the last 5 years but has not yet returned to its historical level before 2008.

The Barcelona-Genoa maritime link also has a dynamic focus on the freight transport market in the region with growth that led to a 2.5-fold increase in traffic between 2012 and 2020: these volumes remain however limited compared to road traffic on the same axis, concentrated on massified logistics.

In 2020, overall freight transport on the Alpine arc fell by around 8% due to health conditions deteriorated by the COVID-19 crisis after several years of continuous growth since 2013 at rates of between 2 and 3% per year. The year 2021 is marked by a significant growth in total demand for freight transport compared to 2020 (+15.3%), even exceeding the level reached in 2019 (+5.2%).

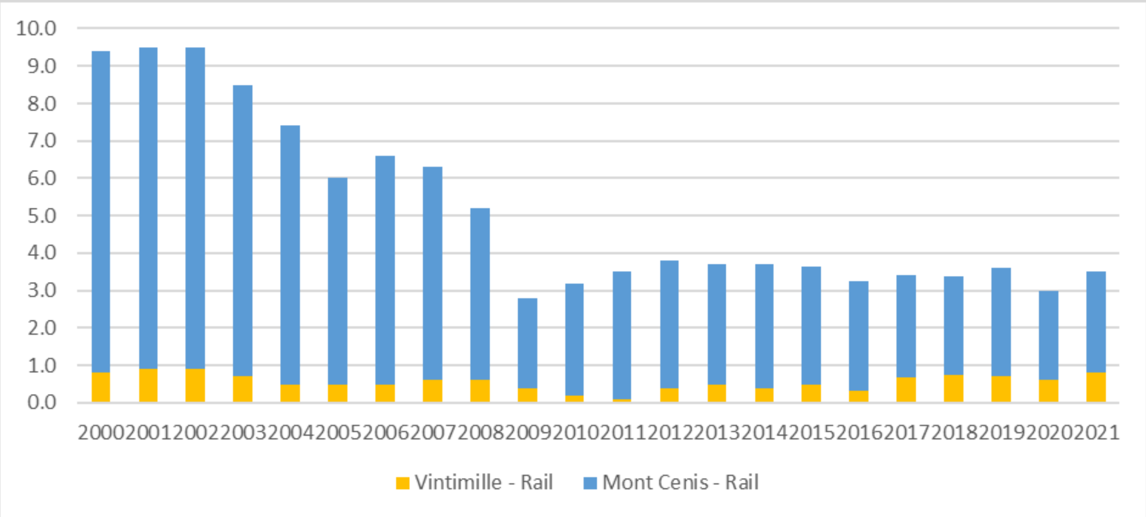
Illustration 29. Total freight transport demand on the western Alpine arc (MT/ year)



Source: ALPINFO 2000-2014; OBSERVATORY 2014 2015 2017 2020; Port of Barcelona traffic statistics 2016, 2017, 2018, 2019, 2020, 2022

On the rail mode alone, operating conditions and capacity sharing clearly do not allow traffic to develop on the Mont-Cenis axis: traffic tends to decrease slowly on the axis from 3.5 MT per year in 2011 to 2 MT in 2020. Losses incurred between 2019 and 2020 due to COVID-19 are estimated at 14% assuming a stable average load over this period. As the Ventimiglia axis has experienced a slightly increasing regional traffic in recent years, the total rail freight transport in the western Alpine arc has remained stable for 10 years, between 3 and 4 MT annually.

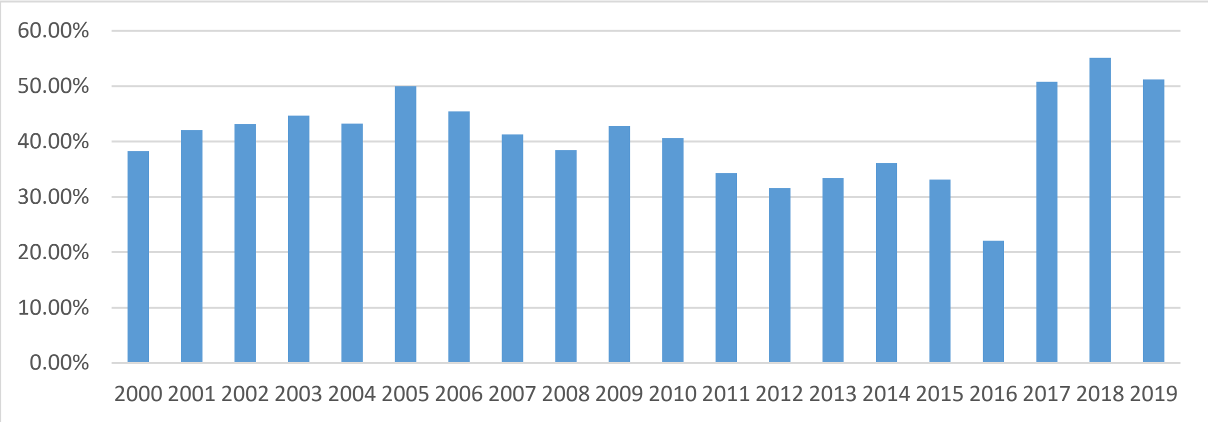
Illustration 30. Rail demand for freight transport on the western Alpine arc (MT/ year)



Source: ALPINFO 2000-2014; OBSERVATORY 2014, 2015, 2017, 2020, 2022

Within rail transport solutions, combined transport already represents a market with high growth potential on the axis, driven both by the sector's own dynamics and by the reduced constraints in terms of towed mass. Indeed, since 2017, combined transport represents a share of almost 50% of rail transport on the French Alpine axis. Aid dedicated to the operation of combined transport services in France further strengthens the dynamics of this market, the aim being to enable combined transport players to establish a more attractive offer in order to allow more efficient intermodality for freight transport.

Illustration 31. Share of combined transport in the western Alpine arc (%MT)



Source: ALPINFO 2000-2014; OBSERVATORY 2014, 2015, 2017, 2020

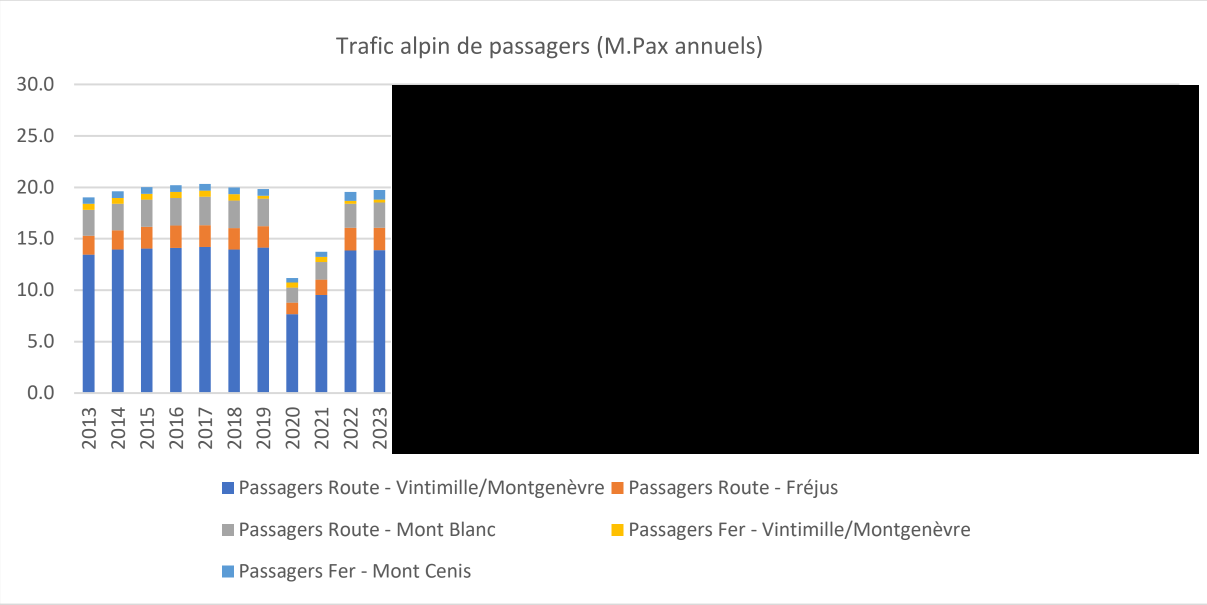
4.3 Results of the traffic forecast

Traffic forecasts are used for passenger transport and freight transport, rail passenger traffic is an input to the simulations while freight traffic is the result through load factors.

4.3.1 Passenger traffic forecast

According to the macroeconomic and forward-looking assumptions previously established, the projection of total passenger transport demand on the Western Alpine arc shows a gradual recovery of mobility after the significant decline in 2020 and 2021 due to the COVID-19 crisis and health restrictions. While the market showed very modest growth between 2009 and 2019 (+0.2%/year), the period 2021-[redacted] preceding the commissioning of the base tunnel and the first part of the accesses would see more marked growth (+1.5%/year) in line with the various national and European recovery plans. The year [redacted] would see a renewed mobility linked to the launch of new high-speed services on the new line (+5%), followed by moderate growth of 1%/year until [redacted]

Illustration 32. Passenger traffic forecast over the western Alpine arc (annual M.Pax)



Source: [redacted] *2023*

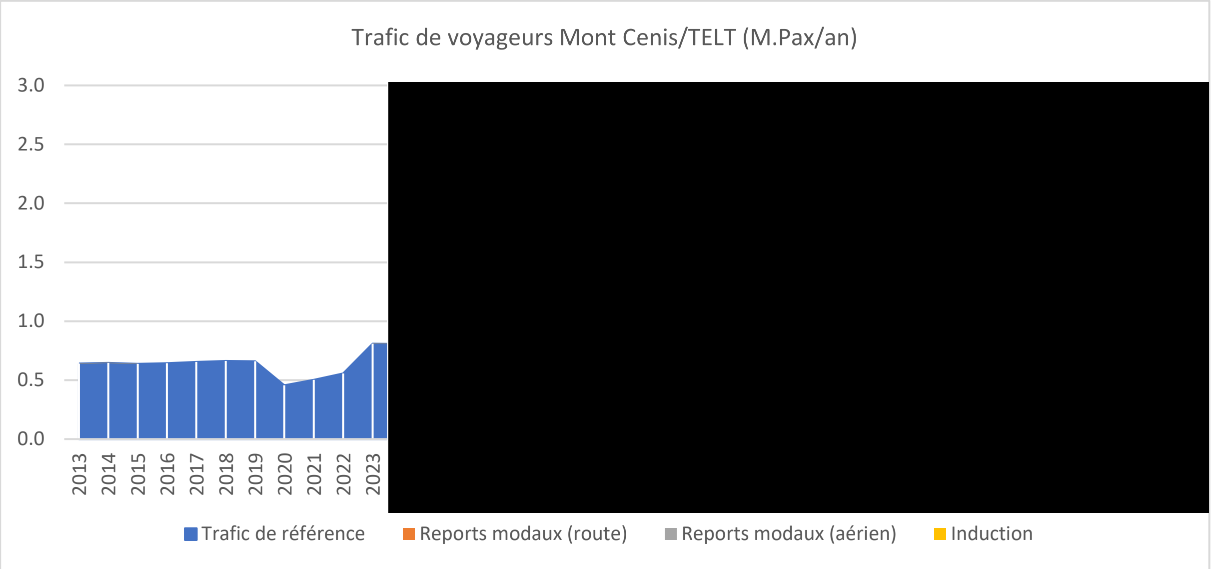
Passenger rail traffic on the Mont-Cenis axis (new and historic line) would experience a gradual recovery between 2022 and [redacted] with a stabilization between 600 and 700,000 pax annually limited by the number of services deployed on the line.

From [redacted] half of the gain in rail passenger traffic would be spread over modal shifts (road and air) and half to induction related to new services deployed.

The expected growth (excluding the ramp-up of services) would make it possible to exceed 2.0 M.Pax annually and to reach 2.5 M.Pax annually around [redacted] .

In the absence of the deployment of new services or changes in service levels in the medium term, traffic would remain stable between [redacted] and [redacted] The corresponding growth rate between [redacted] and [redacted] would be slightly higher than 2.0%, i.e. in the light of the overall evolution of mobility on the axis.

Illustration 33. Forecast of rail passenger traffic on the Mont-Cenis axis (M.Pax/year)



Source: [redacted] *2023*

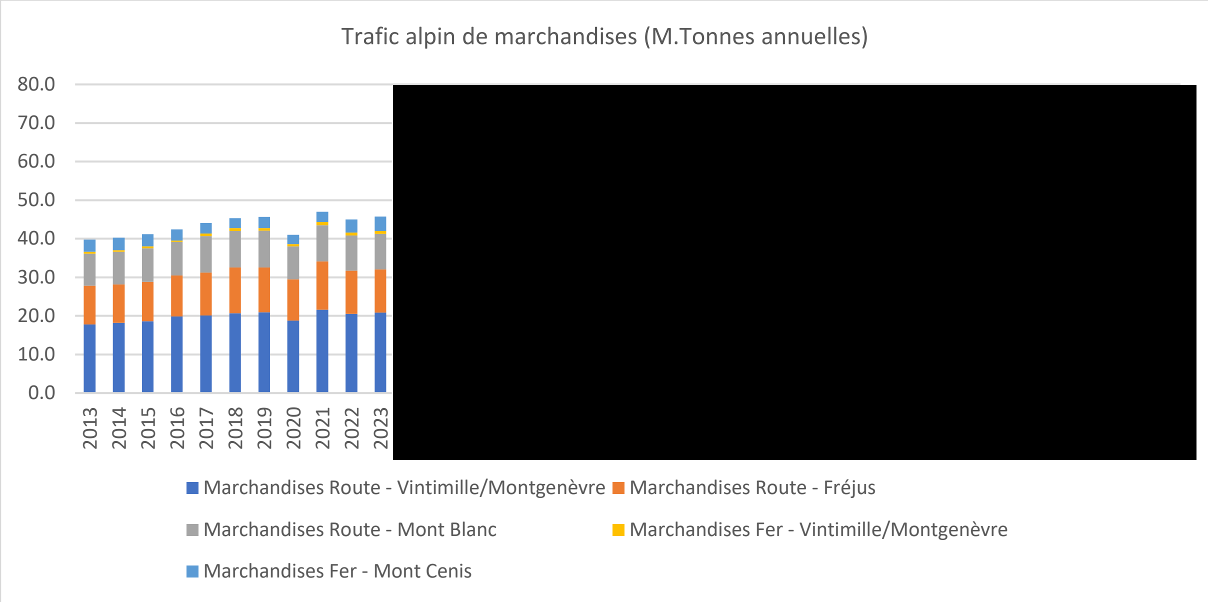
Nota bene: the small observable fluctuations, in particular on the trades of the reference scenario, are linked to the application of the capacity constraint mechanism which evaluates the modal shifts to be applied iteratively.

4.3.2 Freight traffic forecast

The new prospective trajectory defined by integrating the COVID-19 crisis makes it possible to propose a possible evolution for freight traffic on the western Alpine arc: the years following the trough of activity in 2020 take up the orientations given by the recovery policies, and the forecasts for the growth of economic activity with an average growth rate of 1.6% between 2019 and [redacted]

In [redacted] freight transport is expected to increase more significantly (+2.5%) due to the attraction of new markets not previously present on the western arc, combining for example routes via the new line and the Gotthard tunnel. Beyond [redacted] the overall growth of freight transport in the western Alpine arc would follow a steady growth rate of 1.3% per year.

Illustration 34. Forecast of freight traffic on the western Alpine arc (M.Annual tonnes)



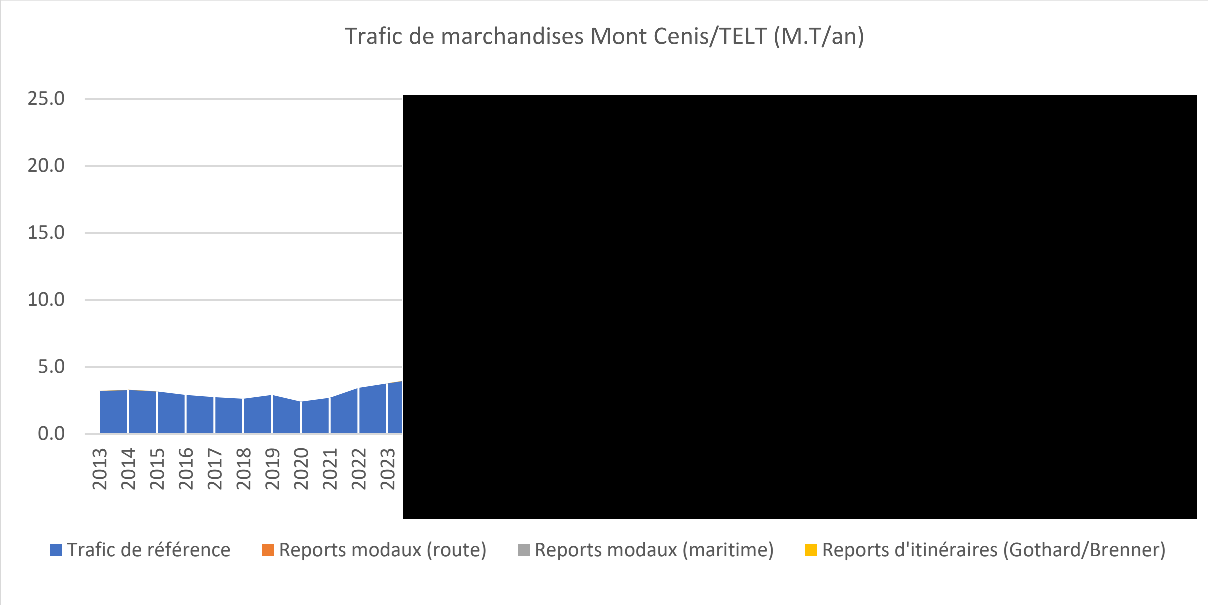
Source: [redacted] *2023*

Forecasts for freight transport by rail on the Mont-Cenis axis (new and historic line) also show a recovery after 2020 with a sustained slope of 12%/year to exceed its historical high point of 2006 in [redacted] before the commissioning of the base tunnel, mainly in anticipation of the deployment of a line to European standards.

The level in [redacted] is very important with a 1.7-fold increase in rail traffic, with average loads and rapidly optimized traction conditions. 90% of this new traffic would consist of modal shifts from the road mode, and 8% of shifts or combinations of routes with other Alpine tunnels (mainly Gotthard).

Carry-overs from the marine mode would remain marginal throughout the operating period. After [redacted] rail traffic would grow continuously at 2.3%/year at a faster pace than the overall market in the western Alpine arc, reaching 20 MT after [redacted]

Illustration 35. Forecast of rail freight traffic on the Mont-Cenis axis (M.Tonnes/year)



Source: [redacted] *2023*

[redacted] [redacted]

5. COST BENEFIT APPRAISAL

5.1 Principles of the cost benefit appraisal

5.1.1 Applicable guidelines and objectives of the appraisal

The applicable reference documents for the expected cost-benefit analysis in the framework of the European grant application files of the CEF Transport call for projects are as follows:

- Guide to Cost-Benefit Analysis of Investment Projects, Cohesion Policy 2014-2020, EC, 2014.
- Guide on economic appraisal for CEF-T Transport Projects / CINEA, 2022
- Economic Appraisal Vademecum 2021-[redacted] General Principles and Sector Applications, EC/DG REGIO, 2021
- Handbook on the external costs of transport, Version 2019, CE DELFT
- Technical guidance on the climate proofing of infrastructure in the period 2021-[redacted] EC, 2021
- CBA Guidance Scope of the CBA in the framework of the CEF transport, CINEA, 2022

For this consistency analysis, we will focus on documents that answer the questions posed for the period 2021-2027 (vademecum), integrating references to the period 2014-2020 (guidelines) which is authoritative for topics that have not been detailed in more recent documents.

The definition of the respective content of the economic analysis and the financial analysis is based on the various elements indicated consistently in the benchmarks, for example in the CBA Guidance scope of 2022 as follows:

Tableau 42. Scope of economic and financial evalution

Economic analysis	Financial analysis
Net impact of the project on society as a whole (page 3)	Impact in terms of revenues and costs for the bidder or any other party involved in the development of the project (page 16)
Self-sufficient unit and functionally complete investment (pages 4 and 5)	Consolidated analysis in the case where the operator and the owner of the investment is separate (case of concessions or railway infrastructure), so as to present an overall profitability (page 16)
Incremental costs and benefits due to the full investment program incorporating network effects (page 6 and 11)	

Source: European Commission, CBA Guidance Scope of the CBA in the framework of the CEF transport (page 16), 2022

5.1.2 Conversion factors and shadow prices

Methodological scoping documents require an understanding of the principles surrounding two key concepts in cost-benefit analysis, namely:

- Shadow *prices*,
- Conversion factors.

5.1.2.1 Shadow prices

As part of financial analysis, private and public investors generally rely on market prices. In their eyes, it is a relevant and reliable signal for the evaluation of the financial performance of a project. However, these prices are no longer as relevant when it comes to measuring the economic contribution of a project to society ("economic *welfare*").

In this respect, all revenues and costs considered when evaluating the financial performance of a project, and valued according to the prices observed on the market, can be revalued according to "*shadow prices*". The *shadow price* is similar to the marginal value of a tangible effect generated by the evaluated project on society. In other words, it is the opportunity cost for society to produce or consume a good or service (related to the project concerned) on a larger or smaller scale.

Market prices and *shadow prices* would theoretically be identical in a context where markets are perfectly competitive and efficient. However, in reality, markets are biased by many economic factors such as taxes, duties, subsidies, exchange rates, limitations on production or consumption, regulated tariffs, oligopolistic or monopolistic prices, or information asymmetry. All these elements contribute to widening the gap between the price observed on the market and the marginal social value of the resource in question.

The general theoretical framework of cost-benefit analysis enacted by Drèze and Stern[20][21] defines *shadow prices* as the net impact on the general welfare function related to the unit increase of an input or output.

5.1.2.2 Conversion factors

Conversion factors make it possible to monetize shadow *prices*. Their application makes it possible to convert financial flows into economic flows. There are several approaches to calculating the value of shadow prices, and each of them could be more or less well adapted to certain typologies of goods and sectors. Indeed, these methods may vary if the effect or resource to be valued is an input or output data of the project, if it is substitutable or non-substitutable, if it is dimensioning or not, etc. In fact, several approaches exist including: the border price rule for tradable inputs, the long-run marginal cost, the *standard conversion factor* (SCF), the "willingness-to-pay" (WTP).

In practice, for the cost-benefit analysis of the TELT project, we retain the involvement of the following conversion factors:

[20] Drèze, J. and Stern N., 1987, 'The Theory of CostBenefit Analysis', Handbook of Public Economics*, NorthHolland: Elsevier Science Publishers.*

[21] Drèze, J. and Stern N., 1990, 'Policy reform, shadow prices and market prices', *Journal of Public Economics*, 42 (1): 1-45.

- A null conversion factor on financial costs, value added tax and non-energy taxation according to usual practice justified by the elements presented below;
- A unit conversion factor majority of the opportunity cost of public funds for energy taxation.

Other financial values are translated into economic values by means of a unit conversion factor in the measurement.

5.1.2.3 Tax corrections

Regarding the consideration of tax elements in the cost-benefit analysis, the scoping methodology included in the 2014-2020 guidelines notes that taxes and subsidies are monetary transfers that do not represent real economic costs or benefits for society: they simply correspond to a transfer of control over certain resources from one group of the company to another.

To ensure that the actual economic value of flows is taken into account in the cost-benefit analysis, the recommendations focus on 3 rules:

- The prices of entrants and exits must be considered net of VAT,
- Incoming prices must be considered net of direct and indirect taxes,
- Prices (e.g. tariffs) used as a proxy for the value of exits should be considered net of any subsidies and other transfers granted by a public entity.

In some cases, indirect taxes (or subsidies) are intended to correct certain externalities. In this case, it is justified to include these taxes (respectively subsidies) in the costs (respectively benefits) of the project, provided that they adequately reflect the underlying marginal cost, and that there are no duplications (e.g. by including both energy taxes and estimates of total external environmental costs).

5.1.3 Indirect and wider effects

The economic analysis of CBA takes a microeconomic approach. The indirect and wider effects generated by an infrastructure project are, in principle, excluded from the analysis (see below), for 2 reasons:

- most indirect and/or extended effects are generally transformed, redistributed and capitalized forms of direct effects,
- The methods of taking these effects into account are not necessarily reliable and robust.

More specifically, according to the 2014-2020 guidelines, indirect effects related to secondary markets (e.g. the impacts of infrastructure on the tourism industry) should not be included in the assessment of the costs and benefits of the project. The main reason for this exclusion is that, if secondary markets are sufficiently efficient, then taking these effects into account is not relevant in a general equilibrium framework, as they are already captured by *shadow prices*. Therefore, adding these effects to the costs and benefits already measured in primary markets generally results in duplication.

However, the 2021-[redacted] Vademecum is more open on the subject and suggests considering the broader and indirect economic benefits in the CBA at least qualitatively, unless the potential impacts of the project justify a quantitative approach. However, there are no plans to include these valuations in the calculation of net present value.

5.1.4 Consumer surplus and economic benefits

Consumer and producer surplus

As part of a cost-benefit analysis structured according to the recommendations of the European Commission, the benefits associated with the development of a transport project are measured according to the variations of two criteria:

- The consumer's surplus,
- The producer's surplus.

Consumer surplus is defined as the difference between what a consumer is willing to pay for a good and the amount actually paid, corresponding to the generalized cost of that good. In practice, generalised cost considers the monetary costs borne by the consumer (toll, fuel, etc.) and the value of travel time calculated in monetary units of equivalence.

The main elements to be taken into account in estimating the consumer's surplus are:

- Fees paid by the user,
- Travel time,
- The cost of operating the vehicle for road users.

The surplus of the producer (network operator, operator) is defined as the difference between the income accumulated by the producer (i.e. the operator and the operators) and the costs incurred. The change in producer surplus is calculated as the difference between the change in producer income (for example, the increase in revenue from train tickets) and the change in producer costs (for example, the increase in train operating costs). The main elements to consider when estimating the producer's surplus are:

- Tariffs paid by users (and collected by the producer),
- Producers' operating costs.

The tariffs paid by users for the use of the infrastructure therefore appear as an expense for the user (in estimating the consumer's surplus) and as income for the producer (in estimating the producer's surplus). Thus, **for existing traffic and modal shift**, the tariffs paid by consumers and collected by producers must cancel out each other in the cost-benefit analysis.

However, for the calculation of the benefits relating to induced **traffic (see deferred according to certain approaches)** generally approximated via the *Rule of Half*, the producer's income and the costs paid by consumers do not cancel each other out. This reading of economic balances leads to the definition of two use cases described below:

- <u>Case n°1</u>: In the event that the project should not have an effect on traffic volumes (no induction), it is not necessary to estimate the variations in tolls paid by the consumer and collected by the producer because these flows will always be zero. Under the assumption of pure and perfect competition, the surplus of producers will be entirely transferred to consumers and a simplified approach will be adopted with the sole estimation of the net effects on users on the one hand (savings in travel time and operating costs of toll-free vehicles) and the operating costs of producers on the other hand;

- Case n°2: In the event that the project is expected to have an effect on traffic volumes (induction) or when transport pricing strategies are implemented, the fares paid by users are not cancelled. The analysis therefore consists of estimating the net impacts on the surplus of the consumer and the producer. This implies that tariffs must be taken into account independently, as well as any changes related to the producer's operating costs (if they are not already taken into account in the financial analysis - as happens when the analysis is not consolidated).

Principle for calculating the surplus by type of user

We will retain the above principles for the basic evaluation of the costs and benefits of the project, i.e. the calculation of the generalized cost variation broken down by mode in reference and project scenario as follows:

- **Former rail users**: valued journey time differential weighted by origin-destination of the rail mode (Mont-Cenis);
- **Modal and route reports**: travel time and price differential weighted by origin-destination of the original mode and Alpine crossing (Route – Fréjus, Mont Blanc, Ventimiglia, Air, Sea, St Gotthard-Brenner Rail);
- **Rail induction**: half unit surplus of former rail users weighted by origin-destination of the rail mode.

An alternative method of valuing surpluses is to apply the half-surplus method to all new users, including deferred users. This method is presented as a sensitivity test.

Surplus approach by origin-destination

In order to have a detailed description of user surpluses and toll and tax costs, an analysis by macro-origin-destination is conducted. This approach aims to define:

- A breakdown of reference volumes, carryovers and induction by macro-origin-destination;
- An estimate of variations in service levels and transport prices by macro-origin-destination with a view to valorization in the socio-economic balance sheet;

This approach is carried out separately for passenger transport and for freight transport vis-à-vis current and future demand.

The definition of origin-destination weights to calculate surpluses is defined in two stages, in parallel for passenger and freight transport:

- Step 1: recording the weights of a limited number of macro-ODs covering transport transiting the Alpine axis of Mont Cenis / Fréjus, resulting from the available surveys;
- Step 2: Expert identification of origins-destinations compatible with route and mode postponements to the TELT, i.e.:
    - with at least an equivalent distance via TELT from the reference rail route (Ventimiglia, Gotthard);
    - not presenting a significant additional cost via TELT vis-à-vis the reference mode (Road, Air, Short-Sea);

[redacted] [redacted]

- Step 3: The weights of the non-compatible origin-destinations are then canceled and the remaining weights are standardized so that the total weights remain equal to 100%.

In practice, the weights by origin-destination are applied in such a way as to value the appropriate surpluses according to the mode or route of origin: the unit surplus is then equal to the sum of the generalized unit cost differences between project and reference, weighted by the weights defined in the tables presented.

For the postponement of rail routes (former rail users), the weightings are those of the origins-destinations of the routes of origin (Mont Cenis, Ventimiglia). For modal shifts, the weightings are those of the origins-destinations of the modes and crossing points of origin (Route Mont Blanc/Fréjus/Ventimiglia, Air).

The unit surplus of market users M in euro per tonne or per passenger can then be expressed as follows:

$\text{SurplusM} = \Sigma_{i,j} [(CG\ i,j,TELT - CG_{i,j,M}).\ PD_{i,j,M}]$

Where I and j are the set of origin-destination analysed

CGi,j,TELT is the generalized cost of transport on the origin-destination i,j in project for the project rail mode including the development of the TELT

CGi,j,M is the generalized cost of transport on the origin-destination i,j in reference for the mode and crossing of the market M without the development of the TELT

PDi,j,M is the weighting defined on the origin-destination i,j for the mode and crossing of the market M.

5.1.5 Discounted and comparative calculation

Principle of updating

The cost-benefit analysis integrates current and future financial and socio-economic flows into the same calculation: for this, the valuation method recommended by the cited benchmarks implies a minimization of future effects through discounting: this principle of present preference results in a lower weighting of the expected benefits in the long term.

In practice, if X^*_{T1} is the present value, in year T1 with a constant discount rate "a", of a quantity XT0 of year T0, then this value is expressed as follows:

$$X^*_{T1} = \frac{X_{T0}}{(1+a)^{T1-T0}}$$

The discount rates are defined separately for socio-economic and financial valuation taking into account the base rates in force and the applicable risk premiums.

The European Commission recommends a social discount rate (excluding risk) of 2.77% applicable in particular to France and Italy[22]: Member States are however free to establish a specific rate insofar as they can:

- justify this reference on the basis of the forecast of economic growth;

[22] COMMISSION IMPLEMENTING REGULATION (EU) 2015/207 of 20 January 2015, Annex III

- ensure its systematic application in all similar projects in the same country, region or sector.

As these two conditions are met in France and Italy, it is therefore legitimate to maintain the discount rate set out below.

The calculation is carried out in constant euros (excluding monetary inflation), expressed at 2016 economic conditions by the need for comparability with previous assessments. The year for which the discount factor will be unit is 2021, with discounting to reduce costs applying from 2022 onwards.

Principle of differential calculus

The cost-benefit analysis only takes into account the net effects attributable to the project, comparing:

- a **project scenario** where the developments are carried out **;**
- a **reference scenario** where the improvements are not carried out;

The definition of this reference scenario is therefore of a strategic nature, as it must make it possible to define the project environment, the infrastructure blows and the foreseeable developments in transport networks.

The aggregation of the effects of the project that affect all the actors concerned allows its evaluation for the community and the calculation of its socio-economic profitability. A project is profitable in socio-economic terms if the discounted sum of the benefits it generates is greater than the discounted sum of its costs.

Summary of valuation parameters

In summary, the main parameters adopted elsewhere are as follows:

- Evaluation period: commissioning to [redacted]
- Residual value:
  - Socio-economic: cumulative net present value between [redacted] and [redacted]
  - Financial: book value considering a straight-line depreciation of investments with a life of 100 years counted from [redacted]
- Discount rate:
  - Economic discount rate: 3.0% according to European values and the recommended value for Italy (DGITM recommends a value of 4.5% for France)
  - Financial discount rate: 5.0% according to the values recommended in the European reference guides in the absence of a reference value for Italy and France, it includes the inflation rate which explain the distinction with the economic discount rate;
- Opportunity cost of public funds: 130% applied and national public expenditure and local or energy tax flows

The parameters for the assessment period and the residual value are detailed below.

5.1.6 Summary indicators selection

Several indicators of socio-economic and financial profitability are useful, the main ones being the net present value and the internal rate of return, the definitions of which are recalled below.

Net present value

The Net Present Value of the project is the sum of the valued and discounted benefits and costs of the project. Its expression is formulated in various equivalent ways, for example as follows for **socio-economic net present value** :

$$VAN\text{–}SE = -\Delta I *_T - \Delta E *_T + \Delta A*_T + VRE*_T$$

With:

- T: year of update;
- ΔI *T: variation, between the project scenario and the reference scenario, of investment costs (excluding taxes) and discounted to year T, i.e. the discounted sum, according to a foreseeable phase, of expenditure on studies, land acquisitions and works, including those for renewal and any subsequent additional developments;
- ΔE *T: variation, between the project scenario and the reference scenario, of maintenance and operating costs discounted to year T, taking into account any avoided costs;
- ΔA*T: variation in benefits, between the project scenario and the reference scenario and discounted to year T;
- VR*T: economic residual value of the investment, discounted to year T.

In the financial calculation, the financial **net present value** is defined as follows:

$$VAN\text{–}FI = -\Delta I *_T - \Delta E *_T + \Delta R*_T + VRF*_T$$

With the previous notations as well as:

- ΔR*T: change in revenue, between the project scenario and the reference scenario and discounted to year T;
- VRF*T: financial residual value of the investment, discounted to year T.

The calculation of the Net Present Value can be interpreted as an eigenvalue: if the NPV is positive, the project is said to be "profitable in terms" either socio-economic or financial depending on the approach. NPV values can also be carefully compared between projects provided that the refresh and valuation parameters are similar. Under this condition, if the NPV of a project is higher than that of a competing project, the first project will be more advantageous for the community (socio-economic NPV) or the project leader (financial NPV).

[redacted] [redacted]

Internal rate of return

The Internal Rate of Return (IRR) corresponds to the discount rate that would cancel the Net Present Value. It is determined by iteration separately for the socio-economic and financial component. In other words, an internal rate of return higher than the discount rate necessarily produces a positive net present value (the benefits are greater than the costs).

{ IRR = DISCOUNT RATE } ⇔ {NET PRESENT VALUE= 0}

and

{ SORT > DISCOUNT RATE } ⇔ {NET PRESENT VALUE> 0}

The internal rate of return can be interpreted as a rate of return corresponding to the investment of investments on the project or conversely as an interest rate for the investment of an amount equivalent to the investment.

Note: due to the numerical resolution of the IRR calculation, there may be several IRR solutions for the same net present value. In other words, an increase in net present value will not always imply an increase in internal rate of return and vice versa.

5.1.7 Period, residual value and stakeholders

Valuation period and residual value

The evaluation period chosen can be based on French recommendations[23] and extends from the commissioning of the new terminal until [redacted] regardless of the lifetime of the infrastructure. On this basis and according to the same benchmark, the socio-economic residual value **would be calculated** as the sum of the socio-economic effects (benefits and costs) valued beyond the end of the assessment period until 2140 and reduced to the last year of the evaluation.

To apply this methodology, the following additional assumptions should be taken into account:

- Stability of project benefits and costs beyond [redacted]
- Growth of the value of carbon at the same rate as the discount rate between [redacted] and [redacted] then stability of the value in constant euros beyond this date until [redacted]

As a precautionary measure, we will use a lower value, equivalent to the **financial residual** value, estimated on an accounting basis as equal to the amortized value of the initial investments, plus the regeneration costs realized until [redacted] The overall lifespan of the selected structure is 100 years with the base tunnel expected to be commissioned in [redacted] i.e. a depreciation value of 62% of the initial value.

[23] Monetarization and socio-economic indicators, August 2018, DGITM

Actors and flows taken into account

The purpose of the cost-benefit analysis of project developments is to estimate the net impact of the project on the community by including the effects for:

- Transport activity;
- The environment;

To do this, the actors in each sector are grouped more or less aggregated, according to the level of analysis required and the level of precision of the input data. A list of actors covered is given below.

For the **socio-economic component**, the actors who record the benefits and costs of the project are grouped as follows:

Tableau 43. Table 2 List of groups and sub-groups of community actors

Groups	Subgroups
Users	Shippers, customers of rail, road and sea freight transport operators
	Customers of long-distance rail and air passenger transport companies, users of private vehicles
Investors	Public or private financiers of the project's infrastructure and equipment
Infrastructure managers	Base Tunnel Lyon Turin
	Railway network operators
	Road network managers
Transport operators	Rail carriers
	Motor carriers
	Air carriers
	Marine carriers
Local residents	Inhabitants within the project's impact perimeter
Public authorities	European Union, State, Local authorities

Source: [redacted] *2022*

The **financial aspect** is treated from the point of view of the project promoter (TELT SAS) (and its possible delegates) in charge of investments on the cross-border link, the operation, maintenance and renewal of the new and historic line as well as the collection of rail charges on this perimeter.

[redacted] [redacted]

5.2 Cost benefit appraisal results

5.2.1 Financial Analysis

The financial analysis conducted from the project promoter's point of view includes both initial capital expenditure, operating costs, expected revenues (rail charges) and the residual value of the infrastructure at the end of the evaluation period.

The net present values of the components of the financial analysis are as follows:

Tableau 44. Components of the financial analysis (net present value, M€2023)

Component	Financial NPV (M€2023)
Capital expenditure, of which…	**-17 928**
…Alpine accesses - Italian side (connection to Turin 1st and upgrade of Bussoleno-Avigliana 1st phase)	*-1 642*
[redacted]	*-504*
…Alpine crossing - TELT (preliminary and exploratory works)	*-1 986*
…Alpine crossing - TELT (base tunnel)	*-8 956*
…Alpine crossing - TELT (historical tunnel doubling avoidance)	*979*
[redacted]	*-3 773*
…Alpine accesses - Italian side (Bussoleno-Avigliana 2nd phase)	*-679*
[redacted]	*-627*
…Alpine accesses - French side (Connection to Chambery)	*-527*
[redacted]	*-212*
Operating expenditure	**1 342**
…Railway operation and maintenance	*-786*
…Road operation and maintenance (passengers)	*261*
…Road operation and maintenance (freight)	*1 869*
Revenues	**1 490**
Financial residual value	**2 163**
FNPV without subsidies	**-12 929**
Funding gap rate	**72,1%**

Source: [redacted] *2023*

Tableau 45. Components of the financial analysis including all grants (net present value, M€2023)

Indicator	Financial NPV (M€2023)
FNPV without subsidies	**-12 929**
EU contribution - present submission (base tunnel)	2 326
FNPV with CEF contribution	**-10 602**
Other public subsidies (including previous EU subsidies)	15 601
…of which past European fundings (not discounted)	859
…of which road operation and maintenance costs savings	2 129
…of which other public contributions	12 613
FNPV with all grants	**4 999**

Source: [redacted] 2023

The financial profitability indicators calculated for all the developments carried out (base tunnel and access) and their long-term effects ([redacted]-[redacted] and residual value over [redacted]-[redacted] show that the financing plan is based largely on public funding, both national and European. European funding is being used to complete the financing plan as follows:

1. Past European contributions are not enough to shift the net financial present value into a positive range.

2. The addition of the expected European contribution in this call for projects does not in itself shift the net financial present value into a positive range, as this grant is in relation to just over half of the eligible amounts of the cross-border section only.

3. Additional European funding on the remaining part of the cross-border section and on Italian and French access will be necessary to ensure the financial viability of the operation.

4. The other public subsidies are composed of European past subsidies, road operation and maintenance costs future savings and other future fundings to be defined from the Member States and the European Commission;.

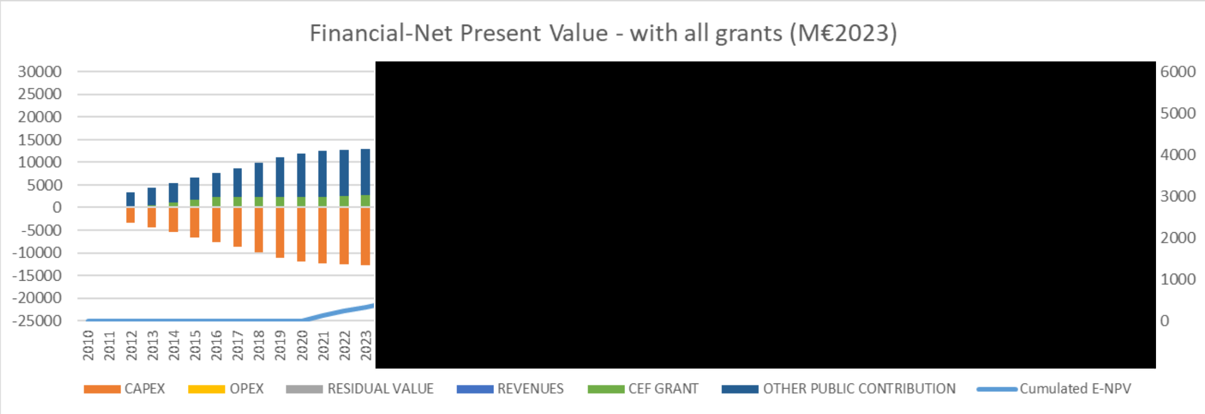
If we consider that all the funding is obtained, either at the national or at the European level, then the usual financial indicators are no longer relevant insofar as there is no equity capital mobilised on the project, and therefore no financial profitability of its own.

Tableau 46. Financial profitability indicators

Indicator	Value	Unit
FNPV without subsidies FIRR without subsidies	-12 929 N/C	M€2023 -
FNPV with EU subsidies (present submission only) FIRR with EU subsidies (present submission only)	-10 602 N/C	M€2023 -
FNPV with all grants FIRR with all grants	4 999 >5%	M€2023 -

Source: [redacted] 2023

Illustration 36. Time distribution of financial net present value with all grants (M€2023)



Source: [redacted] 2023

5.2.2 Economic Analysis

The economic analysis compares the financial expenditures incurred by the project proponent (capital expenditure, operating expenditure) with the benefits provided by the project over a perimeter extended to the entire community.

From this perspective, the project has significant benefits despite its significant investment costs, particularly in terms of transport costs for users and avoidance of external costs, reflecting its contribution to establishing a decarbonised and efficient European transport system.

The net present values of the components of the economic analysis are as follows:

Tableau 47. Components of the economic analysis (net present value, M€2023)

Component	Economic NPV (M€2023)
Capital expenditure, of which…	**-23 507**
…Alpine accesses - Italian side (connexion to Turin 1st and upgrade of Bussoleno-Avigliana 1st phase)	*-1 842*
[redacted]	*-574*
…Alpine crossing - TELT (preliminary and exploratory works)	*-2 284*
…Alpine crossing - TELT (base tunnel)	*-11 067*
…Alpine crossing - TELT (historical tunnel doubling avoidance)	*1 055*
[redacted]	*-5 027*
…Alpine accesses - Italian side (Bussoleno-Avigliana 2nd phase)	*-1 236*
[redacted]	*-1 105*
[redacted]	*-929*
[redacted]	*-497*
Operating expenditure, of which…	**2 238**
…Railway operation and maintenance	*-1 304*

[redacted] [redacted]

Component	Economic NPV (M€2023)
…Road operation and maintenance (passengers)	*409*
…Road operation and maintenance (freight)	*3 133*
Economic benefits and costs, of which	**41 339**
…Passenger user surplus (time and costs)	*6 325*
…Freight user surplus (time and costs)	*22 037*
…Passenger external costs	*6 262*
…Freight external costs	*6 713*
Economic residual value	**5 341**
TOTAL	**25 417**

Source: [redacted] *2023*

The socio-economic profitability indicators calculated for all the developments carried out (base tunnel and access) and their long-term effects ([redacted]-[redacted] and residual value over [redacted]-[redacted] lead to the conclusion that the project remains within its own profitability ranges. To produce these indicators, for the record, the Italian parameters recommended by the Ministero delle Infrastrutture e dei Trasporti are applied (discount rate of 3%, opportunity cost of public funds of 30%).

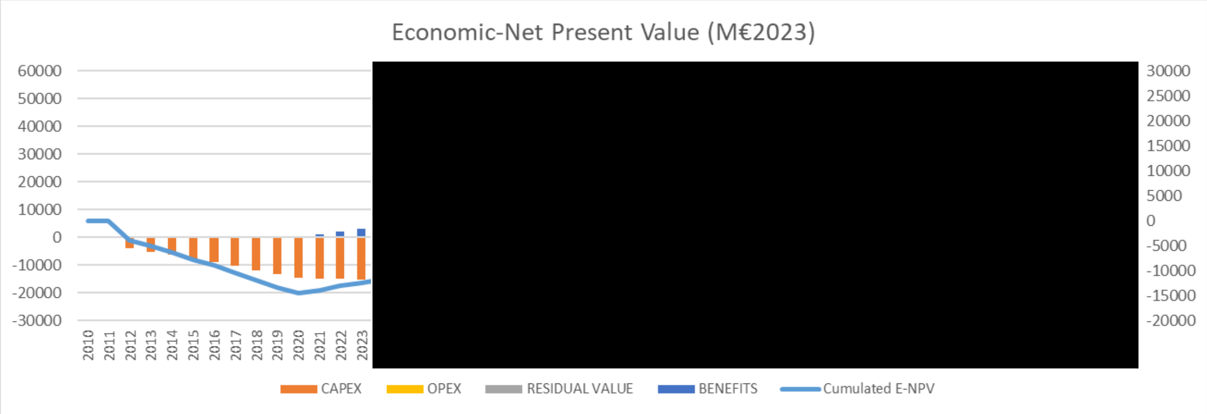
Tableau 48. Socio-economic profitability indicators

Indicator	Value	Unit
TOTAL ENPV	25 417	M€2023
TOTAL ENPV per invested euro	1,08	-
TOTAL ENPV per invested euro except european subsidies	1,20	-
EIRR	7,0%	-
B/C ratio	2,60	-

Source: [redacted] *2023*

The representation of the cumulative net present value and the various expected benefits shows a return to equilibrium after investment around [redacted] i.e. just over 20 years after the commissioning of the Base Tunnel. The benefits then gradually contribute to generating a largely positive net present value over the longer term.

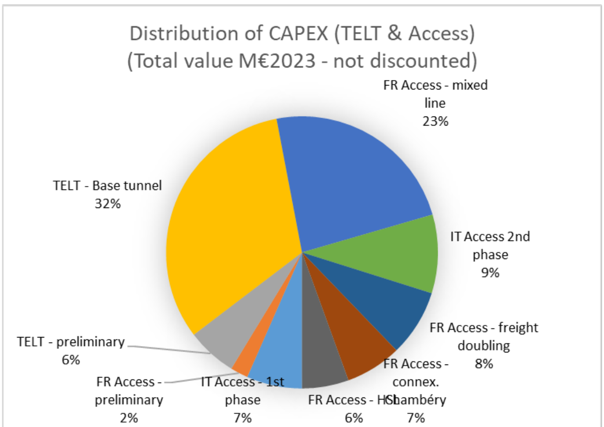
Illustration 37. Time distribution of economic net present value (M€2023)

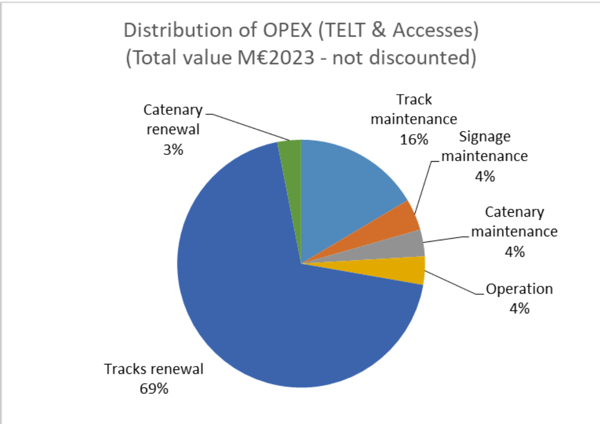


Source: [redacted] 2023

The breakdown of capital expenditure shows the relative importance of each component of the project. These amounts include the base tunnel [redacted] and the French accesses to be built before [redacted] which represent more than half of the expenditure.

Illustration 38. Distribution of capital and operating expenses of the project

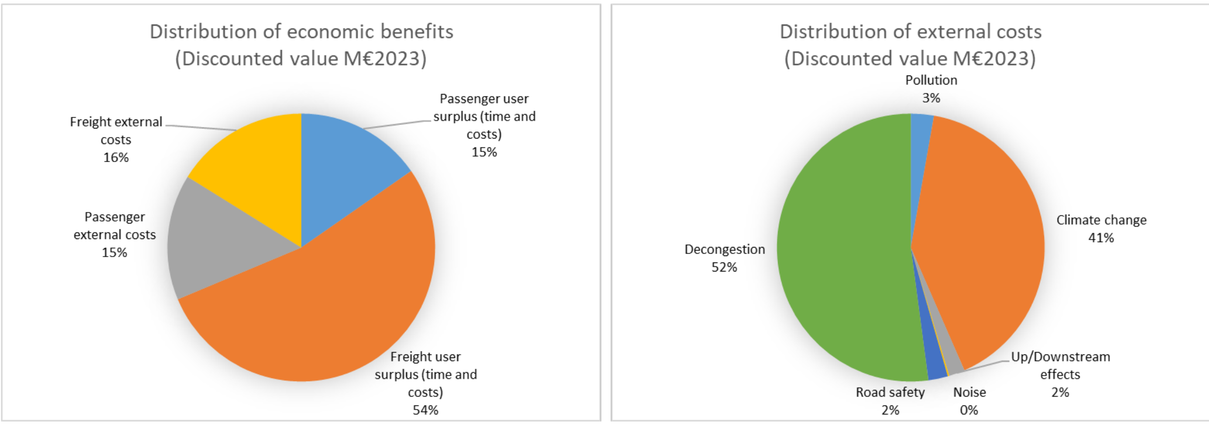




Source: [redacted] 2023

The distribution of the benefits of the project shows the importance of the economic benefits for freight users, mainly through the productivity of the rail mode (increased load, lower energy expenditure, etc.) and the corresponding modal shift. The externalities are mainly divided between decongestion (especially in road tunnels) and avoidance of greenhouse gases in the short term, with a cushioning effect of environmental gains linked to the assumptions of decarbonisation of road transport after [redacted]

Illustration 39. Distribution of project benefits



Source: [redacted] 2023

5.3 Critical and risk analysis

The critical analysis is based on the review of previous cost benefit analysis produced for the Lyon-Turin railway link project and a comparison with other base tunnel cost benefit appraisals.

The present chapter covers successively:

- The references of studies reviewed and compared.
- A review of traffic forecast and economic appraisal of each.
- An analysis of the convergence, divergence and their reasons

5.3.1 References of cost benefit appraisal reviewed

Economic and traffic studies of the Lyon-Turin railway link

Several traffic forecast and cost benefit appraisal of the **Lyon-Turin railway link** project have been produced on the various stages of the project, each of them having a distinct purpose and objective:

- The public enquiry dossier for the public utility declaration includes a cost benefit appraisal led according to the French guideline as a compulsory document to produce in such legal process (source: Public inquiry file prior to the declaration of public utility: Chapter 8 - Socio-economic assessment, LTF, 2006" concerning the section FROM Saint-Jean de Maurienne to the French-Italian border)
- The preliminary project update led to an update of the latter in 2011 in terms of passenger and freight traffic forecast, cost benefit appraisal and carbon footprint submitted to the intergovernmental conference (CIG) for the French-Italian common section as defined in the treaty of the 29th January 2001. The sources are the following:
    - Preliminary draft revision: submission n°41 passenger traffic studies, LTF, 2010
    - Preliminary Project Revision: Submission No. 46 Freight Traffic Forecasts, LTF, 2011
    - Preliminary draft revision: submission n°72 economic and socio-economic studies, LTF, 2011

- An update of the capital expenditure amounts, and planning was then conducted to appraise its impact in terms of cost benefit appraisal (source: Aggiornamento dell'analisi di impatto socioeconomico del nuovo progetto TEN-T Turin - Lyon con fasaggio, CERTeT - Bocconi, 2014)

For a review of older studies of the project, the reader could also refer to the study conducted by COWI and ECORYS (source: Analysis of studies made by LTF on the Lyon - Turin project (international section), Framework Contract TREN/CC/03-2005, Lot 2: Economic assistance activities, 2005)

Other major alpine railway projects economic and traffic studies

For other major alpine railway projects, either publicly available documents or privately shared documents have been reviewed, among which:

- The local economic benefit study for the **Brenner base tunnel**, conducted in 2013 (source: I benefici economici della Galleria di Base del Brennero nella fase di costruzione éd esercizio - Relazione finale, Comunità di Azione Ferrovia del Brennero, 2013) and the Cost benefit analysis conducted by Ernst & Young Financial Business Advisors in 2007
- The traffic forecast of the **San Gottardo base tunnel**, developed in 2015 (source: Trendszenario Gotthard Achse - Mögliche Auswirkungen des neuen Gotthard und Ceneri Basistunnels auf Raum und Verkehr, BHP - Brugger und Partner AG, 2015)
- The economic appraisal of the **Semmering base tunnel**, realized in 2014 (source: Analyse der "Gesamtwirtschaftlichen Bewertung des Projekts Semmering-Basistunnel neu" und Erstellung einer neuen Nutzen-Kosten-Bewertung in Anlehnung an das Verfahren für den deutschen Bundesverkehrswegeplan, VIEREGG - RÖSSLER GmbH, 2014).
- The ex-ante and ex-post traffic and economic analysis of the **Lötschberg base tunnel** (sources: Wirtschaftlichkeitsstudie NEAT, Ergebnisse im Überblick, Ecoplan, 1997,
- ; Verkehrliche und räumliche Auswirkungen des Lötschberg-Basistunnel, Ernst Basler+Partner, 2012).
- The **Koralm tunnel** economic appraisal (source: Gesamtwirtschaftliche Bewertung der Baltisch Adriatischen Achse, Dr. Karl Frohner, 2012).

5.3.2 Project description and basic assumptions

The first aspect reviewed in the studies mentioned above concern the features of the project (commissioning date, work duration, amount of investment), the macro-economic and demographic assumptions and the cost evolution assumptions.

As the following table shows, the project features have been modified since the past cost benefit appraisal in terms of commissioning year, the investment amount has been slightly modified but remain in the same order of magnitude. The economic and demographic assumptions nonetheless have been updated to with lower pace after [redacted] according to the last available forecast. Energy and transport prices now include a full scenario of decarbonation according to the European and national strategic plans, the rail freight costs evolution has been shifted down to integrate the productivity increase in terms of average load and energy consumption. In the documents analysed, none of the economic studies mention in detail the underlying assumptions except the investment amounts which are at least twice lower than those of the Lyon Turin railway project.

Since the last cost benefit appraisal of the Lyon-Turin project, the following aspects have been specifically analyses to update properly the parameters:

Economic and demographic assumptions:

- **Short term macroeconomic growth projections**: the newly available projections have been integrated and generally reduced regarding the previous trends. For instance, in France, the Retirement Orientation Committee (COR) proposed GDP growth rates which have been reduced between the publication of 2018 and 2022. In Italy, more cautious projections have been published by the Finance Ministry and more slightly reduced in the past years;

- **Long term macroeconomic growth projections**: The long-term projections used previously before the COVID-19 and Ukraine war are less sensitive to the present scenario and follow a better continuity, whereas mid-long-term projections of GDP are now under 1,5%/y for France and Italy according to a panel of available publications.

- **Demographic projections**: the demographic projections are slightly reduced for the whole Europe, where existing trends seem to reinforce such as population decrease in Italy and slowdown in France.

Cost evolution assumptions:

- **Private vehicles occupancy rates:** whereas the public enquiry studies (LTF, 2006) considered a low rate of 1,3 pax/vehicle which was consistent with practices at that date, the present situation follows a much higher trend and those rates have been updated in the projective scenario to reach around 2 pax/vehicle for international and leisure trips averages. This cautious approach significantly reduces the potential impact of modal shift to rail in terms of pollution and ghg avoided emission and of modal shift user surplus (the road transport costs per person reveals to be lower which a higher occupancy rate) ;

- **Road fleet decarbonation**: no decarbonation assumptions were used in the previous cost benefit appraisal of the project. A full set of assumption has been to make consistently with the national and European objectives. This consists in a cautious approach which reduces the potential gains of the road to rail modal shift where the road sector is supposed to reach carbon neutrality around 2050.

[redacted] [redacted]

Tableau 49. Benchmark of projects' features, economic and demographic assumptions

Project	Project Features	Economic and demographic assumptions	Cost evolution assumptions
Lyon – Turin (CEF CBA 2023)	- Commissioning: [redacted] - Work duration: 22 years - Investment amount: 23,51 B€2023 (discounted in 2023 at 4,5%/y))	- GDP: France +1.17%/y for [redacted]-[redacted] and +1.17%/y for [redacted] Italy +1.10%/y for [redacted]-[redacted] and +0.95%/y for [redacted]-[redacted] - Demography: France +0.20%/y for 2020-[redacted] and -0.03%/y for [redacted] Italy -0.10%/y for 2020-[redacted] and -0.50%/y for [redacted]-[redacted]	- Energy prices: Fuel: +4.6%/y for 2015-[redacted] and +0,3%/y for [redacted]-[redacted] in constant euros Electricity: +6.0%/y for 2015-[redacted] and +0,6%/y for [redacted]-[redacted] in constant euros - Freight transport prices: Rail (ref): +0,66%/y for 2020-[redacted] and +0,14%/y for [redacted]-[redacted] in constant euros Rail (project): -4,33%/y for 2020-[redacted] and -0,79%/y for [redacted]-[redacted] in constant euros Road: +1,91%/y for 2020-[redacted] and -0,04%/y for [redacted]-[redacted] in constant euros - Passenger transport prices: Rail: -0.13%/y for 2020-[redacted] and -0.12%/y for [redacted] in constant euros Road: +3,64%/y for 2020-[redacted] and -0,40%/y for [redacted]-[redacted] in constant euros Air: +2,55%/y for 2020-[redacted] and +1,50%/y for [redacted]-[redacted] in constant euros
Lyon-Turin (Bocconi 2014)	- Commissioning: [redacted] Work duration: 22 years- Investment amount: same assumptions as "Revision of the preliminary draft 2011" below (23,56 B€), but distinct phasing	Same assumptions as "Preliminary draft revision 2011" below	NC
Lyon-Turin (Revision of preliminary draft 2011)	- Commissioning: 2023- Work duration: 22 years- Investment amount: 23,56 B€	- GDP:Average EU +1.70%/y for 2009-[redacted] and +1.50%/y for [redacted]-[redacted] France +1.45%/y for 2009-[redacted] and +1.80%/y for [redacted] Italy +1.18%/y for 2009-[redacted] and +1.29%/y for [redacted]-[redacted] - Demography: Average EU +0.24%/y for 2009-[redacted] and -0.07%/y for [redacted] France +0.43%/y for 2009-[redacted] and +0.23%/y for [redacted] Italy +0.20%/y for 2009-[redacted] and -0.11%/y for [redacted]-[redacted]	-Road toll Fréjus-Mont Blanc : +3,5%/y in constant euros for 2010-2014 for private vehicles -Air tariffs: steady in constant euros since 2006 -Fuel prices: steady in constant euros since 2006 -Railway pax tariffs: +0,08%/y in constant euros on the Paris Milano services
Lyon-Turin(Impact studies 2006)	- Commissioning: 2017- Work duration: 10 years- Investment amount: 16,91 B€	- GDP: 8 major countries of EU +1.80%/y for 2001-2020 and +1.50%/y after 2020	- Road freight transport costs: +0.4%/y in constant euros
Brenner (EY 2007 & CAB 2013)	- Commissioning: [redacted] Work duration: 18 years- Investment amount: 10,29 B€	- GDP: after 2025 +0.71% in Italy and +2.33% in Austria	- Energy price: according to the Eurac (2010) study, energy costs decrease in constant euros (values not communicated)
St. Gotthard(BHP 2015)	- Commissioning: 2016- Work duration: 20 years- Investment amount: 8,56 B€	NC	NC
Semmering(VIEREGG - RÖSSLER GmbH 2014)	- Commissioning: [redacted] Work duration: NC- Investment amount: 2 B€	NC	NC

[redacted] [redacted]

Project	Project Features	Economic and demographic assumptions	Cost evolution assumptions
Lötschberg (WIRE 1997 & Ernst Basler+Partner 2012)	- Commissioning: 2007- Work duration: 13 years- Investment amount: 4,20 B€	NC	NC
Koralm(Dr. Karl Frohner 2012)	Commissioning: [redacted] Work duration: NCInvestment amount: 8,46 B€	NC	NC

Source: [redacted] 2020-2023

5.3.3 Market growth and traffic forecast

The second aspect reviewed among previous cost benefit appraisal of the Lyon-Turin and other base tunnel project concern the traffic forecast, reviewed along the methodology applied, the market growth calculation and the resulting average elasticities.

The elasticities calculation takes into account the traffic forecasts indicated in each study and the GDP growth assumptions where these are specified. In the absence of assumptions about GDP, their series are reconstructed on the basis of recognized national and international sources (European Commission, World Bank, OECD, Swiss Federal Statistical Office, etc.).

According to the macro-economic growth assumptions which have been reduced, the global market growth rates of the present appraisal remain under those of the previous estimations. Nonetheless, the review of the rail freight productivity assumptions permits to maintain a significant project traffic growth with reasonable elasticities. In comparison, all economic studies published for other Alpine rail project between 2010 and 2015 present higher market growth rates, which are now less relevant regarding the global market trends. The present study takes thus into account this new paradigm in a cautious approach.

Tableau 50. Benchmark of projects' traffic forecast methodology, market growth and elasticities

Project	Forecast methodology	Market growth	Elasticities calculation
Lyon – Turin (CEF CBA 2023)	Elasticity-based model inspired by the previous Lyon-Turin traffic forecast models, structured in 2 main: 1.Alpine transport market growth (long distance passenger and freight) and 2.Alpine crossings' modal shift (price and time sensitivities under road and rail capacity constraints).	-Passenger: Total alpine traffic: 0.20%/y for 2010-[redacted] and 0.93%/y for [redacted]-[redacted] Project rail traffic: 0.56%/y for 2010-[redacted] and +3.39%/y for [redacted]-[redacted] - Freight: Total alpine traffic: 1,00%/y for 2010-[redacted] and 1.32%/y for [redacted]-[redacted] Project rail traffic: 2,64%/y for 2010-[redacted] and 5.07%/y for [redacted]-[redacted]	Arc-elasticities calculated as the ratio of : reference traffic growth / GDP growth (France + Italy): - Passengers: 0.79 until [redacted] and 0.74 after [redacted] - Freight: 1.52 until [redacted] and 1,10 after
Lyon-Turin (Bocconi 2014)	Same source and traffic model as "Preliminary draft revision 2011"	Same source and results as "Preliminary draft review 2011"	Same source and arc-elasticities as "Revision of preliminary draft 2011"

[redacted] [redacted]

Project	Forecast methodology	Market growth	Elasticities calculation
Lyon-Turin (Revision of preliminary draft 2011)	Four-steps traffic model development for passenger and rail at a European scale, updated from the Impact study traffic model	- Passengers: +44% (1.1%/y) of annual passengers between 2023 and [redacted] in reference scenario, +45% (1.2%/y) in project, and +1% to +2% between the project scenario and the reference to each forecast horizon (2023, [redacted]) - Freight: +73% (1.7%/y) of annual tonnes between 2023 and [redacted] in both baseline and project scenarios, stability of traffic between the project scenario and the reference to each forecast horizon (2023, [redacted]	Arc-elasticities calculated as the ratio of: reference traffic growth / GDP growth (France + Italy): - Passengers: 0,79 for 2023/[redacted] and 0,74 for [redacted] -Freight: 1.52 for 2023/[redacted] and 1.10 for [redacted]/[redacted]
Lyon-Turin(Impact studies 2006)	Four-steps traffic model for freight and passenger covering: - Cross-border passengers: trend demand by mode, according to the relative evolution of prices paid by the users, services or traffic conditions, journey times, access times to stations and airports, and quality of service. Distribution of rail demand between 4 Alpine crossing points (Chiasso, Domodossola, Ventimiglia, Montecenisio) by applying a route choice model - National passengers: calculation of traffic volume shifted to rail using a model including transport costs and times - Freight: forecast of overall demand, depending on Italy's economic growth, structure of trade between different countries (according to the evolution of the GDPs of each). Calculation of modal split and corridor assignment according to the features of the different routes (capacity, infrastructure tolls, operating costs)	- Passengers: +16% (1.1%/y) of annual passengers between 2017 and [redacted] in reference scenario as in project, +25% (1.7%/y) between the project scenario and the reference to each forecast horizon (2017, [redacted] - Freight: +31% (2.1%/y) of annual tons between 2017 and [redacted] in reference scenario, +35% (2.3%) in project	Arc-elasticities calculated as the ratio of: reference traffic growth / GDP growth (France + Italy): - Passengers: 0.79 for 2017/[redacted] - Freight: 1.50 for 2017/2030
Brenner (EY 2007 & CAB 2013)	Forecast provided by the consultant Progtrans without detail on the methodology	- Passengers: +32% (+2.0%/y) of passengers between 2011 and [redacted] and +46% (2.0%/y) until [redacted] in project scenario (no forecast in reference scenario) - Freight: +41% (2.5%/y) of annual tonnes between 2011 and [redacted] and +50% (2.2%/y) until 2030 in project scenario (no forecast in reference scenario)	Arc-elasticities calculated as the ratio of: reference traffic growth / GDP growth (Italy+Austria): - Passengers: 1.42 for [redacted]/[redacted] - Freight: 0.80 for [redacted]/[redacted]
St. Gotthard(BHP 2015)	NC	- Passengers: +80% (7.0%/y) of passengers between 2010 and 2016, +100% (3.5%/y) until [redacted] in project scenario (no forecast in reference scenario) - Freight: NC	Arc-elasticities calculated as the ratio of: project traffic growth / GDP growth (Switzerland): - Passengers: 1,98 for 2010/[redacted] - Freight: NC

Project	Forecast methodology	Market growth	Elasticities calculation
Semmering(VIEREGG - RÖSSLER GmbH 2014)	Two different forecasting methods: - Austrian method (without details on the methodology and the identity of the underlying assumptions, method criticized by VIEREGG - RÖSSLER GmbH, author of the report) - German method by VIEREGG - RÖSSLER GmbH (without methodological details in the report)	German method: - Passengers: +10.5% (0,5%/y) of annual passengers between 2005 and [redacted] in reference and project scenario - Freight: +46% (1.9%/y) of annual tonnes between 2005 and [redacted] in reference scenario, +70% in project scenario (+2.7%/y)	Arc-elasticities calculated as the ratio of: project traffic growth / GDP growth (Austria), German method: - Passengers: 0,2 for 2005/[redacted] - Freight: 0.83 for 2007/[redacted]
Lötschberg (WIRE 1997 & Ernst Basler+Partner 2012)	Ex-ante forecast to feed in a business model with new transport analysis and costs Ex-post observations	Ex-post analysis: -Passengers: +73% (+14.7%/y) between 2007 and 2011 in project scenario (no reference scenario)-Freight: +17% (4.0%/y) between 2007 and 2011 in project scenario (no reference scenario)	Arc-elasticities calculated as the ratio of: project traffic growth / GDP growth (Switzerland): - Passengers: 9.40 for 2007/2011 - Freight: 2.19 for 2007/2011
Koralm(Dr. Karl Frohner 2012)	Forecast provided by Dr. Hans Wehr (without detail on the methodology in the document)	- Passengers: NC- Freight: +84% (1.4%/y) between 2010 and [redacted] in the project and reference scenario	NC

Source: [redacted] 2020-2023

5.3.4 Economic and financial impact

The third point reviewed in the available studies of the Lyon-Turin and other base tunnel project tackles the cost benefit appraisal itself through the identification of the guidelines applied, the summary indicators and the breakdown of benefits. Where necessary, the benefit / cost ratio has been recalculated on the basis of the available information.

Following the most recent guidelines, the present cost benefit appraisal of the Lyon Turin railway project implies a hight carbon valuation of climate change avoidance and a significant increase of external costs weight in the accounted benefits. The analysis or more detailed assumptions of rail freight productivity increase in particular through comparison with the average load transported in other Alpine base tunnel, let to strengthen the freight costs savings and maintain the balance with external effects. The proportion of economic and environmental benefits are very similar to those of the Brenner base tunnel and corresponds to the hierarchy of benefits given for the Saint Gotthard base tunnel. The summary economic indicators for the present analysis are quite similar to those presented in 2014 with an Italian-based social discount rate, and a step higher to the results of 2011 which was considering lower time value of transport, external costs factors and level of congestion in the road tunnels at that date. The benefit – cost ratio remains in order of magnitude which are comparable to those of the Brenner base tunnel and higher of the Lötschberg which is part of the NRLA (New Railway Link through the Alps) and, as such, may present a lower innerprofitability.

[redacted] [redacted]

Tableau 51. Benchmark projects' cba guidelines, indicators and benefits

Project	Applicable guidelines	Summary indicators	Benefits' breakdown
Lyon – Turin (CEF CBA 2023)	- Guide on economic appraisal for CEF-T Transport Projects / CINEA, 2022 - Handbook on the external costs of transport, Version 2019, CE DELFT - Technical guidance on the climate proofing of infrastructure in the period 2021-[redacted] EC, 2021	NPV : 25.42 B€2023 B/C : 2.60 IRR : 7.0%	- Freight costs and times savings (53%) - Passenger costs and times savings (16%) - Extenal costs of transport (31%)
Lyon-Turin (Bocconi 2014)	Same guidelines as "Revision of the preliminary draft 2011"	- NPV: €20,306 million 2010 - B/C: 1.66 - IRR: 5.63%	- Costs and time savings (77%) - External costs avoidance (23%)
Lyon-Turin(Revision of preliminary draft 2011)	- Framework Instruction of 25 March 2004, revised in part by the ministerial letter and its annexes of 27 May 2005 - Developing Harmonised European Approaches for Transport Costing and Project Assessment, HEATCO, 2002 - Guide to Cost Benefit Analysis of investment projects", European Commission, DG Regio, 2008 - Linee guida per la misura dei Costi Esterni nell'ambito del PON Trasporti 2000 – 2006, Quaderni del POnTrasporTi n. 08 . 2008	- NPV: 11,533 to €14,961 million 2009 - B/C: 1.50 to 1.60 - IRR: 4.7% to 5.2%	- Freight costs savings (37%) - Passenger costs and time savings (27%) - External costs avoidance (36%)
Lyon-Turin (Impact studies 2006)	Framework Instruction of 25 March 2004, revised in part by the ministerial letter and its annexes of 27 May 2005	- NPV: -550 to 940 M€2006 - B/C: 0.90 to 1.30 - IRR: 3.8% to 4.8%	- Costs and time savings (62%) - External costs avoidance (38%)
Brenner (EY2007 & CAB 2013)	- Developing Harmonised European Approaches for Transport Costing and Project Assessment, HEATCO, 2002 - European Investment Bank Railway Project Appraisal Guideline (RAILPAG), 2005	Discount rate: 2.5% - NPV: 2.4 B€ - B/C: 1.9 - IRR: 4.7%	- Costs and times savings (~70%) - External costs (~30%) - Added value and local taxes (15 M€2002)
St. Gotthard (BHP 2015)	Standard integrated "IRRpode" method given by the Federal Office for Spatial Development (ARE)	NC	- Costs and times savings - External costs avoidance (noise, pollution) - Local taxes
Lötschberg (WIRE 1997 & Ernst Basler+Partner 2012)	NIBA (Nachhaltigkeitsindikatoren für Bahninfrastrukturprojekte) evaluation method	- NPV: NC - B/C: around 1 - IRR: NC	NC

Source: [redacted] 2020-2023

5.3.5 Sensitivity tests

5.3.5.1 Demographic evolution

The objective of this test aims to assess the consequences of a significant variation in demographic development in France and Italy on the key indicators of economic viability of the project (IRR, NPV) compared to the reference values considered for the socio-economic assessment. This test of demographic variation is simultaneously coupled with an alteration of GDP.

Indeed, the two variables are closely linked in the model. Altering one of the two without modifying the second could have undesirable effects on the calculation of GDP/capita, a key indicator on which several parameters of the model are indexed, and which would result in counterintuitive results for the analysis. It is therefore imperative to act on these two parameters simultaneously to obtain consistent and usable socio-economic indicators.

The test consists of simulating a contraction in demographic growth by dividing the positive average annual population growth rates by 2 and multiplying the negative average annual growth rates by 2 between 2022 and [redacted] In parallel, the hypothesis according to which a demographic contraction would be accompanied by an economic recession (a decrease of -0.3 points in the GDP growth rate per year between 2022 and [redacted] compared to the reference values) is applied.

The results of this test are as follows:

Tableau 52. Summary results of the sensitivity test linked to the evolution of the population

	NPV (M€ 2016)	IRR
Test – Demographic contraction	-21 %	-0.7 pts

This test highlights the importance of establishing a coherent set of hypotheses between demography and economic growth. A combined contraction in demographic growth and GDP, in the context of a long-term recession scenario, generates a clear and mechanical decline in the NPV and the IRR without, however, calling into question the specific socio-economic profitability of the project.

5.3.5.2 Macroeconomic evolution

This test aims to assess the consequences of a significant variation in GDP on the key indicators of economic viability of the project (IRR, NPV) compared to the reference values considered for the socio-economic evaluation. The test consists of simulating a contraction in the evolution of GDP by reducing the annual growth rate of this same GDP by -0.5 points between 2022 and [redacted] compared to the reference values.

The results of this test are as follows:

Tableau 53. Summary results of the sensitivity test linked to the evolution of GDP

	NPV (M€ 2016)	IRR
Test – Economic contraction	-36 %	-1.3 pt s

The results of this test significantly illustrate the direct relationship between the macro-economic situation of the project perimeter and the socio-economic viability of the project. A scenario of strong and long-term economic recession generates a significant drop in the project's profitability indicators but does not achieve the project's own profitability in the proportions assessed.

5.3.5.3 Evolution of transport costs

This test aims to measure the consequences of a significant variation in transport costs (passengers and goods) on the key indicators of economic viability of the project (IRR, NPV) compared to the reference values considered for the socio-economic evaluation. Three tests are performed here:

- The first consists of simulating an increase in transport costs for **all modes** of around +2 points per year between [redacted] and [redacted] **after the project commissioning**;
- The second consists of simulating an increase in transport costs **for road mode only** of +2 points per year between [redacted] and [redacted]
- The third consists of simulating an increase in transport costs **for rail only** of +2 points per year between [redacted] and [redacted]

The results of these three tests are as follows:

Tableau 54. Summary results of sensitivity tests linked to the evolution of transport costs

	NPV (M€ 2016)	IRR
Test 1 – Increase of transportation costs **All modes**	+2.8 0%	+0.1 0 pt s
Test 2 – Increase of transportation costs **Road mode**	+3.4 0%	+0.12 pts
Test 3 – Increase of transportation costs **Rail mode**	-0.03%	-0.05 pts s

The results of the first two tests show a modest increase in the project's NPV and IRR. Indeed, all modes combined, the increase in transport costs mainly penalizes the road mode, still largely the majority, for the benefit of the rail mode. On the other hand, it favors the shift towards the fastest routes and the least expensive modes, in particular those offered through the new rail infrastructure. This phenomenon is logically accentuated when the increase in transport costs is concentrated solely on the road mode, as is the case in the second test.

On the other hand, the third test causes a reduction in the socio-economic indicators of the project. In fact, the increase in costs exclusively penalizes the rail mode offered by the new infrastructure, and generates a loss of attractiveness and, therefore, a mechanical shift of traffic towards other modal alternatives, which contributes to the deterioration of profitability of the project. This degraded situation for the railway sector does not, however, call into question the socio-economic profitability of the project.

5.3.5.4 Evolution of investment costs

This test aims to assess the consequences of a significant increase in investment costs on the key indicators of economic viability of the project (IRR, NPV) compared to the reference values considered for the socio-economic evaluation. These tests aim to put recent developments in energy and material costs into perspective with the socio-economic profitability indicators of the project. Two tests are carried out here:

- The first consists of simulating an increase in investment costs of around +10% compared to the cost of the base scenario;
- The second consists of simulating an increase in investment costs of around +20% compared to the cost of the base scenario.

The results of these two tests are as follows:

Tableau 55. Summary results of sensitivity tests linked to the evolution of investment costs

	NPV (M€ 2016)	IRR
Test 1 – Increase of investment costs (+10%)	-7.0%	-0.46 pts
Test 2 – Increase of investment costs (+20%)	-13.9 %	-0.9 0 pt s

These two tests highlight the connection between investment costs and indicators of the socio-economic profitability of the project: the increase in investment costs mechanically generates a clear deterioration of profitability indicators in proportions which prove to be important. However, the measurement of the benefits of the project is not called into question, no correction has been made on the local economic benefits (employment, added value).

The systemic impacts on the economy should therefore prove more complex with a combination of these cost increases, and a downward modulation of growth hypotheses which will have to be evaluated in future scenarios.

5.3.5.5 Evolution of carbon value

This test aims to evaluate the consequences of a significant increase in the value of carbon on the key indicators of economic viability of the project (IRR, NPV) compared to the reference values considered for the socio-economic evaluation. This scenario echoes political discussions on the prioritization of public investments in relation to their carbon impact, and the national transcription of the European "Fit for 55" objectives. Two tests are performed here:

- The first consists of simulating an increase in the value of carbon of around +10% points per year over the project time horizon;
- The second consists of simulating an increase in the value of carbon of around +20% per year over the project time horizon.

The results of these two tests are as follows:

Tableau 56. Synthetic results of sensitivity tests linked to the evolution of the value of carbon

	NPV (M€ 2016)	IRR
Test 1 – Increase of carbon value (+10%)	+2.10 %	+0.07 pt
Test 2 – Increase of carbon value (+20%)	+4.20 %	+0.14 pt

These two tests illustrate the impact of a more or less marked increase in the value of carbon on the viability of the project. The increase in this value generates a net increase in the NPV because it degrades the performance of transport modes that emit high amounts of carbon (road, air, maritime) to the benefit of the rail mode which is more economical than the others in terms of this type of emissions. The magnitude of these results shows that the project would remain well placed in the investment hierarchy in the event of a revision of the carbon values applicable at European level.

[redacted]

[redacted]

5.3.5.6 Evolution of the value of time

This test aims to evaluate the consequences of a significant change in the value of time (passengers and goods) on the key indicators of economic viability of the project (IRR, NPV) compared to the reference values considered for the socio-economic evaluation. Two tests are performed here:

- The first consists of simulating a reduction in the value of time of around -10% per year over the time horizon of the project compared to the French benchmark.
- The second consists of using the Italian benchmark for the calculation of time values instead of the French benchmark, which is equivalent to a reduction in this value of the order of -30% per year over the time horizon of the project compared to the French standard.

The results of these two tests are as follows:

Tableau 57. Summary results of sensitivity tests linked to the evolution of the value of time

	NPV (M€ 2016)	IRR
Test 1 – Reduction in the value of time (-10%)	-5.9%	-0.18 pts
Test 2 – Reduction in the value of time (-30%)	-15.0%	-0.46 pt

The time savings relating to passenger transport made possible by the commissioning of the new infrastructure contribute significantly to socio-economic profitability. These two tests show, however, that this profitability remains proven with a modulation of the time values or a change of reference. Altering this parameter, however, degrades the valuation of time savings on the overall profitability of the project.

5.3.5.7 Alternative surplus calculation

An alternative method of surplus valuation consists in apply the "rule of the half" to all new rail users, including induced users and uses stemming from modal shift (instead of calculating the difference of generalized cost between road and rail for the modal shift). This method leads to the following results:

Tableau 58. Summary results of sensitivity tests linked to the surplus calculation method

	NPV (M€2016	IRR
Test – "Rule of the half" applied to modal shift	-82%	-3.0 pts

Beyond the theoretical debate on its relevance, the choice to value users' surplus via the "rule of the half" method for all new users (shifted and induced) has a significant advantage when the project is essentially characterized by endogenous productivity savings for a specific mode of transport whose basic cost is high (example: river transport from small to large gauge such as Seine Scheldt project). On the other hand, when the project is essentially characterized by savings on the differential generalized costs between modes stemming from modal shift, the "rule of the half" method applied to modal shift strongly and artificially degrades the estimate of the benefits of the project.

It should be noted that within the framework of the proposed hypotheses, this method keeps the Euralpine Lyon-Turin link project within a range of proven economic profitability (which limits the scope of theoretical debates on the subject).