

Studies for the Technical, Economic-Financial,
Environmental, Vulnerability & Social Feasibility
for the Construction, Equipment, Test &
Commissioning, Operation and Maintenance
under Works Concession with Public Service of
the Passenger Rapid Train in the Great
Metropolitan Area

Fourth Report: Economic and Financial Survey

Document 2: Cost-Benefit Analysis

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1 INTRODUCTION

This document is the second of the four documents that make up the fourth report of the Studies for the Technical, Economic-Financial, Environmental, Vulnerability & Social Feasibility for the Construction, Equipment, Test & Commissioning, Operation and Maintenance under Works Concession with Public Service of the Passenger Rapid Train in the Great Metropolitan Area.

This study consists of six reports:

- First Report: Work Plan.
- Second Report: Technical environmental, social, vulnerability assessment and gender studies.
- Third Report: Technical Feasibility Study.
- **Fourth Report: Economic and Financial Study.**
- Fifth Report: Financial Structuring and Document for the Bidding Process.
- Final Report.

Specifically, the objective of the economic-financial study is to bring together and analyze the elements necessary to evaluate and structure the proposal that would give the project the greatest economic-financial viability.

To this end, the Third Report: Technical Feasibility will be taken into account, as well as the fiscal contingencies for the analysis of the competent authorities.

Based on the cost estimates made, the overall impact of all the interventions that have been successful from the technical point of view is analyzed and the preliminary cost of the project will be assessed based on the technical feasibility made. This includes a unit price study and an element costing supported by the local experience of the consulting firm in the country.

For a correct understanding of the contents included in this report, it is distributed in six large sections according to the different typologies of economic-financial studies required by the project throughout the evaluation horizon.

These are:

- Cost-Benefit Analysis ("CBA")
- Risk analysis
- Value for money analysis
- Financial analysis at a conceptual level
- Technical and user fee analysis
- System integration analysis

In short, the Fourth Report: Economic and Financial Survey consists of four documents:

- Document 1: Economic and financial analysis.
- **Document 2: Cost-Benefit Analysis.**
- Document 3: Risk Analysis and Value for Money.
- Document 4: Technical Pricing and System Integration Analysis.

In the economic and financial analysis document, various alternative scenarios for remuneration and scope of the project have been put forward. Given this diversity of models, one of which must be selected for the bidding process, only one scenario has been evaluated for this analysis: the total development at the beginning of lines 1 to 5, both inclusive.

As the CBA does not affect the private operator's remuneration model, no distinction is made between revenue scenarios. As this scenario includes the maximum estimated investment and is in the middle range in terms of final cost to the Administration, it is considered a good indicator. Once the final bidding scenario has been selected, the specific analysis corresponding to it will be carried out.

1.1 Project description

The GAM Electric Train consists of the development of a two-way railway system connecting the cities of Cartago, San José, Heredia and Alajuela. To do so, the intention is to take advantage of the existing route to promote the east-west connection of the GAM and to make this transport system the reference mode of public transport in the area, promoting sustainable mobility.

The proposed system covers a length of over 84 km with 46 stations along the route and is made up of 5 lines delimited by the INCOFER right-of-way. Lines 1 (Paraíso-Atlántico), 2 (Atlántico-Alajuela) and 3 (Atlántico-Ciruelas) will operate independently, while lines 4 (Alajuela-Ciruelas) and 5 (Ciruelas-El Coyol) are proposed as extensions of lines 2 and 3 respectively. There will also be four depots and a workshop with its corresponding administrative buildings. The Paraíso depot, located on Line 1, will be able to accommodate up to 20 trains, the Pacífico depot, which serves Line 3, will have a capacity for 24 trains and the Ciruelas depot, corresponding to Line 4, will have space for 12 trains. The Las Cañas depot, which is located on Line 2, apart from being able to accommodate 24 trains, will be in charge of carrying out the most complex maintenance tasks of the entire system since it will be the only one with a workshop.

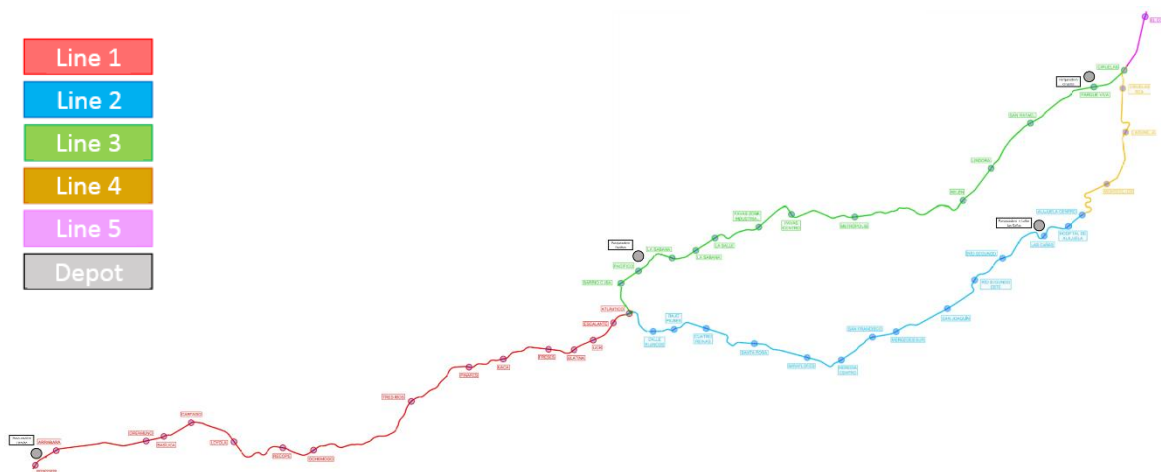


Figure 1. GAM Electric Train.

The stops that make up the GAM Electric Train can be seen in the following figure.



Figure 2. GAM Electric Train Stations.

In order to meet the demand, it is proposed to operate the 3 main lines (i.e. lines 1, 2 and 3) with frequencies of 5 minutes at peak time (15 minutes at off-peak time) and with frequencies of 10 minutes at peak time (30 minutes at off-peak time) for extensions on working days. On non-working days, weekends and public holidays, the frequencies are reduced to 10 minutes at peak time (20 minutes at off-peak time) and 20 minutes at peak time (40 minutes at off-peak time) for lines 1-2-3 and 4-5 respectively.

All of this is detailed in Chapter 21: Operation of the Third Report, with its corresponding technical justification.

	Start	Finish
Morning off-peak time	05:00	06:00
Morning rush hour	06:00	10:00
Midday off-peak time	10:00	15:30
Afternoon rush hour	15:30	19:30
Afternoon off-peak time	19:30	23:00

Table 1. Periods of variation in demand.

	Lines 1,2 and 3		Lines 4 and 5	
	Working	Nonworking	Working	Nonworking
Off-peak	15 minutes	20 minutes	30 minutes	40 minutes
Rush hour	5 minutes	10 minutes	10 minutes	20 minutes

Table 2. Operating frequencies in the lines as a function of time and day.

From the tariff point of view, each line will be charged independently with a base rate for the main lines and a reduced fare for extensions.

In order to meet the system's demand, with the frequencies explained, 78 trains are required (including maintenance and reserve trains) as detailed in Chapter 21: Operation and Maintenance of the Third Report, which will be 5-module electric traction light articulated trains in double composition. The capacity of this type of train ranges from 430 passengers (4 passengers/m²) to 600 passengers (6 passengers/m²) without exceeding a length of 70 m. However, given the length of the station platforms (80 m), if future demand so requires, the rolling stock could be adapted to the seven modules in order to increase its transport capacity.

In summary, the following table shows the main characteristics of each line.

	Layout	Length	Stations	Depots	Workshop
Line 1	Urban/Interurban	27,4 km	16	Paraíso/Pacífico	Las Cañas
Line 2	Urban/Interurban	21,6 km	15	Pacífico/Aeropuerto	Las Cañas
Line 3	Urban/Interurban	25,4 km	14	Pacífico/Ciruelas	Las Cañas
Line 4	Interurban	7,8 km	5	Ciruelas/Las Cañas	Las Cañas
Line 5	Interurban	2,7 km	2	Ciruelas	Las Cañas

Table 3. Main characteristics of the lines.

In addition, 14 of the stations mentioned are proposed as intermodal stations, where the transfer of passengers between the bus system and the Electric Train would take place.

The following is a summary of the main magnitudes and characteristics of the project in order to have a more appropriate idea of its dimension:

- Infrastructure: Track infrastructure, systems and rolling stock.
- Length of the route: 84.85 km.
- Number of stations: 46.
- Rolling stock required: 78 in the year of commissioning.
- Maximum speed: 25 km/h in urban areas, 50 km/h in semi-urban areas, and 70 km/h in interurban areas.
- Train frequency: 5 minutes during peak hours.
- Passenger transport capacity: 600 passengers per unit in a double train.

In short, the Electric Urban Train project consists of improving the current train that operates between San José de Costa Rica and the towns of Alajuela, Belén and Paraíso on three respective lines, along with the extension from Belén to Ciruelas and two new sections from Alajuela to Ciruelas and from Ciruelas to El Coyoil, respectively.

2 ECONOMIC ANALYSIS

2.1 Introduction

The economic analysis allows to evaluate the contribution of a project to the economic welfare of a specific geographical area (region, province, metropolitan area...). Cost-benefit analysis ("CBA") is carried out from the point of view of society as a whole and not only from that of the owners of the infrastructure (which would be the case with financial analysis).

In this respect, the CBA analyses whether the total economic benefits expected to be generated by the Project are greater than the costs expected to be generated.

2.2 Methodology

The methodology applied for the CBA carried out for the Project has been based on that contemplated in the following documents:

- Methodological Guide for the Identification, Formulation and Evaluation of Road Infrastructure Projects in Costa Rica, by MIDEPLAN. March 2012.
- Methodological Guide for the Identification, Formulation and Evaluation of Public Investment Projects in Costa Rica, by MIDEPLAN. February 2010.

In addition, the methodology applied has been verified as being consistent with the European Commission's "Guide to Cost-benefit Analysis of Investment Projects" of December 2014.

Thus, the working procedure of the Project CBA is carried out by comparing a "non-project" solution (or "Solution 0") with a "project" solution (or "Solution 1").

In order to carry out the CBA, firstly the geographical scope of the analysis must be determined so that the initial scenario can be established (Without Project), which represents the continuity of the current situation, and thus compare it with Solution 1 (With Project), which represents the one in which the development of the Project is carried out. In our case, the geographical scope is limited to the metropolitan area affected by the urban transport movements described: The Greater Metropolitan Area.

In both Solutions (Without Project and With Project) the traffic and demand that are not captured by the Project and that remain in the current mode of transport (bus and private vehicle) are established, as well as the traffic and demand transferred to the new mode of transport (the train) and, if applicable, the traffic and demand generated by the fact of having a new infrastructure. These demand prognoses are the ones that will allow to compare both Solutions and to estimate the socio-economic benefits of the Project.

Subsequently, the projected flows of economic benefits and costs will be generated from the Project's assumptions, making the calculations of net flows as shown below:

INCREMENTAL FLOWS (Without Project - With Project)	
	Time Saving
	Vehicle Operating Cost ("VOC") Savings
	Fare Savings
(B1)	Consumer Surplus
	Bus Operator
	Operator FF.CC.
	Other Operators
(B2)	Producer's Surplus
	Reduction of accidents
	Reduction of environmental pollution
	Noise pollution reduction
(B3)	Externalities
(B4)	Residual value of the works
(B)=(B1)+...+(B4) TOTAL INCREMENTAL BENEFITS (USD)	
(C1)	Initial investments
(C2)	Operating costs
(C3)	Maintenance Costs
(C4)	Other direct costs + Indirect costs
(C5)	Extraordinary conservation and replacements
(C)=(C1)+...+(C5) TOTAL COSTS (USD)	
R.N. = (B) - (C) NET RESULTS (USD)	

Figure 3. Scheme for generating incremental economic flows.

Among the hypotheses, those related to the different groups of socio-economic Benefits (Consumer's Surplus, Producer's Surplus and Externalities) as well as the Residual Value

of the Works will be considered, and the incremental benefits (= Situation With Project - Situation Without Project) will be calculated for each year of the analysis period.

On the other hand, the economic flows of the total incremental costs will be estimated, taking into account the investment costs, replacement costs and operation and maintenance costs of the With Project Situation with respect to the Without Project Situation, once the market prices of these have been converted to shadow prices by means of the so-called social conversion factors. The difference between the incremental profit and the incremental cost for each year will be the corresponding net flow.

Based on the projection of these net flows during the CBA analysis period, the following three results will be generated:

- Net present value of incremental economic flows: NPV-E
- Internal Rate of Return of incremental economic flows: IRR-E
- B/C ratio or ratio of accumulated profit NPV to accumulated cost NPV.

In addition, the following Cost/Effectiveness Indicators (USD) will be generated:

- Time Saving
- Vehicle Operation Cost Savings
- Accident Cost Savings
- Beneficial users

2.3 Identification of the project's scope of influence

Once the Project has been described in terms of its technical characteristics and its corresponding layout, the scope of influence of the infrastructure is analyzed together with the associated transport service. In this way, it is possible to observe which means of transport and which areas show the most direct competition on the demand of the Project:



Figure 4. Project's area of influence - Section 1.

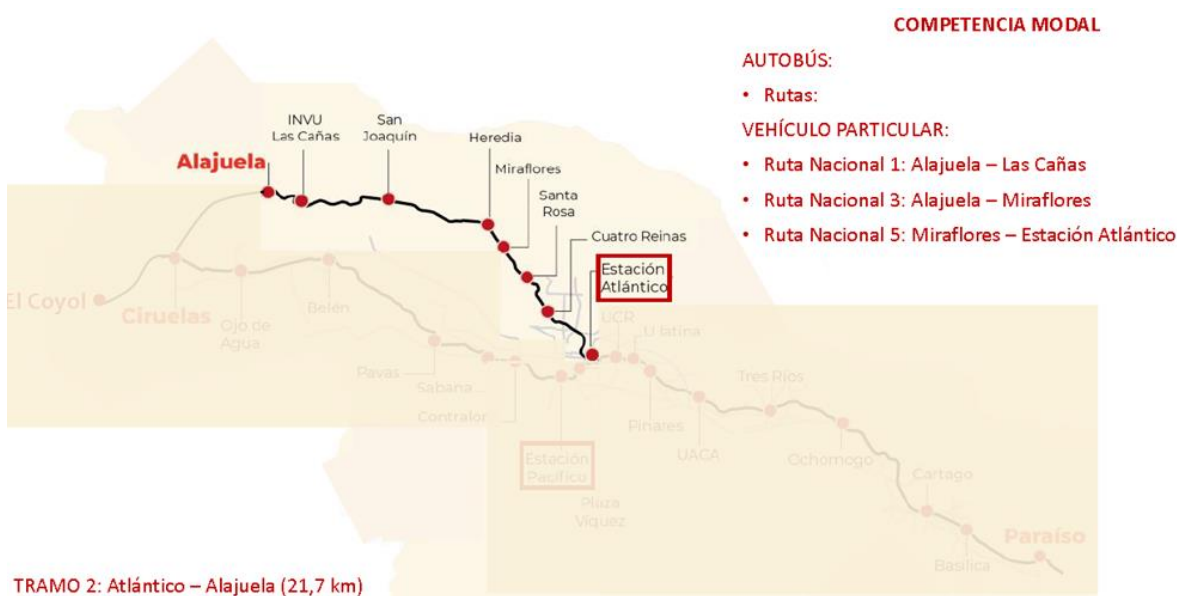


Figure 5. Project's area of influence - Section 2.



Figure 6. Project's area of influence - Section 3.

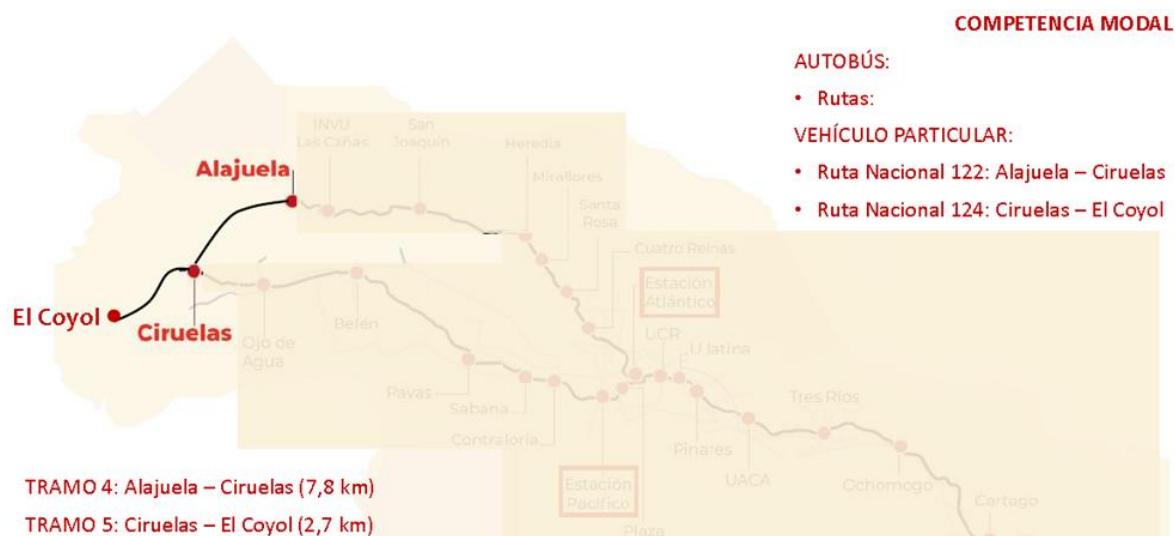


Figure 7. Project's zone of influence - Sections 4 and 5

As you can see, we must take into account the competition by areas, from the 4 sections described, because there are different bus routes that compete with one or another section, as well as the routes (mainly National Routes).

2.4 Hypothesis considered

2.4.1 General hypothesis

The general applicable hypotheses to the CBA are all those concerning macroeconomic and fiscal information and will serve as a basis for the calculations of other parameters to be used in the estimation of economic flows. This information is shown in the following table:

MACROECONOMIC ASSUMPTIONS	DATA	SOURCE
Inflation rate (previous year)	1,60%	Source: The World Factbook - CIA (2017)
Expected average inflation rate (for capitalization)	3,00%	Source:
Social discount rate	8,31%	Source: MIDEPLAN
EUR / USD exchange rate	1,11	Source: www.oanda.com (24-10-19)
Exchange rate CRC / EUR	633	Source: www.oanda.com (24-10-19)
CRC / USD exchange rate	570	Source: www.oanda.com (24-10-19)
Average annual growth rate GDP (real terms)	3,30%	Source: The World Factbook - CIA
Annual population growth rate	1,13%	Source: The World Factbook - CIA
Annual GDP growth rate p.c. (real terms)	2,92%	
GDP per capita 2017 (USD)	16.900	Source: The World Factbook - CIA
Value Added Tax (VAT)	13,00%	Source: Ministry of Finance of Costa Rica

Table 4. General applicable Hypothesis.

On the other hand, the information relating to the periods considered is included, as shown in the following table:

TIME ASSUMPTION	DATA	REMARKS
Year analysis started	2021	
Analysis period (years)	35	
Year construction began	2021	Halfway through the exercise
Construction period (years)	5,0	Includes testing period
Year of commencement of operation	2026	Halfway through the exercise
Operating period (years)	30,0	
Final year of the analysis	2056	

Table 5. Hypothesis on deadlines and timetables applicable to the Project.

2.4.2 Data relating to demand

Traffic and demand forecasts are one of the most relevant groups of data in the CBA, as they allow the calculation of the incremental benefits generated each year in the comparison of the No Project and With Project scenarios. This group of scenarios allows the calculation of the following types of demand projections:

- Situation Without Project: Demand of the different modes of public transport and private vehicle in the trend scenario in the area of influence of the Project.
- Situation with Project:
 - Uncaptured demand or Normal demand: is the demand that remains in the current modes of transport and does not make the modal shift to the train.
 - Captured Demand or Transferred Demand is the demand that, once the Project is put into operation, is transferred to the train, ceasing to use the previous respective modes of transport (bus and private vehicle). The sum of Demand captured, and Demand not captured is equal to the demand of the situation Without Project
 - Demand created or demand generated: this is the new demand or new users who, in the situation without a project, did not use the existing modes of transport but who, because the project is being put into operation, are generated as a new group of users who are taking advantage of the new benefits of the train.

For the purposes of the study, buses have been considered as a single group, without distinction between the different companies providing the service. In view of the above, the assumptions regarding demand and traffic obtained from the demand study have been considered applicable, as shown in the following tables:

DEMAND "WITHOUT PROJECT"	2026	2031	2036	2041	2046	2051	2056
Bus (trips / year)	261.922.124	273.218.294	283.703.381	298.195.759	304.109.381	307.673.502	306.566.030
Private vehicles (trips / year)	913.790.962	937.810.769	970.342.784	996.491.676	1.017.578.629	1.030.213.538	1.039.112.547
Current Train (trips / year)	3.959.441	4.894.160	5.218.533	5.157.078	4.836.904	5.015.730	4.878.920
Total	1.179.672.527	1.215.923.223	1.259.264.698	1.299.844.513	1.326.524.914	1.342.902.770	1.350.557.497

Table 6. Demand hypothesis (trips / year) - Situation WITHOUT Project.

DEMAND "WITH PROJECT" - Normal (Not captured)	2026	2031	2036	2041	2046	2051	2056
Bus (trips / year)	245.992.469	256.521.006	266.508.177	280.547.727	286.200.607	289.440.759	288.292.005
Private vehicles (trips / year)	885.495.610	908.454.826	939.774.230	965.068.637	985.055.549	997.044.733	1.005.646.946
Total	1.131.488.080	1.164.975.831	1.206.282.406	1.245.616.364	1.271.256.155	1.286.485.493	1.293.938.952
DEMAND "WITH PROJECT" - Transferred to the train	2026	2031	2036	2041	2046	2051	2056
Bus (trips / year)	15.929.654	16.697.288	17.195.204	17.648.032	17.908.774	18.232.742	18.274.025
Private vehicles (trips / year)	28.295.351	29.355.943	30.568.555	31.423.038	32.523.080	33.168.805	33.465.600
Current Train (trips / year)	3.959.441	4.894.160	5.218.533	5.157.078	4.836.904	5.015.730	4.878.920
Total	48.184.447	50.947.392	52.982.291	54.228.149	55.268.759	56.417.277	56.618.545
DEMAND "WITH PROJECT" - Generated	2026	2031	2036	2041	2046	2051	2056
Bus (trips / year)	0	0	0	0	0	0	0
Private vehicles (trips / year)	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0

Table 7. Demand Hypothesis (trips / year) - Situation WITH Project.

It should be mentioned that the train is currently transporting around 3.4 million passengers annually which, projected to the year 2026, is estimated at 3.9 million (as shown in the table above regarding the Demand Without Project. These passengers are included, in the tables of the With Project scenario, within the Demand Transferred to the new TRP.

As a result of such assumptions, the following figures show the graphs corresponding to the estimated evolution of the demand in the project:

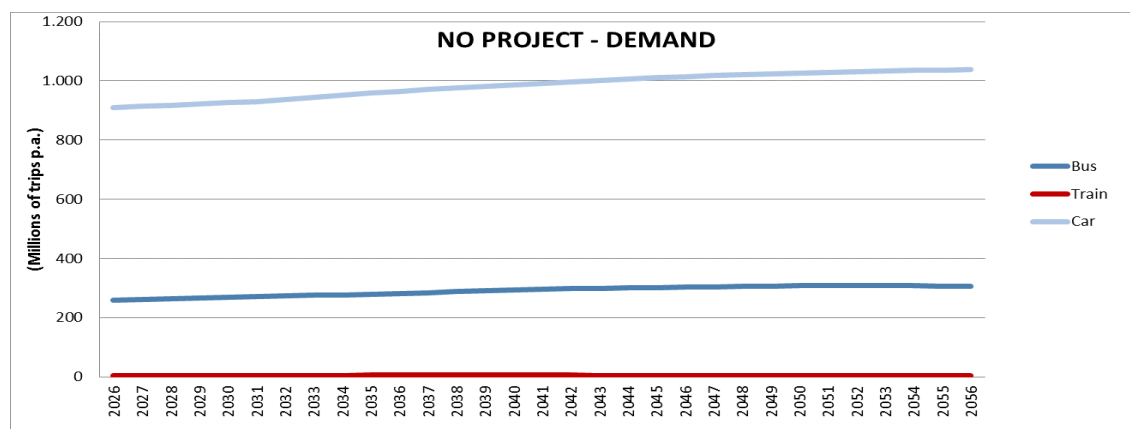


Figure 8. Scenario Without Project. Total Demand.

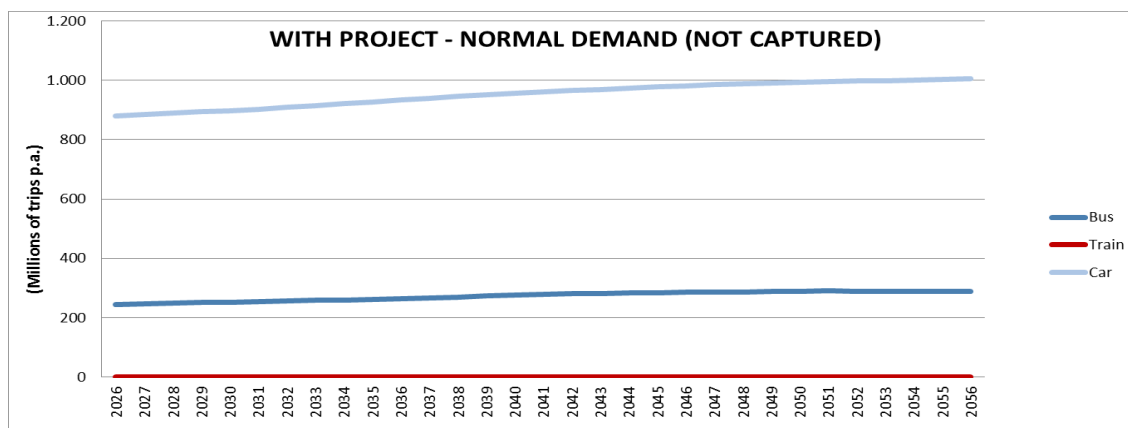


Figure 9. Scenario with Project. Uncaptured demand.

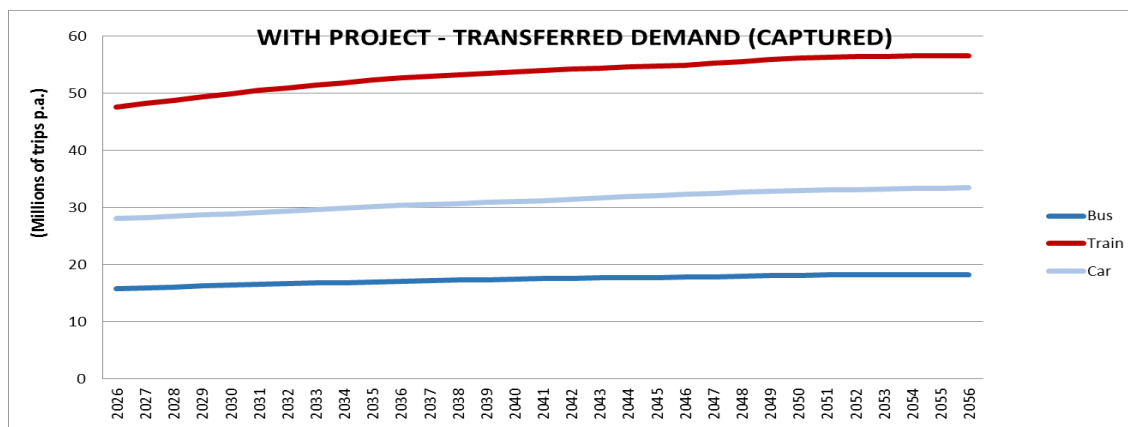


Figure 10. Scenario with Project. Captured demand.

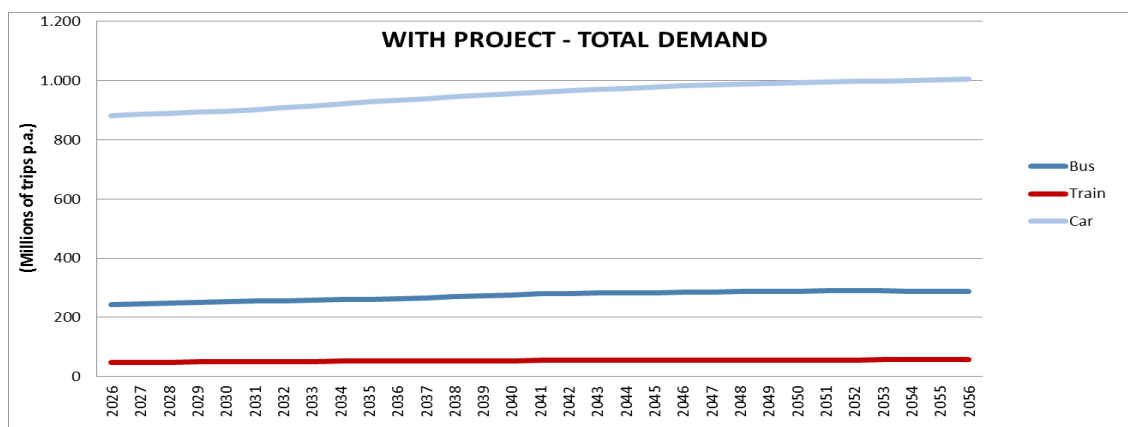


Figure 11. Scenario with Project. Total Demand.

On the other hand, it is necessary to take into account the assumptions regarding lengths, average speeds and journey times by modes of transport, as shown in the following tables, generated from the information of the demand study:

DATA Train (NO PROJECT)	Length (km)	Speed (km/h)	Duration (hour.)
Section 1	27,30	22,50	1,21
Section 2	21,70	22,50	0,96
Section 3	25,30	22,50	1,12
Sections 4 & 5	10,50	22,50	0,47
Sections 1 - 5	84,80	22,50	3,77
Average Sections	21,20	22,50	0,94

DATA Train (WITH PROJECT)	Length (km)	Speed (km/h)	Duration (hour.)
Section 1	27,30	30,00	0,91
Section 2	21,70	30,00	0,72
Section 3	25,30	30,00	0,84
Sections 4 & 5	10,50	30,00	0,35
Sections 1 - 5	84,80	30,00	2,83
Average Sections	21,20	30,00	0,71

Table 8. Hypotheses of lengths and average speeds relative to the train (Without and With Project).

DATA Bus (NO PROJECT)	Length (km)	Speed (km/h)	Duration (hour.)
Section 1	30,00	13,70	2,19
Section 2	21,50	12,40	1,73
Section 3	29,30	8,50	3,45
Sections 4 & 5	10,10	5,70	1,77
Sections 1 - 5	90,90	10,83	8,40
Average Sections	22,73	10,83	2,10

DATA Bus (WITH PROJECT)	Length (km)	Speed (km/h)	Duration (hour.)
Section 1	30,00	14,20	2,11
Section 2	21,50	12,90	1,67
Section 3	29,30	9,00	3,26
Sections 4 & 5	10,10	6,20	1,63
Sections 1 - 5	90,90	11,33	8,02
Average Sections	22,73	11,33	2,01

Table 9. Hypothesis of lengths and average speeds relative to the bus (Without and With Project).

DATA PRIVATE VEHICLE (NO PROJECT)	Length (km)	Speed (km/h)	Duration (hour.)
Section 1	29,80	23,00	1,30
Section 2	20,70	21,50	0,96
Section 3	26,10	27,00	0,97
Sections 4 & 5	10,20	18,00	0,57
Sections 1 - 5	86,80	23,26	3,73
Average Sections	21,70	23,26	0,93

DATA PRIVATE VEHICLE (WITH PROJECT)	Length (km)	Speed (km/h)	Duration (hour.)
Section 1	29,80	24,50	1,22
Section 2	20,70	23,00	0,90
Section 3	26,10	28,50	0,92
Sections 4 & 5	10,20	19,50	0,52
Sections 1 - 5	86,80	24,76	3,51
Average Sections	21,70	24,76	0,88

Table 10. Hypotheses of lengths and average speeds relative to the private vehicle (Without and With Project).

Finally, the hypotheses considered regarding the average number of users per mode of transport, WITHOUT and WITH project, are shown:

AVERAGE NUMBER OF USERS PER MODE	Without Project	With Project
Average number of passengers - Bus	30	25
Average number of passengers - Private vehicle	1,40	1,40
Average number of passengers - Train	275	465

Table 11. Average user assumptions by mode of transport.

2.4.3 Investments

The assumptions relating to investments and initial costs are classified in the following tables under the With Project situation, since they are considered to be the incremental investments to be made with respect to the Without Project situation; in both cases, the amounts are shown at market values and in economic values, once the corresponding social correction factors have been applied.

The execution schedule for the years 2021-2026, both inclusive, shows the following evolution:

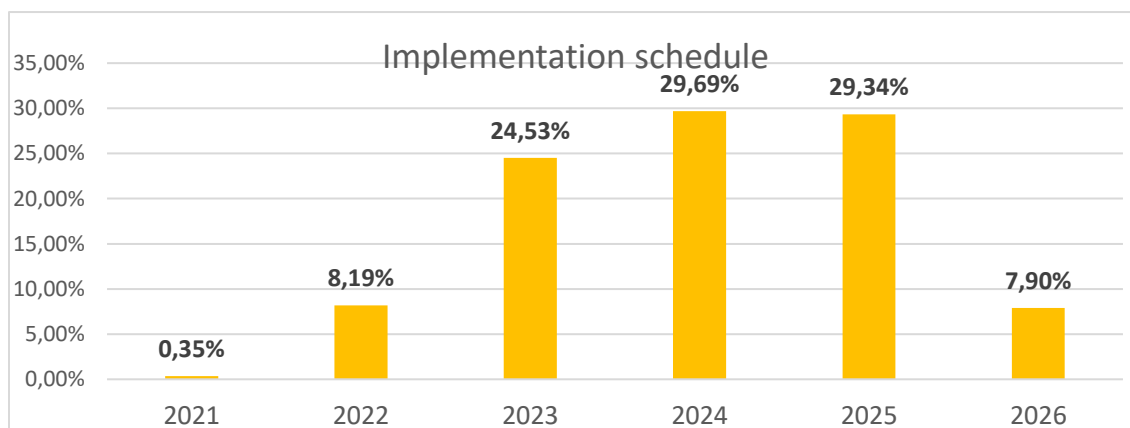


Figure 12. Implementation schedule.

The tables below show the detailed amounts of the different investment concepts, both in market prices and in shadow prices once the social correction factors have been applied:

CAPEX WITH PROJECT (USD, Market prices)	TOTAL	2021	2022	2023	2024	2025	2026
Infrastructure (Preliminary Work + Structure + Drainage + Serv	146.534.973	0	12.035.051	54.930.992	55.560.628	23.745.006	263.296
Platform and superstructure	178.260.169	0	0	35.092.951	73.909.754	69.257.463	0
Stations, depots, workshops and admin buildings	103.889.347	0	5.839.474	31.029.139	37.391.077	26.937.700	2.691.955
Installations (Electrification + Systems)	197.908.309	0	0	19.125.375	75.307.163	99.212.074	4.263.698
Urban Integration + Historical Heritage Rehabilitation	37.258.000	0	0	0	13.872.800	19.357.018	4.028.182
Rolling stock	452.400.000	0	51.040.000	116.000.000	51.040.000	122.960.000	111.360.000
Design and implementation + Seg.y Sal. + C.Quality + G.Res.	98.334.386	3.937.182	15.515.640	24.006.939	26.041.835	22.160.057	6.672.733
Land	66.131.959	0	25.461.946	32.479.260	0	8.190.753	0
Other costs	91.548.514	0	2.821.751	20.070.132	34.126.354	31.604.478	2.925.799
Total	1.372.265.657	3.937.182	112.713.862	332.734.788	367.249.611	423.424.550	132.205.663

Table 12. Execution budget at market prices - Situation with project.

CAPEX WITH PROJECT (USD, Shadow prices)	TOTAL	2021	2022	2023	2024	2025	2026
Infrastructure (Preliminary Work + Structure + Drainage + Serv	132.300.848	0	10.865.990	49.595.101	50.163.575	21.438.462	237.720
Platform and superstructure	160.944.318	0	0	31.684.090	66.730.303	62.529.926	0
Stations, depots, workshops and admin buildings	103.889.347	0	5.839.474	31.029.139	37.391.077	26.937.700	2.691.955
Installations (Electrification + Systems)	179.008.065	0	0	17.298.901	68.115.329	89.737.321	3.856.515
Urban Integration + Historical Heritage Rehabilitation	37.258.000	0	0	0	13.872.800	19.357.018	4.028.182
Rolling stock	358.484.687	0	40.444.426	91.919.150	40.444.426	97.434.300	88.242.384
Design and implementation + Seg.y Sal. + C.Quality + G.Res.	98.334.386	3.937.182	15.515.640	24.006.939	26.041.835	22.160.057	6.672.733
Land	66.131.959	0	25.461.946	32.479.260	0	8.190.753	0
Other costs	82.655.667	0	2.547.651	18.120.558	30.811.386	28.534.480	2.641.593
Total	1.219.007.277	3.937.182	100.675.127	296.133.138	333.570.731	376.320.016	108.371.082

Table 13. Implementation budget in economic terms - Situation with project.

On the other hand, it is necessary to take into account in this section the asset replacement and extraordinary maintenance investments, which are calculated on the basis of the useful life of the different investment items with respect to the investment items, as shown in the following table:

	Useful life (years)
Structures	80
Ballast track	35
Slab track	50
Track devices	40
Stations	15
Depots, workshops and administrative buildings	20
Drainage	25
Catenary	15
Others	60
Signaling system	15
Systems and communication	15
Rolling stock	35

Table 14. Lifetime of the different investment phases.

As a result of the annual calculations generated, it is shown in the following figure, taking into account the aforementioned life cycles of the different types of assets. As with any cost items, these replacement and extraordinary maintenance amounts are converted into economic values by applying the social correction factors described in this report. As a result of this process, the cost curve shown in the following figure is generated:

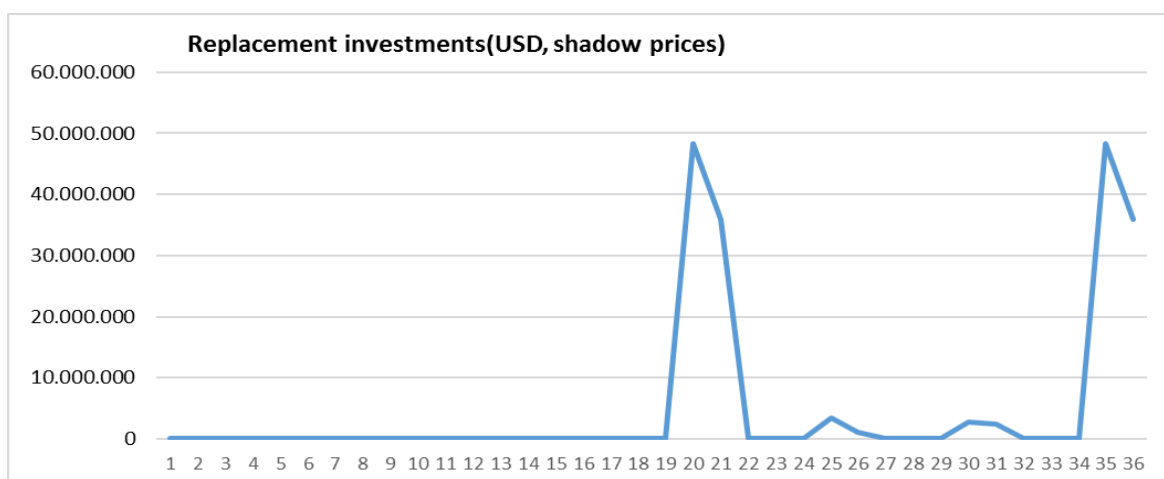


Figure 13. Evolution of replacement and extraordinary maintenance costs (USD, economic values).

Since it is considered that the costs for this concept in the "No Project" situation are zero, these amounts cited in economic values are those considered as differential costs to be taken into account in the economic analysis.

2.4.4 Operating costs

The final chapter on project costs is the operating costs, which include both operating and routine maintenance costs and operating expenses. These costs are presented below in two tables, one at market prices and the other at shadow prices once the social correction factors described in this report have been applied, together with the graph showing their distribution:

DIFFERENTIAL COSTS: Without Pr. - With Pr.	USD / year	
OPEX Spread - Market Prices	44.007.418	
Overheads	1.666.725	3,8%
Staff and Operating Expenses	9.441.886	21,5%
Energy	11.377.773	25,9%
Conservation and maintenance	15.838.950	36,0%
Other Direct Expenses + Indirect Expenses	5.682.084	12,9%

Table 15. Average annual operating costs. Market Prices - Project Situation.

DIFFERENTIAL COSTS: Without Pr. - With Pr.	USD / year	
OPEX Differential - Shadow prices	41.740.154	
Overheads	1.595.472	3,8%
Staff and Operating Expenses	10.008.399	24,0%
Energy	10.729.240	25,7%
Conservation and maintenance	14.069.293	33,7%
Other Direct Expenses + Indirect Expenses	5.337.750	12,8%

Table 16. Average annual operating costs. Shadow Prices - Project Location.

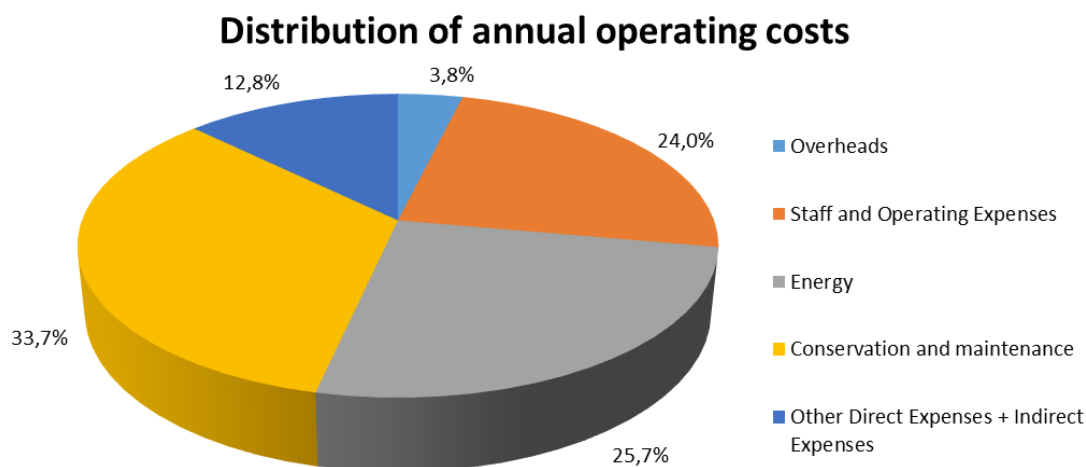


Figure 14. Average annual operating costs. Shadow Prices - Project Location.

As shown in the figure above, the five concepts in this chapter have a different weight, with the heading Conservation and Maintenance standing out, followed by Energy, and Personnel and Operations. As in the case of Investments, these costs are considered to be incremental with respect to the No Project situation.

2.4.5 Economic benefits

The economic benefits are set out in the three groups of beneficiaries: consumers, producers and society as a whole.

Consumer Surplus

The consumer's surplus is calculated from the so-called Generalized Travel Costs ("GTC"). The GTC include the set of factors by which the private consumer may benefit in the With Project situation as compared to the Without Project situation. These factors are as follows:

- Time Savings ("TS") → are a positive benefit if such savings occur.
- Fees to be paid ("FP") → represent a negative benefit if the fees to be paid in the With Project situation are higher than Without Project. The fees are included because they are part of the GTC and of the willingness to pay of potential users.
- Cost of Vehicle Operation ("CVO") → represent a positive benefit if these costs are lower in the With Project situation than Without Project situation.

In summary, $GTC = (+/-) TS (-/+) FP (+/-) VCO$. These GTCs are unitary, that is, they are generally calculated as monetary units (CRC, USD...) per kilometer. Therefore, if the GTCs in the With Project situation are lower than the GTCs in the Without Project situation, the project makes sense for private users, as it will be beneficial to them.

The time savings are calculated from the distances travelled in the various modes of transport and their corresponding average travel speeds. With this information, the time spent by the user in each mode of transport is calculated and compared with and without the project. From this comparison, the total number of hours saved in each period is obtained and multiplied by the estimated value of time (in monetary units per hour), thus generating the amount (in monetary value) of potential annual time savings.

The assumptions considered for the calculation of time savings are shown in the table below:

Time value assumptions (1)	DATA
Medium salary in Costa Rica in CRC (2019)	469.728
Average working hours per month	208,0
Travel arrangements: work	70%
Travel arrangements: leisure	30%

Table 17. Assumptions considered in time savings.

The average salary in Costa Rica 2019 has been considered as the base according to INEC¹. For conservative purposes, the general average has been considered. It could be considered that the train users will be predominantly urban, in which case it would be appropriate to take the average urban wage, which is higher.

The process of analysis and estimation of the value of time is set out below, first showing the table applied in this process:

TIME VALUE	DATA	EUR	USD	CRC
Average salary in Costa Rica (2019)		742	824	469.728
Weighted average salary		832	923	526.095
Business trip	70%	1.039	1.154	657.619
Leisure trip	30%	346	385	219.206
Time value (per hour) - Weighted average (2020)		4,00	4,57	2.529

Table 18. Time value estimation process.

¹ Costa Rica: Average monthly income in the main job according to job characteristics. 2 quarter 2019. INEC

The estimation of the value of the time is exposed in the following process:

- First, the average monthly salary in Costa Rica is calculated from the above-mentioned INEC data. As indicated above, this is considered a conservative approach, taking the national average and not the urban average.
- The weighted average wage is then calculated, taking into account the percentages for work travel (70%)² and leisure travel (30%).
- These weightings are applied to the weighted average working and leisure wage amounts. In both cases, the European Commission's CBA Methodology of December 2014 is applied, which considers that working time usually represents around 40% of the average wage, while the value of the work trip is estimated at 3 times the leisure trip.
- Finally, dividing said weighted average salary by the number of monthly hours, 208, the average value of the hour of time is obtained.

The hypotheses considered of unit fares in the train and in the bus, for the different sections, are shown in the following table. The bus fares have been estimated from the ARESEV spreadsheet called "Tarifas_Pliego_Autobus_2019-11-07.xlsx", making journeys equivalent to those of each section. It should be noted that the unit fares of the train are a weighted average of the fares at off-peak and peak times, and the fares for single journeys and combined journeys:

Tariff Unit	Train (USD/trip)	Bus (USD/trip)
Section 1	1,25	1,74
Section 2	1,25	2,41
Section 3	1,25	0,90
Sections 4 & 5	1,25	0,75
Sections 1 - 5	5,01	5,80
Average Sections	1,25	1,52

Table 19. Hypothesis of unit rates for train and bus.

The hypotheses considered of unitary toll in the road alternatives to the different sections are shown in the following table:

² As stated in Juan Sauma's Externalities report, "According to the Transport Supply and Demand Study in the GAM of the PRUGAM Project, 70% of passenger trips are for work purposes".

UNIFORM TARIFF	Toll (USD/trip)
Section 1	0,13
Section 2	0,13
Section 3	0,13
Sections 4 & 5	0,00
Sections 1 - 5	0,39
Average Sections	0,12

Table 20. Hypothesis of unit toll rates on the roads corresponding to the sections.

As a third and final component of the GTC, there are the VOCs of individuals, which include the costs shown in the table below, as an average of the different types of light vehicles. The table includes the items foreseen in MIDEPLAN's guide, including in the Annual Maintenance Cost those related to the hourly cost, the lubricant and the spare parts:

VEHICLE OPERATING COSTS (COV) -V. Lightweight	Vehicle Lightweight (USD)	V.O.C (USD)	USD / 100 km
Annual maintenance cost (includes spare parts and lubricant)	500	Maintenance	3,33
Annual tyre consumption	240	Tires	1,60
Vehicle depreciation	3.125	Depreciation	2,08
Annual fuel consumption	633	Fuel	4,22
Average annual use (km per year)	15.000	Total	11,24

Table 21. Assumptions on the Operating Costs of Private Vehicles (VOC)

The values in the table above are the social prices of the different components estimated for the annual consumption of each one and taking into account the following criteria

- Tires: it has been considered a cost of 180 USD per tire, being 4 tires and with a life around 45,000 km, which means replacing them every 3 years.
- Vehicle cost: an average cost of 25,000 USD and an average life of 8 years has been considered
- Fuel: an average use of 15,000 km per year has been considered with a social price of the litre of fuel of 0.603 USD/litre as a weighted average of the different types of fuel (Diesel 50, 48.8%, Gasoline Plus 91, 25.1%, and Super Gasoline, 26.1%)³ once

³ Source: <https://www.recope.go.cr/productos/precios-nacionales/estructura-de-precios/>

taxes have been eliminated. An average of 7 litres/100 km is considered for the analysis period, in line with the general consumption assumptions used.

As shown in the table, the unit VOCs per 100 km travelled are 11.24 USD. This cost is applied to the distance travelled on the alternative roads to the different sections, comparing the situation Without Project. The different distances and average travel speeds are shown in the following tables, which reflect the improvement in average speed on the different sections comparing the situation With Project with the situation Without Project:

DATA PRIVATE VEHICLE (NO PROJECT)	Length (km)	Speed (km/h)
Section 1	29,80	23,00
Section 2	20,70	21,50
Section 3	26,10	27,00
Sections 4 & 5	10,20	18,00
Sections 1 - 5	86,80	23,26
Average Sections	21,70	23,26

DATA PRIVATE VEHICLE (WITH PROJECT)	Length (km)	Speed (km/h)
Section 1	29,80	24,50
Section 2	20,70	23,00
Section 3	26,10	28,50
Sections 4 & 5	10,20	19,50
Sections 1 - 5	86,80	24,76
Average Sections	21,70	24,76

Table 22. Hypothesis of lengths and average speeds of private vehicles

With regard to the above table, it is necessary to highlight the difficulty of having precise data on the distances to be covered by the train's passengers from their point of origin of the journey to the point of departure of the corresponding section plus the distances from the station of arrival to the point of destination. However, this possible additional distance could be partially compensated by the distance that in the case of private vehicles could be between the place of origin/destination and the parking place. For all these reasons, it was considered reasonable that the distances to be compared should be those of the journeys of the different train lines as opposed to the distance to be travelled in a private vehicle to link the same points of origin and destination. For their part, the average speeds of the train and the private vehicle have been obtained from the demand study and the technical reports carried out.

Producer's Surplus

The Producer's surplus is estimated on the basis of the operating margins of the various operators involved in the Project, comparing their situation Without Project with their situation With Project.

To estimate the train's operating margin, data from the financial study of the TRP project have been taken, dividing the estimated average operating income and expenses, respectively, by the vehicle-km travelled. For the bus ratios and given the diversity of companies operating the different lines, references from similar bus operators such as Bogotá have been used. The following table shows the data considered in the analysis:

PRODUCER'S SURPLUS	Train	Bus
Operating income (USD / Vehicle-km)	9,100	1,314
Operating costs (USD / Vehicle-km)	6,092	0,932
Operating margin (%)	49,4%	40,9%

Table 23. Assumptions on operators' operating margins.

In this case, the unit operating margins shown are applied on the estimated demand, measured in vehicle-km/year, and considering the weighted average tariffs, generating the surpluses of each of the operators.

For this purpose, no variation in such margins is considered by comparing the situation Without Project and With Project, so the variation in the corresponding operator's surpluses in the analysis carried out depends on the variation in demand in both scenarios. In those operators where demand increases and they have a positive operating margin, their surplus will increase; on the contrary, in those where demand is reduced, as is the case of buses, or where there is a negative operating margin, as is the case of trains, their surplus will be reduced.

To this end, criteria of prudence have been considered in the case of the Bus Operators, for which no account has been taken of potential improvements in their operations that would result from the reorganization of lines and optimization of their supply, which would translate into improvements in operating margins. Neither have they taken into account, for the same reasons, potential improvements in train operations - and operating margins - resulting from fare integration and the reorganization of bus routes.

Externalities

Externalities have been classified into three groups:

- Reduction of the accident rate

Various parameters are used to convert the potential reduction in accident rates due to the modal shift into economic benefits. Thus, firstly, the accident rates by type of vehicle are taken into account, differentiating between accidents due to material damage, injuries and deaths. Such ratios, obtained from references of similar projects (Guatemala, Bogotá) are shown in the following table:

ACCIDENT RATE	Veh. Private	Bus	Train
Accident rate per 100 million vehicles-km	23,98	37,78	20,00
Injury rate per 100 million vehicles-km	6,70	6,38	4,00
Death rate per 100 million vehicles-km	0,57	0,41	0,15

Table 24. Hypothesis of accident rates by vehicle type.

Once these ratios have been applied to the projected traffic, the economic ratios of estimated values for each type of accident are applied, as explained below. These values have been obtained from the average ratios of the European Commission's CBA Guide of December 2014, updated with the annual growth rate of GDP per capita in real terms until 2025:

ACCIDENTS - AVERAGE COST (2019)	USD	CRC
Cost per accident (monetary units / accident)	23.751	13.537.920
Cost per injured person (monetary units / injured)	114.355	65.182.578
Cost per deceased (monetary units / deceased)	703.726	401.123.555

Table 25. Hypothesis of accident costs by type of accident.

Apart from the hypotheses shown, and in order to compare the results generated with them, average accident cost ratios per km travelled by the different modes of transport have been taken into account, as shown in the table below. These ratios have been calculated using data from SNC Lavalin and the European Commission's methodology on external transport costs for 2014, and adapted to Costa Rica's GDP per capital in comparison with the average GDP of the European Union:

AVERAGE ACCIDENT COST BY MODE	Veh. Propio	Bus	Train
Unit cost (USD per 1,000 pax / km)	1,50	0,20	1,00

Table 26. Hypothesis of accident costs per km travelled.

As a result of the above, an annual amount of accident cost is obtained in both scenarios (Without Project and With Project) and its difference will result in a positive or negative benefit depending on the variations in demand due to the modal shift towards lower accident modes of transport, such as the train.

- Reduction of environmental and noise pollution

In this case, various parameters are also used to convert the potential reduction in environmental pollution into economic benefits, both in terms of noise pollution (noise) and environmental pollution (pollution and greenhouse gases). Thus, a series of ratios per passenger/km are taken into account according to the mode of transport, as shown in the table below. These international ratios have been calculated using data from SNC Lavalin and the European Commission's methodology on external costs of transport for 2014:

EXTERNALITIES (NOISE AND POLLUTANTS)	Private Vehicle	Bus	Train
Noise - Unit cost (USD per 1,000 pax / km)	1,30	0,70	0,30
Pollution - Unit cost (USD per 1,000 pax / km)	22,70	16,30	6,10
G.E.I. - Unit cost (USD per 1,000 pax / km)	24,10	6,80	5,10

Table 27. Hypothesis of cost ratios of environmental and noise pollution.

In addition to the above-mentioned ratios, the following specific environmental pollution assumptions have been taken into account⁴:

COST OF ENVIRONMENTAL POLLUTION	USD	CRC
Cost of Carbon (USD / Ton. CO ₂)	27,00	15.390
Cost of NO _x (USD / Ton. NO _x)	248,92	141.882
Cost of Particles (USD / Ton. PM ₁₀)	1.213	691.410

Table 28. Cost hypotheses of environmental pollution components.

EMISSIONS AND FUEL CONSUMPTION (PER KM)	Private Vehicles	Bus
Emissions 1 (grams CO ₂ / km) Gasoline	178,5	
Emissions 1 (grams CO ₂ / km) Diesel	162,5	887,4
Emissions 1 (grams CO ₂ / km) Weighted average	170,7	887,4
Emissions 2 (grams NO _x / km) Gasoline	0,15	
Emissions 2 (grams NO _x / km) Diesel	0,50	0,78
Emissions 2 (grams NO _x / km) Weighted average	0,321	0,780
Emissions 3 (grams PM ₁₀ / km) Gasoline	0,000	
Emissions 3 (grams PM ₁₀ / km) Diesel	0,050	0,100
Emissions 3 (grams PM ₁₀ / km) Weighted average	0,024	0,100
Fuel consumption (litres / 100 km)	7,0	34,0

Table 29. Environmental pollution emission scenarios.

As a result of the above, an annual amount of the cost of environmental pollution and noise pollution is obtained in both scenarios (Without Project and With Project) and its difference will result in a positive or negative benefit depending on the variations of the demand for the modal shift towards modes of transport with lower emissions, as is the case of the train.

⁴ Sources: C&M; Duarte, Güterman & Cía. Table 17-2

For FP10: "Evaluation of Externalities by Fixed Sources in Costa Rica"; CubaEnergy 2004

For the table of Emissions and Consumption, average foreseen according to Euro-4 policy; it has been considered that Costa Rica currently complies in general with Euro-2, and as an average standard during the life of the Euro-4 project

2.4.6 Social correction factors

Social correction factors allow market prices to be converted into economic prices or shadow prices, in order to apply them to CBA costs.

For this purpose, the social correction factors obtained from the MIDEPLAN methodology and the table of tradable and non-tradable goods have been considered. The following table shows the social correction factors considered, grouped by chapters based on the values obtained from the corresponding codes in the table of tradable and non-tradable goods:

CONVERSION FACTORS	DATA	REMARKS
Investments		
Expropriations and Right of Way	1,000	
Civil works	1,000	NP124: Construction of public service projects and other civil engineering works
Building	1,000	NP122: Non-residential buildings
Facilities	0,905	Average NP101 (Motors, electric transformers...) and NP106 (General purpose machinery)
Equipment	0,905	Average NP101 (Motors, electric transformers...) and NP106 (General purpose machinery)
Rolling stock	0,792	NP117: Motor vehicles, bodywork, trailers and semi-trailers
Engineering and supervision	1,000	NP158: Architectural, engineering, and related services
Other initial costs	0,939	Standard Conversion Factor
Residual Value	0,800	Life expectancy at the end of the contract. Factor applied to the value of the investments
Operation and Maintenance		
Operating expenses (labor)	0,957	Weighted average of high, medium and low skilled labour
Operating expenses (General)	1,060	NP170: Administrative and office support services and other business support activities
Ordinary conservation	0,888	Average NP125 (Specialized Construction Services) and NP127 (Vehicle Maintenance)
Energy	0,943	Electric power, gas, steam and air conditioning
Other Direct Costs + Indirect Costs	0,939	Standard Conversion Factor
Extraordinary preservation and replacement	0,888	Average NP125 (Specialized Construction Services) and NP127 (Vehicle Maintenance)

Table 30. Social correction factors.

These correction factors have been applied to the various investment cost and operating expense items in order to generate the CAPEX and OPEX amounts at shadow prices.

2.5 Economic analysis of the project

2.5.1 Projected economic flows

As a result of the assumptions and data considered in the economic analysis above, the projected economic flows during the period of analysis are generated.

These economic flows take into account the following aspects:

- Both benefits and costs are estimated in economic values or shadow prices, resulting from applying conversion factors to the corresponding market prices.
- The flows of each year are estimated in constant monetary units; that is, without considering inflation.
- Each year the net economic flow is calculated as a result of aggregating the amounts of benefits and costs for that year.
- The estimated annual amounts for each item are generated from the difference between the amount in the With Project situation and the amount in the Without Project situation.

The following pages show the tables of the projected economic flows for the entire analysis period. The flows corresponding to the highest CAPEX scenario of those analyzed in the financial document, associated with a greater number of unleveled crossings, are shown as a basis. This scenario is considered as the basis for analysis

INCREMENTAL FLOWS (Without Project - With Project)	Discounted USD	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Time Saving	3.354.097.932	0	0	0	0	0	206.715.827	421.731.843	430.056.125	438.406.345	446.784.445	452.273.734	458.475.365
Vehicle Operating Cost ("VOC") Savings	519.879.782	0	0	0	0	0	34.236.499	69.000.299	69.505.116	69.988.439	70.451.225	70.894.389	71.586.630
Fare Savings	-4.103.321	0	0	0	0	0	-399.639	-687.177	-578.975	-474.583	-373.903	-276.835	-319.030
Consumer Surplus	3.869.874.394	0	0	0	0	0	240.552.688	490.044.965	498.982.266	507.920.201	516.861.767	522.891.288	529.742.965
Bus Operator	-119.302.797	0	0	0	0	0	-7.835.406	-15.852.465	-16.027.190	-16.195.217	-16.356.775	-16.512.092	-16.616.379
Operator FF.CC.	145.666.222	0	0	0	0	0	5.382.462	21.207.429	21.155.007	21.104.715	21.056.467	21.010.181	20.990.654
Other Operators	0	0	0	0	0	0	0	0	0	0	0	0	0
Producer's Surplus	26.363.425	0	0	0	0	0	-2.452.944	5.354.964	5.127.816	4.909.498	4.699.693	4.498.089	4.374.275
Reduction of accidents	53.494.691	0	0	0	0	0	3.525.639	7.104.882	7.156.198	7.205.329	7.252.370	7.297.415	7.370.051
Reduction of environmental pollution	311.773.915	0	0	0	0	0	20.582.751	41.469.448	41.760.411	42.038.963	42.305.659	42.561.030	43.000.431
Noise pollution reduction	6.039.375	0	0	0	0	0	763.874	770.342	776.541	782.484	788.181	793.642	800.845
Externalities	371.307.981	0	0	0	0	0	24.872.264	49.344.671	49.693.150	50.026.776	50.346.210	50.652.087	51.171.326
Residual value of the works	70.220.288	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL INCREMENTAL BENEFITS (USD)	4.337.766.088	0	0	0	0	0	262.972.007	544.744.600	553.803.233	562.856.475	571.907.670	578.041.465	585.288.566
Initial investments	-1.013.013.260	-4.924.141	-114.046.985	-341.497.206	-413.302.497	-408.501.866	-109.921.863	0	0	0	0	0	0
Operating costs	-160.800.337	0	0	0	0	0	-11.349.606	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213
Maintenance Costs	-101.300.197	0	0	0	0	0	-7.149.969	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937
Other direct costs + Indirect costs	-38.432.289	0	0	0	0	0	-2.712.627	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254
Extraordinary conservation and replacements	-22.332.623	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL COSTS (USD)	-1.335.878.706	-4.924.141	-114.046.985	-341.497.206	-413.302.497	-408.501.866	-131.134.065	-42.424.404	-42.424.404	-42.424.404	-42.424.404	-42.424.404	-42.424.404
NET RESULTS (USD)	3.001.887.382	-4.924.141	-114.046.985	-341.497.206	-413.302.497	-408.501.866	131.837.942	502.320.196	511.378.829	520.432.071	529.483.266	535.617.061	542.864.163

Table 31. Projected economic flows (1/3)

INCREMENTAL FLOWS (Without Project - With Project)	Discounted USD	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Time Saving	3.354.097.932	464.601.896	470.655.299	476.777.789	482.824.382	490.042.842	497.143.385	504.125.671	510.988.215	514.410.521	516.836.506	519.127.462	521.284.698
Vehicle Operating Cost ("VOC") Savings	519.879.782	72.251.070	72.888.476	73.528.866	74.142.019	74.543.672	74.927.166	75.292.735	75.640.503	75.970.606	76.627.394	77.247.642	77.831.703
Fare Savings	-4.103.321	-359.853	-399.305	-439.222	-477.700	-465.385	-453.697	-442.616	-432.129	-422.223	-566.995	-703.718	-832.468
Consumer Surplus	3.869.874.394	536.493.113	543.144.471	549.867.432	556.488.702	564.121.129	571.616.855	578.975.791	586.196.590	589.958.904	592.896.904	595.671.386	598.283.932
Bus Operator	-119.302.797	-16.716.143	-16.811.547	-16.907.105	-16.998.331	-17.111.882	-17.220.224	-17.323.434	-17.421.559	-17.514.647	-17.562.516	-17.607.717	-17.650.275
Operator FF.CC.	145.666.222	20.971.928	20.953.979	20.935.961	20.918.723	20.915.428	20.912.282	20.909.285	20.906.434	20.903.729	20.929.680	20.954.186	20.977.262
Other Operators	0	0	0	0	0	0	0	0	0	0	0	0	0
Producer's Surplus	26.363.425	4.255.785	4.142.432	4.028.855	3.920.391	3.803.545	3.692.058	3.585.851	3.484.875	3.389.083	3.367.163	3.346.469	3.326.987
Reduction of accidents	53.494.691	7.439.769	7.506.649	7.573.841	7.638.174	7.673.604	7.707.434	7.739.683	7.770.364	7.799.488	7.868.558	7.933.787	7.995.209
Reduction of environmental pollution	311.773.915	43.422.162	43.826.715	44.233.142	44.622.267	44.758.659	44.888.913	45.013.104	45.131.270	45.243.454	45.663.786	46.060.734	46.434.521
Noise pollution reduction	6.039.375	807.755	814.382	821.037	827.406	832.094	836.570	840.835	844.893	848.744	855.088	861.079	866.721
Externalities	371.307.981	51.669.686	52.147.745	52.628.019	53.087.846	53.264.357	53.432.916	53.593.623	53.746.527	53.891.685	54.387.433	54.855.600	55.296.451
Residual value of the works	70.220.288	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL INCREMENTAL BENEFITS (USD)	4.337.766.088	592.418.583	599.434.648	606.524.307	613.496.939	621.189.031	628.741.829	636.155.264	643.427.992	647.239.672	650.651.500	653.873.455	656.907.370
Initial investments	-1.013.013.260	0	0	0	0	0	0	0	0	0	0	0	0
Operating costs	-160.800.337	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213
Maintenance Costs	-101.300.197	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937
Other direct costs + Indirect costs	-38.432.289	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254
Extraordinary conservation and replacements	-22.332.623	0	0	0	0	0	0	0	-47.936.766	-35.575.758	0	0	0
TOTAL COSTS (USD)	-1.335.878.706	-42.424.404	-42.424.404	-42.424.404	-42.424.404	-42.424.404	-42.424.404	-42.424.404	-90.361.170	-78.000.162	-42.424.404	-42.424.404	-42.424.404
NET RESULTS (USD)	3.001.887.382	549.994.180	557.010.245	564.099.903	571.072.536	578.764.627	586.317.426	593.730.861	553.066.823	569.239.511	608.227.097	611.449.051	614.482.966

Table 32. Projected economic currents (2/3)

INCREMENTAL FLOWS (Without Project - With Project)	Discounted USD	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056
Time Saving	3.354.097.932	523.309.506	525.203.078	526.973.338	528.616.034	530.133.679	531.529.127	532.805.851	533.429.092	534.028.059	534.603.760	535.157.145	535.689.108
Vehicle Operating Cost ("VOC") Savings	519.879.782	78.379.922	78.892.620	79.309.927	79.697.146	80.054.873	80.383.786	80.684.704	80.884.574	81.076.544	81.260.953	81.438.116	81.608.332
Fare Savings	-4.103.321	-953.321	-1.066.346	-1.058.934	-1.052.049	-1.045.682	-1.039.823	-1.034.457	-1.082.612	-1.128.836	-1.173.214	-1.215.825	-1.256.744
Consumer Surplus	3.869.874.394	600.736.107	603.029.352	605.224.330	607.261.131	609.142.870	610.873.090	612.456.098	613.231.054	613.975.767	614.691.498	615.379.436	616.040.696
Bus Operator	-119.302.797	-17.690.218	-17.727.568	-17.821.995	-17.909.621	-17.990.580	-18.065.023	-18.133.135	-18.144.393	-18.155.242	-18.165.696	-18.175.769	-18.185.476
Operator FF.CC.	145.666.222	20.998.922	21.019.177	21.003.933	20.989.787	20.976.718	20.964.701	20.953.707	20.962.460	20.970.872	20.978.954	20.986.722	20.994.189
Other Operators	0	0	0	0	0	0	0	0	0	0	0	0	0
Producer's Surplus	26.363.425	3.308.704	3.291.609	3.181.938	3.080.166	2.986.138	2.899.678	2.820.571	2.818.067	2.815.630	2.813.259	2.810.953	2.808.713
Reduction of accidents	53.494.691	8.052.862	8.106.780	8.150.925	8.191.887	8.229.730	8.264.524	8.296.357	8.319.415	8.341.562	8.362.839	8.383.280	8.402.920
Reduction of environmental pollution	311.773.915	46.785.370	47.113.486	47.384.900	47.636.745	47.869.409	48.083.333	48.279.050	48.443.151	48.600.784	48.752.223	48.897.726	49.037.537
Noise pollution reduction	6.039.375	872.016	876.968	881.613	885.924	889.906	893.567	896.917	898.815	900.640	902.392	904.076	905.695
Externalities	371.307.981	55.710.249	56.097.234	56.417.438	56.714.556	56.989.044	57.241.424	57.472.323	57.661.381	57.842.986	58.017.454	58.185.082	58.346.152
Residual value of the works	70.220.288	0	0	0	0	0	0	0	0	0	0	0	1.243.170.270
TOTAL INCREMENTAL BENEFITS (USD)	4.337.766.088	659.755.060	662.418.195	664.823.706	667.055.852	669.118.052	671.014.191	672.748.992	673.710.503	674.634.383	675.522.210	676.375.471	1.920.365.831
Initial investments	-1.013.013.260	0	0	0	0	0	0	0	0	0	0	0	0
Operating costs	-160.800.337	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213	-22.699.213
Maintenance Costs	-101.300.197	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937	-14.299.937
Other direct costs + Indirect costs	-38.432.289	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254	-5.425.254
Extraordinary conservation and replacements	-22.332.623	-3.373.259	-990.548	0	0	0	-2.669.488	-2.351.165	0	0	0	-47.936.766	-35.575.758
TOTAL COSTS (USD)	-1.335.878.706	-45.797.663	-43.414.952	-42.424.404	-42.424.404	-42.424.404	-45.093.892	-44.775.569	-42.424.404	-42.424.404	-42.424.404	-90.361.170	-78.000.162
NET RESULTS (USD)	3.001.887.382	613.957.397	619.003.243	622.399.302	624.631.449	626.693.648	625.920.299	627.973.424	631.286.099	632.209.979	633.097.807	586.014.301	1.842.365.669

Table 33. Projected economic flows (3/3)



2.5.2 Results generated (Base Scenario-CAPEX associated with the highest number of uneven crossings)

The results generated by the economic analysis have been made for the Base Scenario, which is the scenario that contemplates the hypotheses with the highest probability of occurrence. This scenario includes higher forecasts of unevenness than those considered in the first technical analyses carried out.

Firstly, the socio-economic results of the total period analyzed are shown: time savings, in hours; reduction of accidents among alternative modes of transport to the train, and reduction of emissions in its three main components of environmental pollution:

ECONOMIC RESEARCH FINDINGS		
Time savings (hours)	3.458 mill. horas	115 mill. / año
Accident Reduction (full period)	Veh. Private	Bus
Accidents	3.589	-330
Wounded	1.002	-56
Fatalities	85	-4
Emissions Reduction	The whole period	Per year
Nx (Tons)	4.120	137,3
CO2 (Millions of Tons)	1,8	0,1
PM10 (Tons)	278	9,3

Table 34. Economic results of the Project. Base Scenario (Extended CAPEX).

As explained in the methodological explanation, the three results to be analyzed are those shown in the following table:

ECONOMIC ANALYSIS RESULTS	ALL LINES
TIR-E (Internal Rate of Return)	26,1%
NPV-E (Net Present Value) Millions of USD	3.001,89
Ratio B/C (Ratio Benefits / Costs)	3,25

Table 35. Economic results of the Project. Base Scenario (Extended CAPEX).

In addition, the resulting Generalized Travel Costs have been estimated, showing a reduction in these costs that translates into a positive consumer surplus:

GENERALISED TRAVEL COSTS ("GTC")	WITHOUT PROJECT	WITH PROJECT
Average GTC (USD / trip)		
Private Vehicle	7,79	7,41
Bus	13,49	12,96
Train	5,14	5,27

Table 36. Comparison of General Travel Costs.

On the other hand, a number of Cost Effectiveness indicators have been estimated, as shown below:

Indicators of Benifit / Cost Ratio (USD):	R B/C
Time saving (total hours)	0,39
V.O.C. Savings	0,58
Accident cost savings	673,35
Beneficial users	0,81

Table 37. Cost-Effectiveness Indicators. Base Scenario.

Finally, the following table shows the distribution of benefits and costs generated in each of the chapters and their contribution to economic profitability:

INCREMENTAL FLOWS (Without Project - With Project)		Discounted USD
	Time Saving	3.354.097.932
	Vehicle Operating Cost ("VOC") Savings	519.879.782
	Fare Savings	-4.103.321
(B1)	Consumer Surplus	3.869.874.394
	Bus Operator	-119.302.797
	Operator FF.CC.	145.666.222
	Other Operators	0
(B2)	Producer's Surplus	26.363.425
	Reduction of accidents	53.494.691
	Reduction of environmental pollution	311.773.915
	Noise pollution reduction	6.039.375
(B3)	Externalities	371.307.981
(B4)	Residual value of the works	70.220.288
(B)=(B1)+...+(B4) TOTAL INCREMENTAL BENEFITS (USD)		4.337.766.088
(C1)	Initial investments	-1.013.013.260
(C2)	Operating costs	-160.800.337
(C3)	Maintenance Costs	-101.300.197
(C4)	Other direct costs + Indirect costs	-38.432.289
(C5)	Extraordinary conservation and replacements	-22.332.623
(C)=(C1)+...+(C5) TOTAL COSTS (USD)		-1.335.878.706
R.N. = (B) - (C) NET RESULTS (USD)		3.001.887.382

Table 38. Distribution of the profits and costs generated in USD discounted. Base Scenario.

From the table of economic results shown, the following conclusions can be drawn:

- The three parameters for measuring economic viability show favorable results, which reflect a viable project with economic profitability.
- Among the chapters with the greatest contribution to NPV-E, the Consumer Surplus stands out, mainly because of the substantial time savings applied to high demand, followed by the VOC savings due to the expected modal shift.
- The Producer Surplus is a negative profit item, taking into account that the train's operating margins are positive and there is an increase in users. In the case of the bus they are positive but are affected by the reduction in users due to the modal shift.

As detailed in the report, criteria of prudence have been taken into account in this aspect and, therefore, the potential benefits that would be generated for bus operators with the efficiency improvements derived from route optimization have not been considered.

- Within the Externalities, the reduction of pollution stands out over the others, with the reduction of accidents and noise pollution also having positive results, but to a lesser extent than the other items. In all of them, the impacts on production stand out, which reflect the multiplying effect that consumer surpluses have on economic benefits.

2.5.3 Results generated (Alternative scenario-lesser CAPEX associated with less uneven crossings)

An additional scenario has been taken into account which considers a lower CAPEX amount due to the existence of fewer high steps to be carried out, corresponding to the one initially considered in the technical analysis. This scenario considers a slight change in the distribution of the execution schedule and a significant downward variation in the CAPEX, as shown in the following tables:

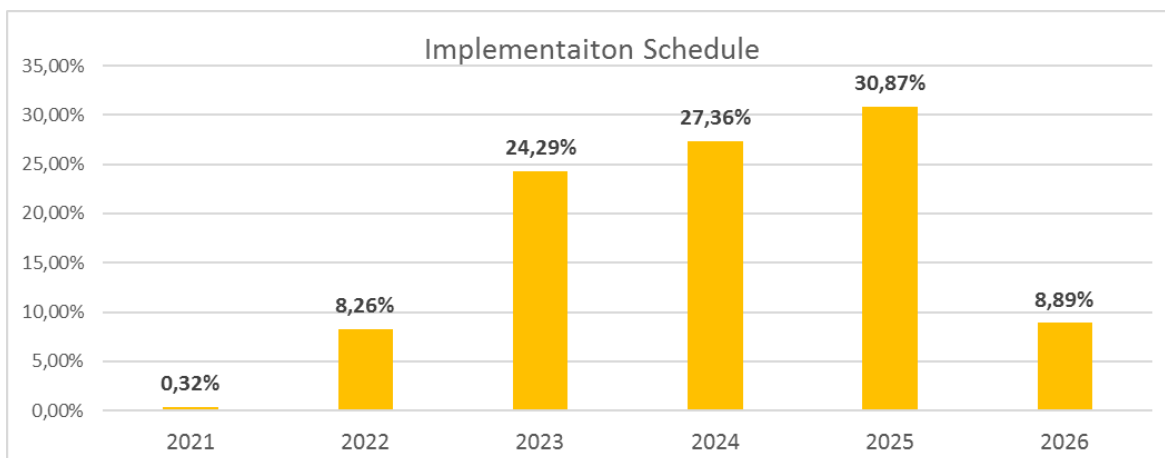


Table 39. Execution Schedule Minor CAPEX Scale

Below are the tables with the detailed amounts of the different investment concepts, both in market prices and in shadow prices once the social correction factors have been applied:

CAPEX WITH PROJECT (USD, Market prices)	TOTAL	2021	2022	2023	2024	2025	2026
Infrastructure (Preliminary Work + Structure + Drainage + Serv	146.534.973	0	12.035.051	54.930.992	55.560.628	23.745.006	263.296
Platform and superstructure	178.260.169	0	0	35.092.951	73.909.754	69.257.463	0
Stations, depots, workshops and admin buildings	103.889.347	0	5.839.474	31.029.139	37.391.077	26.937.700	2.691.955
Installations (Electrification + Systems)	197.908.309	0	0	19.125.375	75.307.163	99.212.074	4.263.698
Urban Integration + Historical Heritage Rehabilitation	37.258.000	0	0	0	13.872.800	19.357.018	4.028.182
Rolling stock	452.400.000	0	51.040.000	116.000.000	51.040.000	122.960.000	111.360.000
Design and implementation + Seg.y Sal. + C.Quality + G.Res.	98.334.386	3.937.182	15.515.640	24.006.939	26.041.835	22.160.057	6.672.733
Land	66.131.959	0	25.461.946	32.479.260	0	8.190.753	0
Other costs	91.548.514	0	2.821.751	20.070.132	34.126.354	31.604.478	2.925.799
Total	1.372.265.657	3.937.182	112.713.862	332.734.788	367.249.611	423.424.550	132.205.663

Table 40. Execution budget at market prices - Situation with Project Minor Scale CAPEX.

CAPEX WITH PROJECT (USD, Shadow prices)	TOTAL	2021	2022	2023	2024	2025	2026
Infrastructure (Preliminary Work + Structure + Drainage + Serv	132.300.848	0	10.865.990	49.595.101	50.163.575	21.438.462	237.720
Platform and superstructure	160.944.318	0	0	31.684.090	66.730.303	62.529.926	0
Stations, depots, workshops and admin buildings	103.889.347	0	5.839.474	31.029.139	37.391.077	26.937.700	2.691.955
Installations (Electrification + Systems)	179.008.065	0	0	17.298.901	68.115.329	89.737.321	3.856.515
Urban Integration + Historical Heritage Rehabilitation	37.258.000	0	0	0	13.872.800	19.357.018	4.028.182
Rolling stock	358.484.687	0	40.444.426	91.919.150	40.444.426	97.434.300	88.242.384
Design and implementation + Seg.y Sal. + C.Quality + G.Res.	98.334.386	3.937.182	15.515.640	24.006.939	26.041.835	22.160.057	6.672.733
Land	66.131.959	0	25.461.946	32.479.260	0	8.190.753	0
Other costs	82.655.667	0	2.547.651	18.120.558	30.811.386	28.534.480	2.641.593
Total	1.219.007.277	3.937.182	100.675.127	296.133.138	333.570.731	376.320.016	108.371.082

Table 41. Execution budget in economic terms - Situation with the CAPEX Minor Project.

The results generated by the economic analysis carried out for this Scenario are shown in the following tables:

ECONOMIC ANALYSIS RESULTS	ALL LINES
TIR-E (Internal Rate of Return)	28,9%
NPV-E (Net Present Value) Millions of USD	3.122,01
Ratio B/C (Ratio Benefits / Costs)	3,59

Table 42. Economic results of the Project. Minor CAPEX scenario

Indicators of Benefit / Cost Ratio (USD):	R C/B
Time saving (total hours)	0,35
V.O.C. Savings	0,52
Accident cost savings	608,66
Beneficial users	0,73

Table 43. Indicators of Relationship Cost / Effectiveness. *Minor* CAPEX Scenario

Finally, the following table shows the distribution of benefits and costs generated in each of the chapters and their contribution to economic profitability:

INCREMENTAL FLOWS (Without Project - With Project)		Discounted USD
	Time Saving	3.354.097.932
	Vehicle Operating Cost ("VOC") Savings	519.879.782
	Fare Savings	-4.103.321
(B1)	Consumer Surplus	3.869.874.394
	Bus Operator	-119.302.797
	Operator FF.CC.	145.666.113
	Other Operators	0
(B2)	Producer's Surplus	26.363.316
	Reduction of accidents	53.494.691
	Reduction of environmental pollution	311.773.915
	Noise pollution reduction	6.039.375
(B3)	Externalities	371.307.981
(B4)	Residual value of the works	62.009.777
(B)=(B1)+...+(B4)	TOTAL INCREMENTAL BENEFITS (USD)	4.329.555.468
(C1)	Initial investments	-884.511.689
(C2)	Operating costs	-160.800.409
(C3)	Maintenance Costs	-101.300.197
(C4)	Other direct costs + Indirect costs	-38.432.289
(C5)	Extraordinary conservation and replacements	-22.501.058
(C)=(C1)+...+(C5)	TOTAL COSTS (USD)	-1.207.545.641
R.N. = (B) - (C)	NET RESULTS (USD)	3.122.009.827

Table 44. Distribution of the profits and costs generated in USD discounted. *Minor* CAPEX Scenario