BORGARLÍNAN SOCIOECONOMIC ANALYSIS

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CONTENTS

APPENDICES

GLOSSARY

Term	Explanation
BRT	Bus Rapid Transit
CO_2	Carbon-dioxide
DT	Delivery Trucks
HGV	Heavy Goods Vehicle
IRR	Internal Rate of Return
ISK	Icelandic Króna
NO_x	Nitrous-oxides
NPV	Net Present Value
Pkm	Person km
$PM_{2.5}$	Particle Matter smaller than 2.5 micro-meter
PPP	Purchasing Power Parity
SLH	Transport Model for the Capital area (Icelandic: Samgöngulíkan fyrir höfuðborgarsvæðið)
SSH	Association of municipalities in the Capital area (Icelandic: Samtök sveitarfélaga á höfuðborgarsvæðinu)
VAT	Value Added Tax
Vkm	Vehicle km

LIST OF TABLES

LIST OF FIGURES

1 Executive summary

This report presents the socioeconomic analysis of Borgarlínan, a proposed new Bus Rapid Transit (BRT) system in the Reykjavík Capital Area. The socioeconomic analysis addresses the impacts of Borgarlínan Phase 1, which includes section 1 from Ártúnshöfði to Hamraborg, section 2 from Hamraborg to Lindir and section 3 from Vogabyggð to Mjódd.

Socioeconomic studies are a tool for policy makers

A BRT line has the potential to provide travel time savings, however a BRT project also imposes costs from construction, operation and maintenance. A socioeconomic study of the proposed BRT project helps policymakers evaluate the benefits of the project against the project costs. The socioeconomic analysis is therefore a management tool for policy makers in order to make informed decisions for large public investments in e.g. transport infrastructure. Socioeconomic studies are widely used in the planning of infrastructure investments worldwide with guidelines set by e.g. the European Commission, World Bank, IFC, and the governmental bodies of among others Denmark, Norway, UK and the Netherlands.

The socioeconomic analysis shows that Borgarlínan Phase 1 has a socioeconomic net benefit of 25.6 billion ISK over the entire analysis period of 30 years and a socio economic return of 7 percent per annum.

Characteristics of Borgarlínan Phase 1

Borgarlínan Phase 1 consists of about 18 km of BRT infrastructure, i.e. dedicated bus lanes and about stops/stations. Thereof section 1 is about 13 km and 25 stops/stations. The BRT infrastructure will include fully dedicated bus lanes, off-board fare collection, be accessible to everyone, and run on clean, domestic fuels (for the purpose of this study electricity has been analysed). Furthermore, cycle and pedestrian lanes will be integrated with Borgarlínan stations and corridors, providing an option for first or last mile connectivity.

Public investment in BRT infrastructure and increased operational expenditures

The socioeconomic study is based on several data sources and assumptions. The construction of Borgarlínan Phase 1 amounts to 38 billion ISK incl. contingency and is expected to open in 2024. Furthermore, the opening of Borgarlínan will lead to increased operational expenditures for Strætó. These are estimated to accrue to 1 billion ISK annually. The improvements in the existing bus network amount to an additional 1 billion ISK in increased operational expenditures. The increased operational expenditures are however partly offset by an expected increase in revenues due to induced public traffic and traffic diverted from private cars to public transport.

Travel time savings modelled in the transport model for the Capital Area

The main impact of infrastructure investments is the travel time savings. A transport model is under development for the analysis of the Governments Transport Plan and has been used for the first time for this socioeconomic analysis of Borgarlínan Phase 1. The transport model includes several transport modes; public transport users, cars, delivery trucks, heavy goods vehicles and bicycles.

Public transport users are the main beneficiary of the project

The results of the transport model predict a modal shift from cars to the use of public transport leading to a socioeconomic benefit for the public transport users and bicycles. This benefit however comes at a cost for private car users, delivery trucks and heavy goods vehicles.

In order to value the traffic consequences an Icelandic set of economic unit values have been developed. Travel time savings, vehicle operating costs, traffic accidents, and environmental impacts have been valued in the study. The economic unit values have been developed in accordance with international practices.

Socioeconomically feasible

As mentioned above the net present value of Borgarlínan Phase 1 is 25.6 billion ISK and an internal rate of return of 7 percent. Thereby the project is socioeconomically feasible with benefits outweighing the costs of the project.

Table 1-1 Borgarlínan socioeconomic summary results

Billion ISK	NPV
Construction costs	-25.4
Operational costs	-17.1
User impacts	71.2
External impacts	3.4
Other consequences	-6.5
Net present value	**25.6**
Internal rate of return	**6.96 %**
Net benefit to cost ratio	**0.5**

Note: All benefits are with a positive sign whereas all costs are denominated with a negative sign. For constructions costs the scrap value of the infrastructure investments is included in the NPV.

Source: COWI and Mannvit

Sensitivity analysis showing a robust result

The result of the socioeconomic analysis has undergone a sensitivity analysis where the primary assumptions are altered in order to investigate the impact on the socioeconomic feasibility of Borgarlínan. The sensitivity analysis show that the result of the study is robust towards changes in all the primary assumptions. The result is primarily sensitive towards a reduction on the travel time savings of the public transport users. A reduction in the travel time savings or value of time of 25 percent lead to a net present value of 5.8 billion ISK and an internal rate of return of 4.7 percent.

2 Introduction

This report presents the socioeconomic analysis of Borgarlínan, a proposed new Bus Rapid Transit (BRT) system in and around the Reykjavík Capital Area. The socioeconomic analysis addresses the impacts of Borgarlínan Phase 1, which includes section 1 from Ártúnshöfði to Hamraborg, section 2 from Hamraborg to Lindir and section 3 from Vogabyggð to Mjódd. The alignment of Borgarlínan is described and shown in chapter 3.

A growing population and a target of reductions in CO_2 emissions

In order to meet its target of achieving carbon neutrality by 2040, Iceland has committed to a 40 percent reduction in CO_2 emissions by 2030.[1] A critical element of this is the need to significantly reduce emissions from road transport, including by way of investment in infrastructure for increased bicycle, pedestrian and public transport in the Capital Area, which contains approximately 62 percent of the population. By 2030, it is anticipated that the share of public transport as a proportion of all transport will be 12 percent (an increase of 8 percentage points from current levels). Within the same timeframe, the aim for bike/pedestrians is to increase the share of trips from 20 percent to 30 percent and for private cars to decrease from 76 percent to 58 percent. At the same time as committing to environmental goals, the population of the Capital Area in Iceland is expected to grow by around 28 percent by 2040 compared to today.[2] Posing an additional challenge in achieving environmental goals.

The purpose of Borgarlínan is to increase public transit use in order to reduce congestion and move towards greener transport. Borgarlínan is a vital part of the government's Transportation Plan 2020-2034 and central to achieving the goals listed above.

Measuring the impacts of Borgarlínan

In order to analyse the impact of the government's Transportation Plan a transport model is under development covering the Capital Area. The transport model has been used for this project in order to analyse the traffic related impact of Phase 1 of Borgarlínan.

Based on the transport model as well as cost estimates for constructing and operating the project, the socioeconomic analysis (often referred to as cost benefit analysis or CBA) provides a quantitative measure of the effects of the project. It seeks to answer whether a new project or initiative will bring the community benefits that exceed the costs of construction and operation.

[1] (Umhverfis- og auðlindaráðuneytið, 2018)

[2] (Association of municipalities in the Capital area, 2015)

Socioeconomic analysis can be a powerful framework for governments making investment decisions and is a vital tool for improving public spending. As such, it has been heavily promoted by various actors:

1. The European Commission has heavily promoted the use of socioeconomic analysis for major infrastructure projects and has introduced legislation for its members outlining basic rules for conducting CBA[3].
2. In OECD´s economic survey of Iceland one of the key recommendations for improving public spending is applying a more comprehensive cost-benefit analysis to infrastructure projects.[4]
3. In all Scandinavian countries, the UK and the Netherlands, a cost benefit analysis must be performed on all major infrastructural projects.

Socioeconomic studies have been performed sporadically in Iceland in recent years:

1. "Hagræn úttekt á sex valkostum fyrir framtíðarstaðsetningu Reykjavíkurflugvallar"[5]
2. 2014: "Svæðisskipulag höfuðborgarsvæðisins"[6]
3. 2015: "Kostnaðar- ábatagreining á alhliða flugvelli í Hvassahrauni"[7]
4. 2017: "Ásvallabraut - Hagræn greining"[8]

The aforementioned analyses were conducted using the Danish socioeconomic model for transport projects, TERESA[9]. Allowing the impacts of alternative transport projects to be compared using a consistent methodology. This project was carried out in TERESA as well.

This socioeconomic analysis of the project was carried out by Mannvit and COWI in 2020.

2.1 Purpose

The purpose of this report is to present the socioeconomic impacts and document the analysis of Phase 1 of Borgarlínan.

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[3] (European Commision, 2014)
[4] (OECD, 2019), page 10, key policy insights.
[5] (ParX, 2007)
[6] (Various, 2015)
[7] (Hagfræðistofnun, 2015)
[8] (Mannvit, 2017)
[9] Transport- og Energiministeriets Regneark for Samfundsøkonomisk Analyse (DTU, TERESA 5.08, 2019)

As a part of this analysis, a set of transport economic unit values[10] for Iceland were developed specifically for the unit values necessary in order to analyse Borgarlínan.

2.2 Structure of the report

The remainder of the report is structured as follows:

- Chapter 3 describes what defines a BRT line and the expected service level of Borgarlínan.
- Chapter 4 shortly summarises the main aspects, the principles of socioeconomic analysis and the impacts included in the analysis of Phase 1 of Borgarlínan.
- In Chapter 5, all input and assumptions of the analysis are described in detail.
- Chapter 6 presents the results of the socioeconomic analysis.
- In Chapter 7, the robustness of the result presented in chapter 6 are investigated by changing the main input parameters. This is a so-called sensitivity analysis.
- Chapter 8 looks into the aspects of BRT as an enabler for green transition and urban development.
- Chapter 9 concludes on the entire socioeconomic analysis.

The subsequent chapters 10 and 11 list the studies used in the analysis and the appendices.

[10] A unit value, is a generic value or price that can be used across CBAs of transport projects expressing e.g. the value of time (ISK/hr) and cost of greenhouse gas emissions (ISK/kg CO_2-equivalent)

3 Borgarlína

This chapter first describes in general what a BRT system is and then the expected Borgalína service level.

3.1 What is Bus Rapid Transit?

BRT offers a higher service level than regular buses

Bus Rapid Transit (BRT) is a high-quality bus-based transit system that delivers fast, comfortable, and cost-effective services with high passenger capacity. It does this through a system of dedicated lanes, with busways and iconic stations typically aligned to the centre of the road, off-board ticketing, and fast and frequent operations.

Because BRT has features similar to a light rail or metro system, it is much more reliable, convenient and faster than regular bus services. With the right features, BRT is able to avoid the causes of delay that typically slow regular bus services, like being stuck in traffic and queuing to pay on board.

There are five essential features that define BRT. These features most significantly result in a faster trip for passengers and make traveling by public transport more reliable and more convenient.[11] The five essential features are:

- Dedicated Right-of-Way: Bus-only lanes make for faster travel and ensure that buses are never delayed due to mixed traffic congestion.
- Busway Alignment: Centre of roadway or bus-only corridor keep buses away from the busy curb side where cars are parking, standing, and turning.
- Off-board Fare Collection: Fare payment at the station, instead of on the bus, eliminates the delay caused by passengers waiting to pay on board.
- Intersection Treatments: Prohibiting turns for traffic across the bus lane reduces bus delays caused by turning traffic. Prohibiting such turns is the most important measure for moving buses through intersections – more important than signal priority.
- Platform-level Boarding: The station should be at level with the bus for quick and easy boarding. This also makes it fully accessible for wheelchairs, disabled passengers, strollers and carts with minimal delays.

3.2 Description of Borgarlínan

Borgarlínan will provide direct connectivity to most key destinations in the Capital Area. The 'full' Borgarlínan project is anticipated to comprise

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[11] Institute for Transportation and Development Policy, ITDP. https://www.itdp.org/library/standards-and-guides/the-bus-rapid-transit-standard/what-is-brt/

approximately 42 km of BRT system to be implemented over a period of approximately 15 years. Phase 1 runs from Lindir, through Hamraborg and to Ártúnshöfði and connects to Mjódd and covers 18 km.

In a screening report from 2017[12], the following five principles were established to guide the vision of the Borgarlínan system:

1 Simple and direct network structure

2 High frequency and extended service hours

3 Low travel time and high regularity

4 Coordinated and convenient transfers to other forms of transport

5 High comfort and quality for buses and stations

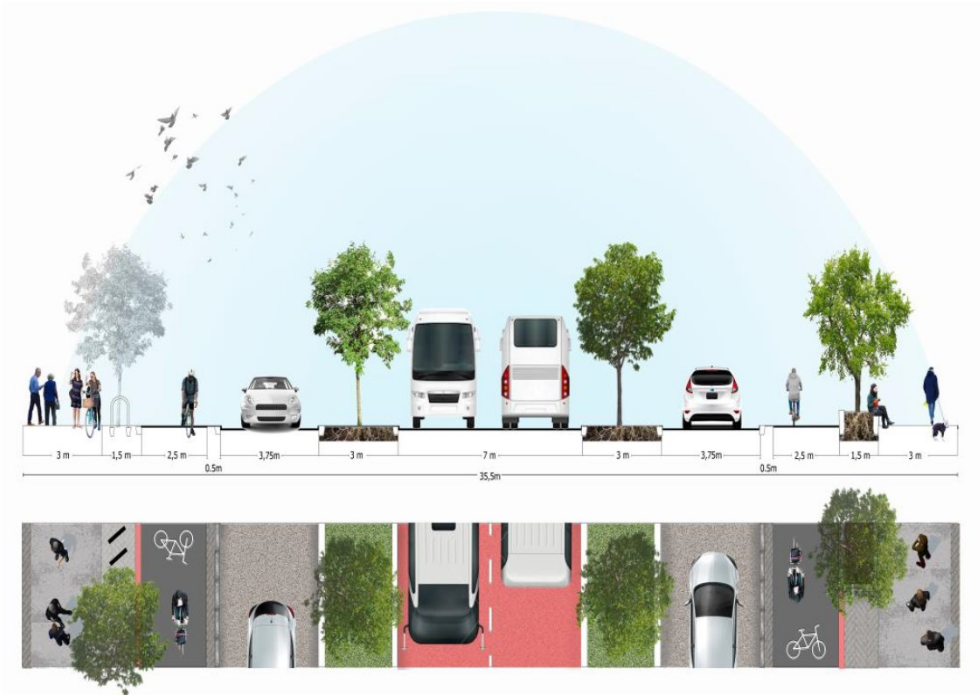
Borgarlínan is intended to have rapid, high quality services and its stations will provide a safe and comfortable experience for waiting passengers under any weather conditions. The new system's stations, buses and service maps are to form an immediately recognisable brand. Borgarlínan will:

- Include fully dedicated lanes, designed in a way that minimizes delay to passengers
- Include off-board fare collection, so that passengers can board quickly, and platform-level boarding so that passengers can board easily
- Be accessible to everyone
- Buses will run on clean, domestic fuels (electricity, methane or hydrogen)
- Cycle and pedestrian lanes will be integrated with Borgarlínan stations and corridors, providing an option for first or last mile connectivity

The majority of Borgarlínan will use existing streets but new infrastructure will be built in several places. Most notably a bike/pedestrian/and transit-only bridge between Reykjavík and Kopavogur (Fossvogur Bay) and a new transit-only bridge at Ellidaárvogur (Ellidaá Bay) will be constructed for Borgarlínan.

[12] Borgarlína Recommendations, screening report. Cowi. September 2017.

Figure 3-1 Borgarlínan typical cross-section.



The system will have the look and feel of light rail in the dedicated lanes and then enter mixed traffic to continue to key destinations on or beyond the Borgarlínan corridor.

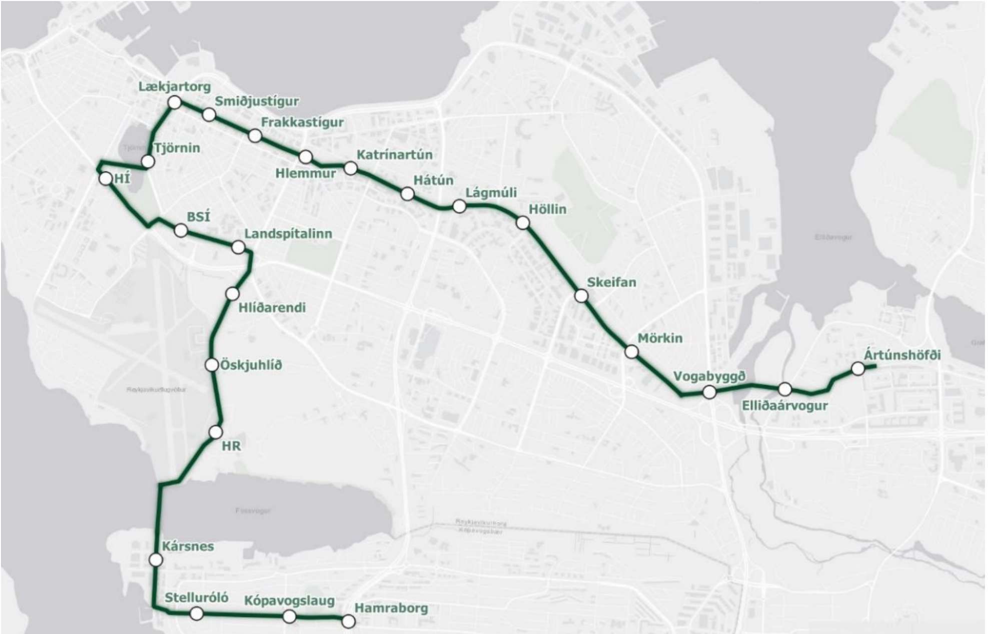
The intention is that Borgarlínan will be aesthetically designed and in-keeping with the surrounding landscapes, whilst also being highly functional. The infrastructure will be well-integrated into the surrounding environment, with a system which is technically very high quality, well-designed, safe and affordable.

It should also be noted that, should demand and other circumstances justify it, the intention is for the new Borgarlínan BRT system to be upgradable to a light rail transit (or LRT) system in the future. Although a decision on upgrading the system to LRT is expected to be well into the future, and relatively uncertain, to the extent that it is feasible the design work is intended to bear this ultimate objective in mind.

According to a local plan change proposal for Reykjavik and Kopavogur in February 2020, the alignment of section 1 of Borgarlínan will be as shown in Figure 3-2 below. It runs from Ártúnshöfði in Reykjavík to Hamraborg in Kópavogur.[13] It consist of around 13 km of BRT infrastructure, i.e. dedicated bus lanes and about 25 stops/stations.

[13] (Kópavogsbær, 2020)

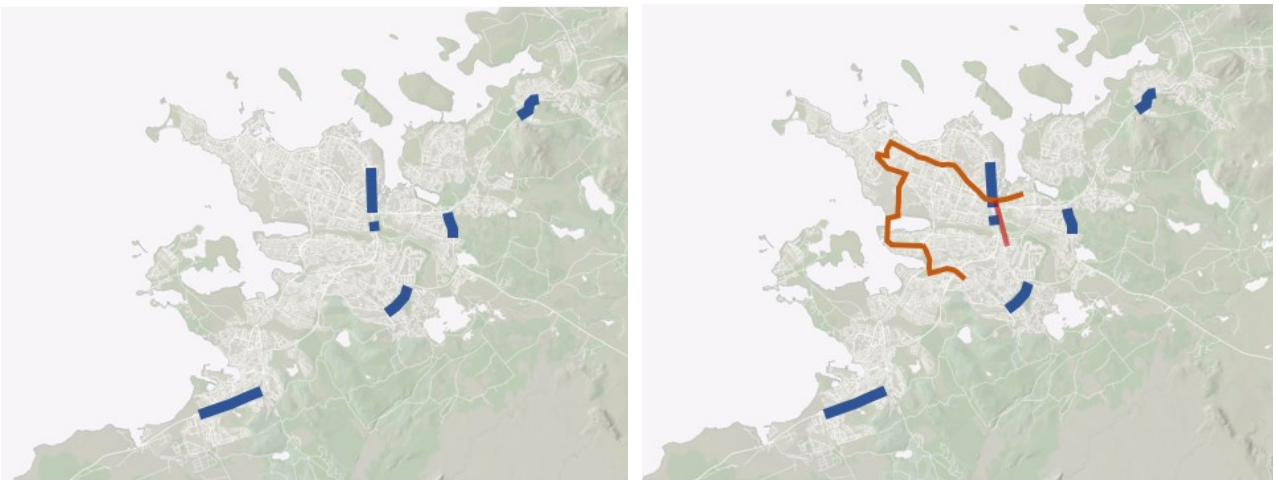
Figure 3-2 Borgarlina section 1 and proposed stations



In this socioeconomic analysis, the Borgarlínan Phase 1 was analysed. Phase 1 includes 3 sections; section 1 from Ártúnshöfði to Hamraborg, section 2 from Hamraborg to Lindir and section 3 from Vogabyggð to Mjódd. Further phases are planned for later stages.

Figure 3-3 below shows the two scenarios that were run in a traffic model for this socioeconomic analysis. The picture to the left shows the baseline scenario and which new road infrastructure investments were included in it. The picture to the right shows the scenario with Borgarlínan. In order to isolate the effects of Borgarlínan, the road infrastructure investments are the same in both scenarios, i.e. the only difference is Borgarlínan.

Figure 3-3 Infrastructure investments in Transport plan Phase 1 for the traffic model run for the socioeconomic analysis of Borgarlínan



a. Baseline scenario: 2024 road infrastructure investments

b. Borgarlínan scenario: 2024 road infrastructure investments incl. Borgarlínan BRT Phase 1

4 Methodology for the Socioeconomic Analysis

A BRT line has the potential to provide travel time savings, however a BRT project imposes costs from construction, operation and maintenance. A socioeconomic study of the proposed BRT project helps policymakers evaluate the benefits of the project against the project costs. The socioeconomic analysis is therefore a management tool for policy makers in order to make informed decisions for large public investments in e.g. transport infrastructure.

The socioeconomic analysis can indicate whether a project is economically feasible, meaning that the present value of benefits over a project's lifetime outweigh its costs. The analysis can also (if used consistently) help policy makers prioritize projects or project alternatives by ranking economic feasibility.

A socioeconomic analysis is used to capture the benefits and costs for both the public and private sector such as neighbours or bus operators. Where possible the analysis includes impacts that are external to the project. These externalities include environment, traffic safety, road maintenance effects etc.

All benefits and costs are monetized – put into kr. values - and included in the analysis. Hereby, it becomes possible to compare in the same unit of measurement – kr. - the benefits of e.g. reduced travel times of the public passengers with the construction and operations cost of the BRT. The socioeconomic analysis also makes it possible to compare the benefits and costs that are realised in different years.

The steps in a socioeconomic analysis are:

1. Identify all relevant costs and benefits of the project.
2. Quantify and monetize the costs of the project.
3. Quantify and monetize the benefits of the project.
4. Compare the costs and benefits of the project in order to analyse the feasibility of the project.

The socioeconomic analysis of Borgarlínan is carried out in accordance with international guidelines for assessment of transport infrastructure investments[14].

The socioeconomic analysis results in three key indicators:

- Net present value. Since the costs and benefits of a BRT project accrue over several years, all the benefits and costs over the project life are

[14] The quantitative analysis is performed in a version of the Danish official model TERESA modified to Icelandic conditions. The Danish guidelines are comparable with the Norwegian and EU guidelines though there are minor differences.

discounted[15] to an estimated net present value (NPV). The NPV is therefore the value of all future benefits and costs should they have occurred today. Hereby, it is possible to compare costs and benefits that are realised in different years.

- Internal rate of return is the discount rate at which the discounted benefits equals the discounted costs. The internal rate of return (IRR) therefore demonstrates the attractiveness of a project. The internal rate of return should at least exceed the social discount rate of 4 percent.

- Benefit-cost ratio. The ratio of discounted net benefits to the discounted public costs indicates the relationship between the net benefits of the project and public costs. A ratio higher than one indicates that the net benefits exceed the public cost of the BRT project.

For a project to be socioeconomically feasible, the net present value should be positive, and the internal rate of return should exceed the social discount rate.[16] The net present value equals zero, when the internal rate of return equals the social discount rate.

Net present value and internal rate of return

The formula for calculation of the net present value of the entire cost and benefit flow of a project is

$$NPV = \sum_{t=0}^{n} \frac{R_t}{(1+i)^t}$$

Where n is the total number of time periods, R is the net revenue per period, is the discounting rate and t is the time period.

The internal rate of return is the discount rate that will return a net present value of 0. Therefore, we know that if the net present value is positive the internal rate of return is higher than the specified discounting rate. The internal rate of return is resolved in an iterative process.

The economic impacts of Borgarlínan that are included in the analysis are described in Table 4-1. Each of these is then elaborated in detail in chapter 5.

[15] Discounting of a future value corrects it to its current value. The social discount rate is therefore and expression of the rate of which society is willing to give up benefits today in order to receive additionally in the future.
[16] The socioeconomic analysis does not by itself determine whether a project should be implemented or not. It solely presents the analysed social return on investment. It can still be a political priority to implement projects with low or negative results.

Table 4-1 Impacts considered in the socioeconomic analysis of Borgarlínan

IMPACTS MONETISED IN THE ANALYSIS			
Subject	Description	Quantification	Monetisation
Construction costs	The construction of a BRT line imposes a cost on society up front.	The construction cost of the project being analysed (Borgarlína Phase 1, see Figure 3-3 in Chapter 3).	Cost of constructing dedicated lanes and stations.
Operational costs	The improved service level comes at a cost of the operator Strætó.	Change in operating hours.	Cost per operating hour incl. cost of depreciation[1] of rolling stock
Revenue	The revenue of the operator increases with additional shifts from private to public transport.	Increase in number of trips with public transport.	The average ticket price per trip.
Travel time savings	Travel time savings is most often the primary benefit of transport infrastructure projects. When projects benefit one travel mode at the expense of another travel mode, it is important to include both the travel time savings as well as the travel time increases. For this project we look at the travel time savings (and increases) of public transport passengers, private cars, DT, HGV, and bicycles.	The travel time savings for each travel mode is quantified using a transport model for the Capital Area.	Calculated unit prices for free travel time, congestion, time in transit, waiting time, and number of transfers.
Travel costs	Travel costs is a part of the cost of transport that the transport user take into account when deciding whether or not to perform a trip.	Change in km driven based on the transport model.	The average cost of driving for each transport mode incl. fuel, depreciation and taxes.
Accidents	Accidents come at a high cost for both the parties involved and society. Changes in risk of accidents is therefore included and monetised in the analysis. The change in the risk of accidents stem from i.e. a reduction in vehicle km, improvements of pedestrian crossings, and the segregation of busses from regular traffic.	Number of avoided accidents based on reduction in vehicle km in the influence area.	The cost of an accident regarding material damage, personal damage and cost to society due to health care services and loss of future productivity.
CO_2 emissions	The reduction in vehicle km as passengers shift to high-capacity busses lead to less traffic-based CO_2 emissions.	Change in vehicle km driven and emission factor.	Unit value for cost of CO_2 emission based on vehicle km.

IMPACTS MONETISED IN THE ANALYSIS			
Subject	Description	Quantification	Monetisation
Pollution	The shift towards cleaner transport forms and fewer overall vehicle km lower the emissions of ambient air pollutants citywide.	Change in vehicle km driven.	Unit value for cost of pollution based per vehicle km.
Noise	Traffic noise imposes both nuisance and health related costs to society why there is a benefit of reduced traffic or a shift towards less noisy traffic modes.	Change in vehicle km driven.	Unit value for cost of noise based per vehicle km.
BRT AS AN ENABLER FOR GREEN TRANSITION AND URBAN DEVELOPMENT (partly monetised in the study)			
Green transition	A successful implementation of Borgalínan can push and inspire other green mobility initiatives and a wider implementation of BRT lines thus further helping the green transition.		
Urban development	High travel time reductions and more pleasant urban environment can lead to attractive areas surrounding the BRT line with increasing property values.		
Beneficiary income group	Investments in reliable sustainable public transport benefit all income groups and can be particularly important for households without car ownership.		

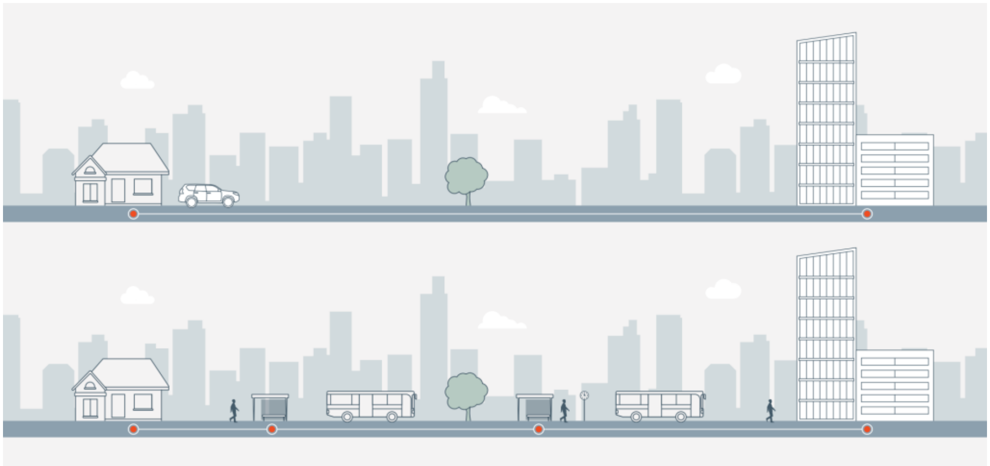
Note: *1. Depreciation of the rolling stock is included in order to take into account the costs of acquiring new rolling stock for the BRT.*
Source: *COWI and Mannvit*

In the socioeconomic analysis, we quantify and monetise the impacts for every year in the analysis period of 30 years. This allows us to investigate the feasibility of the project over time dependent on e.g. expected developments in traffic.

Generalized cost of transport and consumer surplus

The cost of transport is often referred to as a generalized cost of transport consisting of e.g. driving costs and time spent in traffic for private cars, and ticket costs, walking time, in vehicle travel time, waiting time and shift when using public transport.

Figure 4-1 *Trip by private car and public transport*



Transport users decide to travel as the cost of transport is lower than the benefit, they receive from realising the trip. This net benefit is called the consumer surplus. In socioeconomic analysis of infrastructure projects, we therefore analyse and monetise the change in consumer surplus for all transport modes. The methodology of quantification of changes in consumer surplus is elaborated in detail in Appendix B.

5 Description of Data and Assumptions

In this chapter, we describe the data and assumptions for the socioeconomic analysis.

5.1 Constructions costs

Initial investment of Phase 1 of 38 billion ISK incl. contingency

Borgarlínan Phase 1 consists of three sections; Ártúnshöfði to Hamraborg, Hamraborg to Lindir and Vogabyggð to Mjódd. The estimated cost of Phase 1 amounts to 23.6 billion ISK (2018 prices). The cost of each of these sections is displayed below in Table 5-1. The estimate was prepared in 2018 prices, but for the socioeconomic analysis the estimate is extrapolated to 2020 prices. Furthermore, a contingency[17] of 50 percent has been added to the construction costs. The total cost of Borgarlínan Phase 1 is thereby 38 billion ISK in 2020 prices.

Table 5-1 Constructions costs incl. VAT, billion ISK

Section	2018 prices	2020 prices
Hlemmur - Hamraborg	7.96	8.55
Hamraborg – Lindir	2.80	3.00
Svarthöfði – Hlemmur	8.74	9.39
Vogabyggd – Mjodd	4.11	4.42
Total construction costs	23.60	25.37
Contingency		12.68
Total construction costs		**38.05**

Note: The estimate is including VAT and has been validated by the Borgarlínan Project Office

Source: Borgarlína – Kennisnið og kostnaðarmat. Mannvit 2017[18]

The construction of Borgarlínan is expected to take place from 2021 to 2023.[19]

[17] In early phases of a project contingency is often added to the construction cost to take uncertainties into account.

[18] The construction cost is originally extracted from the report "Borgarlína – Kennisnið og kostnaðarmat" from 2017 but in 2019 it was adjusted to different phases by VSÓ Consulting and it was also reviewed by the design team at the Borgarlínan Project Office. In the report from 2017, the construction cost was estimated based on prices per typical sections. Six typical sections were estimated and two typical examples of changes to intersections (small and large) and typical examples of three different sizes of stations. These typical sections and examples were then laid out along corridors as they had been estimated at that time.

[19] A minor share of construction work will be carried out in 2024.

5.2 Operational Costs

The higher service level comes at a higher operational cost

The operation of Borgarlínan will impose additional operation costs on Strætó. The operational costs are expected to increase from 5,9 billion ISK with today's bus system to 7,9 billion ISK with the planned system improvements and Borgarlínan.

The incremental operation costs stem from improvements to the underlying bus network service as well as from the implementation of Borgarlínan. The cost of the increased service on the existing bus network amount to approximately 0.9 billion ISK, whereas the addition to the operational cost because of Borgarlínan amounts to approximately 1 billion ISK.

Table 5-2 Operational costs incl. VAT, billion ISK

	2019-prices	2020-prices
Baseline cost	5.80	5.99
Borgarlína Scenario	7.74	7.99
Incremental cost	1.94	2.00

Note: In the socioeconomic analysis we convert the operation costs from factor costs to market costs by multiplying with the factor for cost of public funds.

Source: Calculations by Strætó

The cost to Strætó includes all operational costs including fixed costs such as cost of offices and depreciation of rolling stock.

5.3 Traffic Impacts

First use of the newly developed transport model of the Capital Area

The traffic related consequences of the construction of Borgarlínan have been estimated in the transport model for the Capital Area. The transport model was developed for the purpose of analysing the traffic related impacts of infrastructure investments in the Capital Area. The model is now for the first time used to analyse the impact of projects under the government's Transportation Plan. The transport model includes several travel modes;

- cars - private cars, delivery trucks and HGV,
- bicycles,
- public transport, and

Based on the transport model, a forecast is made for the traffic flow and levels in the 'baseline 2024' where Borgarlínan is not constructed and the 'project scenario 2024' where Borgarlínan is constructed. See Figure 3-3 in chapter 3. The impact of Borgarlínan is therefore the change in traffic from the baseline 2024 forecast to the 2024 with Borgarlínan forecast.

The transport model in this case is a network model which is an advanced model that allows for detailed study of the traffic impact in the modelled network.

Network transport models

Network models describe a defined impact area and are generally more advanced since they can involve 'feedback loops', where the resulting state of the network can impact user decisions. These complex models incorporate significant volumes of information on the demand structure, the transport network and its dynamics (e.g. timetables, interconnections, etc.) to describe large numbers of transport movements over a specified period. Data is typically coded in the form of attributes for each transport link in the network, including speed, quality, and the travel modes that use each link.

Source: *Guide to Cost-Benefit Analysis of Investment Projects, European Commission December 2014*

The transport model therefore allows the changes in travel times and distances to be valued. All benefits are showed with a positive sign whereas all costs are shown with a negative sign. For the valuation of the traffic consequences we use Icelandic unit values for the value of time.

In the following sections, we will first describe the overall estimated traffic impacts and then we will describe the estimated impacts on travel time savings for each traffic mode. For each traffic mode, we will also present the unit value used in order to monetise the impact. We conclude with the net present value of that traffic mode.

5.3.1 Overall traffic consequences

Increase in public transport service and usage

The introduction of Borgarlínan is a significant improvement of the Capital Area public transport service level with an increase in vehicle km of just over 40 per cent. The increase in vehicle km is mainly due to an increase in frequency.

The increase in the service level of the public transport with Borgarlínan is estimated to lead to an increase in passenger trips by 20 per cent. With daily trips increasing from an estimated level of appr. 41,500 daily trips to appr. 49,800 daily trips[20]. In the baseline 2024 forecast, the average trip length is 13 minutes whereas in the 2024 with Borgarlínan forecast the average trip length is 11 minutes. The average trip length in both forecasts is 6 km. Thereby, the passengers on average travel the same distance but spend less time doing so. A trip can consist of more than one boarding if there is a transit.

Decrease in bicycling

Borgarlínan is estimated to lead to a minor reduction in bicycling traffic. This is due to a shift from bicycling towards public transport.

[20] Currently boardings are 29 percent higher than the number of trips per year. In the new bus network including the Borgarlínan the estimated number of boardings are 26 percent higher than the number of trips per year.

Shift from private car to public transport

The number of trips in private cars is estimated to decrease from appr. 1,205,000 daily trips to appr. 1,196,000. These trips are expected to be travelled by public transport instead of car. There is a reduction in congestion due to the shift away from cars, so even though each abiding driver will experience slightly more congestion (see ch. 5.4.1) the total time spent in congestion will be reduced.

Unchanged number of trips for DT and HGV

Delivery trucks and heavy goods vehicles are estimated to have a constant level of trips across scenarios. However, with the shift from private cars to public transport and the prioritization that must be taken for the BRT leads to a slight decrease in vehicle km and time spent in free flow whereas a slight increase in congestion time is estimated.

Table 5-3 Project traffic impact per day

Transport mode	Unit	Baseline 2024	2024 with Borgarlínan	% change
Public transport	Passenger km	251,289	285,078	13.4%
	Vehicle km	30,545	43,188	41.4%
	Passenger hours	8,779	9,223	5.1%
	# trips	41,492	49,791	20.0%
	# shifts	14,883	16,215	8.9%
Bicycles	km	111,208	106,457	-4.3%
	Hours	7,356	7,024	-4.5%
	# trips	79,844	77,159	-3.4%
Private cars	km	5,528,958	5,488,333	-0.7%
	Hours free flow	133,223	132,110	-0.8%
	Hours congestion	18,769	18,654	-0.6%
	# trips	1,204,875	1,196,356	-0.7%
Delivery trucks	km	492,867	492,117	-0.2%
	Hours free flow	11,963	11,940	-0.2%
	Hours congestion	1,688	1,690	0.1%
	# trips	109,458	109,458	0.0%
HGV	km	251,594	251,221	-0.1%
	hours free flow	6,068	6,057	-0.2%
	hours congestion	855	856	0.1%
	# Trips	54,958	54,958	0.0%

Source: SLH Transport Model

The opening of Borgarlínan will naturally move public transport passengers from previous bus lines to the new BRT line. Red stretches on the map indicate an increase in number of passengers on a specific stretch. From Figure 5-1 below it can be seen that the shift is particularly from Miklabraut to Suðurlandsbraut and from Kringlumýrarbraut to a new bridge over Fossvogur.

Figure 5-1 Changes in trips with public transport in 2024

Source: SLH Transport Model

Due to the priority of the BRT the other road traffic is estimated to shift slightly away from the BRT corridor to other main roads in the area. This shift is depicted in Figure 5-2 below.

Figure 5-2 Changes in trips with car in 2024

Source: SLH Transport Model

5.4 Travel Time Savings

In the following sections we present the results from the transport model regarding the impact on travel time savings for all travel modes. Benefits are shown with a positive sign and costs with a negative sign.

Note that the presented travel time savings are for the opening year of Borgarlínan in 2024. In the socioeconomic analysis, the traffic impacts are forecasted with an annual growth of 1.04 percent. The number is based on Reykjavik Municipality road section traffic counts in the Capital Area between the years 2002-2018.

The traffic impacts are reported for existing, diverted and induced travellers where:

- Existing travellers are the travellers that perform a trip with the same transport mode both with and without Borgarlínan.
- Diverted travellers are travellers that shift transport mode due to Borgarlínan. If a negative value, there are less travellers then before. If there is a positive value more trips are performed which were previously done with another transport mode.
- Induced travellers represent new and additional trips when positive. These are caused by a reduction in the cost of transport leading to more trips. If negative they represent a reduction in overall number of trips by the specific transport mode.

5.4.1 Traffic Impacts for Cars

Negative net impact for cars

The net traffic consequences for private cars are negative. The abiding drivers are estimated to experience longer driving times for the same trips and slightly more time spent in congestion as well.

Table 5-4 Changes in annual travel times for cars, hours

Type	Travel time	Commute	Business	Other
Existing	Free flow travel time	-27,485	-10,053	-61,806
	Congestion	-18,479	-6,759	-41,553
Diverted/induced	Free flow travel time	-4,490	-1,642	-10,096
	Congestion	-176	-64	-395
Total		-50,629	-18,518	-113,851

Note: The values in the table are the net changes. Thereby, they represent the changes in the consumer surplus which can be monetised using unit values. The impacts in this table are therefore not directly comparable with the gross impacts listed in Table 5-3.
Benefits are with positive sign and costs with negative sign.

Source: SLH Transport Model

The traffic consequences for the road traffic is monetised based on the value per hour of less or extra time spent in traffic. The unit value for time spent commuting and other travel purposes are valued at 2,444 ISK per hour whereas the time for business purposes is valued at 5,781 ISK per hour. The value per hour can be seen in Table 5-5 below.

The cost of time spent in congestion is higher than the cost of driving in free flow traffic due to the nuisance the driver experiences.

Table 5-5 Price per hour in traffic, ISK/hour

Subject	Commute	Business	Other
Free flow travel time	2,444	5,781	2,444
Congestion time	3,666	8,671	3,666

Note: 2020 price level and in market prices
Source: See Appendix A

The net present value of the consequences for the car drivers is a total cost of 9,4 billion ISK over the entire analysis period of 30 years.

Table 5-6 NPV of the socioeconomic impacts for cars, billion ISK

Subject	Commute	Business	Other	**Total**
Free flow travel time	-1.9	-1.7	-4.0	**-7.7**
Congestion	-1.7	-1.5	-3.5	**-6.7**
Total	**-3.6**	**-3.2**	**-7.6**	**-14.4**

Source: Calculations performed in TERESA by Mannvit and COWI

5.4.2 Impact for Public Transport Passengers

Overall the project leads to a service improvement for the public transport passengers

The opening of Borgarlínan will result in increased service levels for public transport passengers and their travel time will be reduced. The travel time will be reduced since the frequency of departures increases and the BRT will have right of way at selected sections and therefore will not be affected by congestion.

Public transport passengers are estimated to experience an overall improvement in all service factors i.e. travel time, waiting time, access time to and from stations, hidden waiting time and number of transfers. There may be some passengers that will experience increased number of transfers or travel time, but these are outnumbered by passengers experiencing improvements.

The service improvement is estimated to lead to more (induced) public transport passengers. The change in the service level is causing the shift towards public transport.

Table 5-7 Changes in travel times for public transport users, hours and number of shifts

Type	Travel time	Commute	Business	Other
Existing	Travel time	126,955	27,235	133,088
	Delay	0	0	0
	Waiting time	87,293	18,727	91,510
	Origin/Dest. Time	35,891	7,700	37,625
	Transfer time	11,409	2,448	11,960
	Hidden waiting time	54,915	11,781	57,568
	Number of shifts	54,035	11,592	56,645
Diverted/induced	Travel time	50,952	10,930	53,413
	Delay	0	0	0
	Waiting time	40,143	8,612	42,082
	Origin/Dest. Time	45,000	9,654	47,174
	Transfer time	7,857	1,685	8,236
	Hidden waiting time	22,236	4,770	23,311
	Number of shifts	123,655	26,527	129,628

Note: The values in the table are the net changes. Thereby, they represent the changes in the consumer surplus which can be monetised using unit values. The impacts in this table are therefore not directly comparable with the gross impacts listed in Table 5-3.
Benefits are with positive sign and costs with negative sign.
Source: SLH Transport Model

Travel time in public transport is valued at the same unit value as for private car. However, a trip with public transport also includes access time and waiting time. Furthermore, there may be transfer time in case the journey includes a shift. The access time is valued the same as in vehicle travel time whereas delays are valued at a factor three higher and waiting time as a factor of two higher than regular travel time. Transfer time is valued at a factor of one and a half. Shifts are valued at 244 ISK per shift.

Table 5-8 Price per hour and shift for public transport users, ISK/hour and ISK/shift

Travel time	Unit	Commute	Business	Other
Travel time	ISK/hour	2,444	5,781	2,444
Delay	ISK/hour	7,331	17,343	7,331
Waiting time	ISK/hour	4,888	11,562	4,888

Travel time	Unit	Commute	Business	Other
Origin/Dest. Time	ISK/hour	2,444	5,781	2,444
Transfer time	ISK/hour	3,666	8,671	3,666
Hidden waiting time	ISK/hour	1,955	4,625	1,955
Shifts	ISK/shift	244	578	244

Note: 2020 price level and in market prices
Source: See Appendix A

The net present value of the benefit for the public transport passengers is 93.6 billion ISK over the entire analysis period of 30 years. The main benefit stem from reduced travel time and reduced waiting time with respectively 26.8 billion ISK and 38.3 billion ISK.

Table 5-9 NPV of socioeconomic benefits for public transport passengers, billion ISK

Travel time	Commute	Business	Other	Total
Travel time	10.7	5.5	10.5	26.8
Delay	0.0	0.0	0.0	0.0
Waiting time	15.4	7.9	15.0	38.3
Origin/Dest. Time	4.9	2.5	4.8	12.2
Transfer time	1.7	0.9	1.7	4.3
Hidden waiting time	3.7	1.9	3.6	9.3
Shifts	1.1	0.6	1.0	2.7
Total	37.5	19.3	36.7	93.6

Source: Calculations performed in TERESA by Mannvit and COWI

5.4.3 Traffic Impacts for Delivery Trucks and HGV

Delivery trucks and heavy goods vehicles are estimated to experience minor changes in travel and congestion time.

Table 5-10 Changes in travel times for DTV and HGV, hours

Type	Travel time	DTV	HGV
Existing	Free flow travel time	-9,505	-4,828
	Congestion	-6,431	-3,239
Diverted/induced	Free flow travel time	-1,543	-772
	Congestion	-60	-30

Type	Travel time	DTV	HGV
Total		-17,539	-8,869

Note: *The values in the table are the net changes. Thereby they represent the changes in the consumer surplus which can be monetized using unit values. The consequences in this table are therefore not directly comparable with the gross consequences listed in Table 5-3.*
Benefits are with positive sign and costs with negative sign.
Source: *SLH Transport Model*

The traffic consequences for the commercial road traffic is monetised based on the value per hour gained or lost in traffic. The value per hour can be seen in Table 5-11 below.

The cost of time spend in congestion is higher than the cost of driving in free flow traffic due to the nuisance the driver experience.

Table 5-11 Price per hour in traffic, ISK/hour

Travel time	DTV	HGV
Free flow travel time	6,394	8,551
Congestion	8,951	11,971

Note: *2020 price level and in market prices*
Source: *See Appendix A*

The cost of the increased travel time for DT and HGV amount to 5 billion ISK over the entirety of the analysis period.

Table 5-12 NPV of the socioeconomic impact for DT and HGV, billion ISK

Travel time	DTV	HGV	Total
Free flow travel time	-1.7	-1.1	-2.7
Congestion	-1.4	-0.9	-2.2
Total	-3.0	-2.0	-5.0

Source: *Calculations performed in TERESA by Mannvit and COWI*

5.4.4 Traffic Impacts for Bicycles

Net benefit for bicycles

Bicycles are estimated to experience an improvement in travel time. The travel time improvements originate from several improvements in the bicycle infrastructure.

Table 5-13 Changes in annual travel times for bicycles, hours

Type	Commute	Business	Other
Existing	4,436	965	4,341

Type	Commute	Business	Other
Diverted/induced	3,906	850	3,822
Total	8,342	1,815	8,163

Note: *The values in the table are the net changes. Thereby they represent the changes in the consumer surplus which can be monetized using unit values. The consequences in this table are therefore not directly comparable with the gross consequences listed in Table 5-3. Benefits are with positive sign and costs with negative sign.*

Source: *SLH Transport Model*

The travel time for bicycles are monetised at the same value per hour as private cars and public transport.

Table 5-14 Price per hour in traffic for bicycles, ISK/hour

Travel time	Commute	Business	Other
Free travelling time	2,444	5,781	2,444

Note: *2020 price level and in market prices*

Source: *See Appendix A*

The net present value of the consequences for the bicycles is a total benefit of 1.2 billion ISK over the entire analysis period of 30 years.

Table 5-15 NPV of the socioeconomic impact for bicycles, billion ISK

	Commute	Business	Other	Total
Total	0.5	0.3	0.5	1.2

Source: *Calculations performed in TERESA by Mannvit and COWI*

5.5 Vehicle Operating Costs

Cars, delivery trucks and heavy goods vehicles are estimated to have a negative impact because of Borgarlínan regarding vehicle operating costs.

Table 5-16 Changes in annual net km for cars, DT and HGV, km

Type	Commute	Business	Other	DTV	HGV
Existing travellers	-853,594	-307,824	-2,056,359	-293,287	-147,486
New travellers	-84,445	-30,453	-203,434	-28,737	-14,368
Total	-938,039	-338,276	-2,259,793	-322,024	-161,854

Note: *The values in the table are the net changes. Thereby they represent the changes in the consumer surplus which can be monetized using unit values. The consequences in this table are therefore not directly*

comparable with the gross consequences listed in Table 5-3.
Benefits are with positive sign and costs with negative sign.

Source: SLH Transport Model

The cost of driving is 53 ISK per km for commuting and for other purposes, whereas the cost is 48.87 ISK per km for business purposes. The cost of driving is 51.40 and 114.65 ISK per km for delivery trucks and heavy goods vehicles respectively.

Table 5-17 Price per km, ISK/km

Subject	Commute	Business	Other	DTV	HGV
Vehicle km	53.47	48.87	53.47	51.40	114.65

Note: 2020 price level and in market prices
Source: See Appendix A

The net present value of driving costs amount to 3.7 billion ISK over the analysis period of 30 years. The vehicle operating costs amounts to a total cost as cars, DTs and HGVs are estimated to experience a reduction in consumer surplus.

5.6 Changes in Cost of Traffic Accidents

Traffic crashes are a cost to society

Traffic crashes with casualties often result in substantial costs. Especially to the parties involved but also to society. The cost of crashes can broadly be divided into material costs (e.g. damages, administrative costs, medical expenditures etc.) and immaterial costs (e.g. shorter lifetimes, pain and suffering etc.)

Based on the transport model, it is furthermore possible to estimate the changes in traffic volumes and thereby the risk of crashes.

From 2009 to 2018, there were between 357 and 469 annual accidents with causalities (excl. cyclist only crashes) and between 3,443 and 4,475 annual accidents with material damage only.

Estimated reduction in annual crashes due to Borgarlínan and a shift in the modal split

With the reduction in road traffic due to Borgarlínan the risk of crashes will be reduced. It is therefore estimated that the introduction of Borgarlínan will lead to a reduction of crashes in 2024 of:

- 2 crashes with 3 causalities[21]
- 27 crashes with materiel damage only

The large number of avoided accidents stem from a high level of number of crashes in the baseline. It has not been possible to take into account that the level of walking will increase and thereby experience an increased crash risk for pedestrians. The estimate in this analysis should therefore be seen as the upper

[21] Causalities covers all levels of personal damages from slight injuries to fatalities.

possible benefit in the avoided crashes. The vehicle for busses will increase which can lead to an increased risk of accidents. However, this risk is partly reduced by dedicated bus lanes for the BRT.

The avoided crashes lead to a socioeconomic benefit monetised at the cost of the type of crash.

Table 5-18 Socioeconomic benefit of avoided accidents, million ISK/accident

Subject	Crash with causalities	Material damage only accidents
Benefit per avoided accident	15.5	0.8

Note: 2020 price level and in market prices
Source: See Appendix A

The net present value of the benefit of the avoided accidents amount to 2.6 billion ISK over the 30-year period of the analysis.

5.7 Revenues

Increased revenue from additional passengers

The revenue stream to Strætó will increase as more people will use public transport.

The average bus fare in 2018 was 214 ISK per passenger.[22] The Borgarlínan is not currently planned to lead to changes in the fares. We have therefore adjusted the average fare to 2020 price level. With just below 50,000 expected daily trips with public transport in 2024, the net present value of the increase in revenues from BRT and bus passengers is 9,6 billion ISK over the entire analysis period of 30 years. The expected traffic growth has been taken into account in the estimation of future revenues.

5.8 Environmental impact

The project causes external effects to the environment, neighbours and others. These so-called externalities result from the change in modal split and km driven. With the shift away from (today) dominantly fossil fuelled private cars to public transport based on renewable energy the emissions of transport in the Capital Area will lead to environmental and climate benefits. Furthermore, the shift is expected to lead to a reduction in noise pollution due to traffic. The shift towards a car fleet running on renewable energy is incorporated in the unit values for noise, air pollution and climate.

[22] Fare revenue of 1,952 million ISK. 11,405,692 boardings and an estimated 9,125,000 passengers (Strætó, 2018).

Valuation of externalities based on changes in vehicle km

The monetisation of externalities is based on the change in gross km for the different traffic modes. This is the common method for valuation of externalities.

The vehicle km of cars, delivery trucks and heavy goods vehicles is estimated to fall by approximately 40,000 km, 750 km, and 370 km, respectively, per day due to Borgarlínan. The vehicle km by bus is, however, estimated to increase by appr. 12,640 km per day.

Table 5-19 Changes in gross km per transport mode per day in 2024, km

	Cars	DT	HGV	Busses
Basis	5.528.958	492.867	251.594	30.545
With Borgarlína	5.488.333	492.117	251.221	43.188
Change in km	-40.624	-749	-372	12.642

Note: Change in gross km.
Source: SLH Transport Model

The unit values for externalities are based on the average air pollution, climate impact and noise impact per vehicle km driven per transport mode.

Table 5-20 Unit prices for externalities per km in 2020, ISK/km

Subject	Cars	DT	HGV	Busses (electric)
Air pollution	0.36	1.08	2.75	0.29
Climate	0.43	0.60	2.18	0.02
Noise	2.72	4.61	16.83	3.27

Note: 2020 price level and in market prices. For busses the change in km is solely from the BRT and is therefore based on electric busses.
Source: See Appendix A

The net present value of externalities amounts to 0.8 billion ISK over the entire period of analysis of 30 years. The primary benefit stems from the decrease in km driven in cars and thereby a reduction in air pollution, CO_2 and noise.

Table 5-21 Socioeconomic benefit of externalities, million ISK

Subject	Cars	Delivery trucks	HGV	Busses	total
Pollution	52	6	8	0	66
Climate	101	6	11	0	118
Noise	526	27	49	-1	602
Total	679	39	68	-1	786

Note: *2020 price level and in market prices*

Source: *See Appendix A*

6 Results of the Socioeconomic Analysis

Borgarlínan Phase 1 is economically feasible with a net present value of 25.6 billion ISK and an internal rate of return of 7 percent and above the thresholds of a net present value of 0 and an internal rate of return of 4 percent. This means that the benefits to society are larger than the costs imposed. The main benefit is the travel time savings for public transport passengers. In total the user impacts amount to 71.2 billion ISK.

The shift towards public transport is estimated to lead to a positive impact on accidents, noise, pollution and climate change of 3.4 billion ISK over the entire analytical period as traffic.

Table 6-1 Borgarlínan socioeconomic summary results

Billion ISK	NPV
Construction costs:	-25.4
Operational costs:	-17.1
User impacts:	71.2
External impacts:	3.4
Other consequences:	-6.5
Net present value	**25.6**
Internal rate of return	**6.96 %**
Net benefit to cost ratio	**0.5**

Note: All benefits are with a positive sign whereas all costs are denominated with a negative sign.
Source: COWI and Mannvit

The detailed results of Borgarlínan Phase 1 are shown in Table 6-2 below. The net present value of the construction costs consists of the cost of Borgarlínan up front as well as the benefit of the assets at the end of the analysis period discounted back to 2020. The scrap value is included in the socioeconomic analysis as the asset still is of value given an adequate level of maintenance and rehabilitation.

The change in operational costs consist of three elements; changes in the operational costs of the general road infrastructure, the operational costs of Strætó and the changes in revenue to Strætó.

The user impacts cover the travel time benefits for all analysed travel modes as well as the vehicle operating costs and the user health impacts. The main benefits accrue to bicycles and the public transport user whereas cars, DTs and HGVs is estimated to experience a net loss.

Table 6-2 Borgarlínan socioeconomic results, detailed

Billion ISK	NPV
Construction costs:	**-25.4**
Construction costs	-35.4
Scrap value[1]	10.0
Operational costs:	**-17.1**
Operational costs, road infrastructure	0.1
Operational costs, bus	-26.8
Revenues, public transport	9.6
User impacts:	**71.2**
Travel time benefits, road (cars, DT, and HGV)	-19.4
Travel time benefits, road (bicycles)	1.2
Travel time benefits, public transport	93.6
Travel time benefits, freight	-0.1
Vehicle operating costs, road (cars, DT, and HGV)	-3.7
Driving costs, road (bicycles)	0.0
User health impact (bicycles)	-0.4
External impacts:	**3.4**
Accidents	2.6
Noise	0.6
Air pollution	0.1
Climate (CO_2)	0.1
Other consequences:	**-6.5**
Tax distortion	-3.4
External health impacts (bicycles)	-2.0
Marginal cost of public funds (funding of infrastructure)	-4.6
Marginal cost of public funds (productivity improvements)	3.5
Net present value	**25.6**
Internal rate of return	**6.96 %**
Net benefit to cost ratio	**0.5**

Note: All benefits are with a positive sign whereas all costs are denominated with a negative sign.

1. Scrap value is the discounted value of the road infrastructure at the end of the analysis period. An adequate level of maintenance and rehabilitation has been assumed.

Source: COWI and Mannvit

The change in external impacts covers socioeconomic benefits regarding accidents, noise, air pollution and climate with reductions in all of these.

Other consequences cover the impact on public funds and GDP due to funding of the infrastructure with public funds and productivity improvements due to lower travel times that can partly be used productively for society.

7 Sensitivity analysis

The socioeconomic study of Borgarlínan Phase 1 shows that the project is economically feasible. However, the result of the socioeconomic analysis is based on several assumptions. We therefore perform a sensitivity analysis in order to see how robust the result is to changes in the primary assumptions.

Constructions costs higher by 25 percent

The realized construction cost is often higher than first anticipated during the planning phase of an infrastructure project. Besides the risk premium of 50 per cent added to the construction cost, we perform a sensitivity analysis of an increase in the construction costs of an additional 25 percent.

Operational costs increase of 50 percent

Is the project still feasible if the operational cost is 50 per cent higher than budgeted? We perform a sensitivity test of an increase of operational cost of 50 percent.

Value of travel time reduced by 25 percent

The main driver behind the economic benefit of the Borgarlína is the travel time savings for the public transport passengers. We therefore investigate whether the project is still feasible if the travel time savings are reduced by 25 percent.

External costs lower by 25 percent

Borgarlina imposes positive externalities such as a reduction in pollution, CO_2 reduction and a lower risk of accidents. We perform a sensitivity analysis of the feasibility of Borgarlína under the assumption that the value of the externalities is reduced by 25 percent.

Changes in parking

Increased parking cost is a way to encourage public transport use, walking and cycling. We therefore evaluate the impact of increased parking cost with 20 percent in selected areas and converting some currently free parking into paid parking.

Reduced car ownership

It is expected that the car ownership in the capital area will decrease due to Borgarlína. It is therefore tested what the effects of reduced car ownership for multifamily houses by 5.3 percent and single-family houses by 1.3 percent would be.

Annual traffic growth of 0 percent and 2 percent

It is assumed that the traffic level in the capital area will increase by 1.04 percent annually as it has done in the years 2002-2018. We investigate if the project is still economically feasible in case of annual traffic growth in the Capital area of 0 percent. We also investigate the impact given a traffic growth of 2 percent.

7.1 Results of the Sensitivity Analysis

The results of the sensitivity analysis are summarised in Table 7-1 below. The results are robust towards changes in all the tested assumptions. The economic feasibility of Borgarlínan is mainly sensitive towards a low realization of travel time savings of the existing and future public transport passengers where a reduction of travel time values of 25 percent will result in an internal rate of return of 4.7 percent and thereby close to the threshold of 4 percent.

Table 7-1 Summary of sensitivity analysis

billion ISK	NPV, Internal rate of return (threshold = 0)	Internal rate of return (threshold = 4 %)
Main results	**25.6**	**7.0%**
High construction cost, +25%	22.8	6.4%
High operational costs, 50%	11.2	5.3%
Low value of time values, -25%	5.8	4.7%
Low external costs, - 50%	25.2	6.9%
Parking changes	26.1	7.0%
Reduced car ownership	67.1	11.0%
Zero traffic growth	15.8	6.0%
2 percent annual traffic growth	36.4	7.9%

8 BRT as an Enabler of Green Transition and Urban Development

A BRT is a climate- and user-friendly public transit solution that runs in a separate or congestion-free alignment similar to light rail. Implementation of a BRT line secures a low carbon transport alternative to private cars at a lower investment cost, and with a shorter construction period than for metro and light-rail.

A BRT ticks all three strategic elements of sustainable transport solutions as described in Dalkman et al. (2007) which aim at ensuring mobility while reducing the negative impacts of transport (e.g. congestion):

- Transport avoidance: Create sustainable (urban) infrastructure through proper urban development and transport planning, in turn increasing mobility and accessibility without creating excessive transport.

- Shifting to more sustainable modes: Promote use of more sustainable and low carbon transport modes such as walking, cycling and public transport as alternatives to cars – e.g. through better facilities and infrastructure such as a BRT line.

- Transport efficiency: Improve transport technologies and transport flows in order to provide the needed transport in the most efficient way.

A successful implementation of Borgalínan can push and inspire other green mobility initiatives and a wider implementation of BRT lines thus further helping the green transition. In many situations, a BRT is considered an attractive transport solution to create better mobility in cities around the world for the reasons mentioned above. A BRT solution can solve congestion challenges by offering an alternative to driving a car. A BRT should also be seen as an opportunity to facilitate urban development by boosting a city considerably by creating cohesion between urban development and public transport.

A literature review suggests that BRT lines can attract many passengers if travel time reductions are significantly high, which in turn will lead to attractive areas surrounding the BRT line with increasing property values in close proximity to stations (DTU, 2018). Literature concerning effects of metro and light rail lines suggest that a new line can act as a growth enabler for business. An international review on the effects of new bus and rail rapid transit systems finds that no significant deviations could be identified between effects on property values resulting from BRT, LRT, and metro systems, respectively (DTU, 2018). However, these effects are already at least partly included in the socioeconomic assessment through the monetised travel time savings[23].

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[23] In the socioeconomic analysis we assume a market in perfect competition why an increase in housing prices is caused by the accessibility created by the shorter travel times which is already monetized in the analysis.

Investment in reliable sustainable public transport benefits across all income groups and can be particularly important for households without other viable alternatives (e.g. households with no car ownership).

9 Conclusion and Recommendations

This socioeconomic analysis of Borgarlínan Phase 1 is the first socioeconomic analysis of a major road transport infrastructure investment in Iceland. The groundwork for consistent evaluation of infrastructure projects has now been made. For future transport infrastructure projects, the methodology for socioeconomic analysis can be re-used to analyse different solutions in order to identify the solution with the highest return on investments from a socioeconomic perspective.

The main results of the Borgarlínan socioeconomic analysis are:

- Phase 1 of Borgarlínan is economically feasible with a positive net present value of 25.6 billion ISK and an internal rate of return of 7 percent.
- The result is mainly driven by the high benefit to both existing and new public transport passengers amounting to a net present value of 93.6 billion ISK.
- Especially the reduction in travel time and waiting time as a consequence of higher bus speed and frequency drive the benefits for the public transport passengers.
- Cars, delivery trucks and heavy goods vehicles are estimated to experience a net loss of 19.4 billion ISK.
- There are positive external impacts of Borgarlínan with an estimated reduction in annual traffic accidents, as well as in noise, air pollution and CO_2 emissions.
- The sensitivity analysis shows that the feasibility of the project is robust towards changes in the primary assumptions.

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11 Appendices

Appendix A Unit prices methodology

The traffic impacts arising from Borgarlina in this analysis are stated in time savings (hours) and kilometre savings for various transport modes. Moreover, changes in accidents in the capital area are calculated on the basis of the kilometre savings and other factors as outlined in this report. In order to evaluate the traffic impacts in monetary terms a set of unit prices need to be calculated. These unit prices are central to the quantification of costs and benefits linked to the Borgarlínan project and are a key element for welfare economic analysis. In this analysis the unit prices are adapted into the Danish unit price model "Transportøkonomiske Enhedspriser" and are stated in ISK in 2020 prices. The unit prices in question are summarized in the table below and the methodology is explained in the relevant sections going forward.

Table 11-1 Summary of unit prices

	Traffic impact	Unit prices	Modes of transport	Type	Variations
1	Time savings	ISK/hour	Private traffic	Leisure/work/ other	Travel time/delays
			Public transport		Travel time /delays/waiting time/hidden waiting time/change time/change penalty
		ISK/ton-hour	Freight	Average	
2	Vehicle operating costs	ISK/km	Private cars	Average/marginal	
			Bicycles	Average	
			Vans		
			Trucks		
		ISK/hour	Vans	Average	Travel time/delays
			Trucks		
3	External costs – emissions	ISK/kg	All	CO2, PM2.5, NOx, SO2, CO, HC	Urban/rural
		ISK/km	Private	Gasoline, Diesel, Hybrid, Electric	
			Van	Gasoline, Diesel	
			Truck	Diesel	
			Bus	Electric	
	External costs - accidents	ISK/casualty	All	Killed/Severe injury/Minor injury	
		ISK/accident		Average	
		ISK/km	Private	Average	
			Van		
			Truck		

Traffic impact	Unit prices	Modes of transport	Type	Variations
		Bus		
External cost - noise	ISK/SBT	All	Average	
	ISK/km	Private	Gasoline, Diesel, Hybrid, Electric	
		Van	Gasoline, Diesel	
		Truck	Diesel	
		Bus	Electric	
External cost - congestion	ISK/km	Private	Average	
		Van		
		Truck		
		Bus		

A.1 Description of the methodology

Economic data for transport is scarce in many areas in Iceland. Therefore, in many instances, Danish values have to be converted to Icelandic króna with price level indices from Eurostat and/or ratios of GDP-PPP per capita between Iceland and Denmark as recommended by the EU for values based on willingness to pay.

A.1.1 Time values

The values of travel time savings are quantified with the so-called „value of time" and are split on travel purpose and types of travel time (ordinary travel time, delays, waiting time etc.). The methodology underlying the value of time is based on the The Danish Value of Time Study. The Icelandic value for ordinary travel time is calculated according to the principles set out in the study with the value calculated as 65% of disposable income per hour according to Statistics Iceland. The relative factors between ordinary travel time, delays, waiting time etc. are kept the same as in Denmark. The value of travel time for business purposes however is based on compensation of employees in the national accounts and total hours worked in the base year according to Icelandic productivity statistics.

Table 11-2 Travel time values for 2020 in 2020-prices

ISK per person-hour	Commuting	Business	Other private purposes	Average
Public travellers				
Travel time	2,444	5,781	2,444	2,760

ISK per person-hour	Commuting	Business	Other private purposes	Average
Delays	7,331	17,343	7,331	8,280
Waiting Time	4,888	11,562	4,888	5,520
Hidden waiting time	1,955	4,625	1,955	2,208
Change time	3,666	8,671	3,666	4,140
Change penalty (ISK per	244	578	244	276
Car drivers				
Travel time	2,444	5,781	2,444	2,763
Delays	3,666	8,671	3,666	4,145
Cyclists				
Travel time	2,444	5,781	2,444	2,546
Delays	3,666	8,671	3,666	3,819

Table 11-3 Travel time values for vehicles for 2020 in 2020-prices

ISK per vehicle-hour	Commuting	Business*	Other private	Average
Cars				
Travel time	2,625	6,326	3,715	3,685
Delays	3,937	9,489	5,573	5,527

The values of time for goods transport only cover the time values of the goods. Since no specific Icelandic study on the values of time for goods has been performed the value is converted with a ratio of GDP/PPP per capita between Iceland and Denmark as recommended by the European Union when transferring unit prices based on willingness to pay.

Table 11-4 Values of time for goods transport for 2020 in 2020-prices

ISK per ton-hour	Road
Driving time	59.43

A.1.2 Driving costs

The driving costs for passenger cars describe the costs per km driven. Icelandic data is somewhat lacking in this area and cannot be easily adapted to the setup in "Transportøkonomiske Enhedspriser". Therefore the bulk of the costs are based on Danish unit costs originally compiled by COWI and converted with ratio of PPP price level indices between Denmark and Iceland according to Eurostat.

However, gasoline/diesel/electricity costs are based on Icelandic data. The future projections for energy usage in the private car fleet is based on a memo compiled by VSÓ consultants for the Association of municipalities in the Capital area and the Road Administration.

Table 11-5 Driving costs for private passenger cars for 2020 in 2020-prices

ISK per km	Average Excl. tax	Average Incl. tax	Marginal Excl. tax	Marginal Incl. tax
Propellant	5.593	13.333	5.593	13.333
Battery (hybrids and EV's)	0.271	0.336	0.110	0.137
Tires	2.193	2.719	2.193	2.719
Repair and maintenance	17.750	22.010	6.817	8.454
„Bifreiðagjöld"	-	1.108	-	-
Depreciation	9.650	13.963	2.303	3.327
Total	35.456	53.469	17.016	27.970

Table 11-6 Driving costs for passenger cars, business for 2020 in 2020-prices

ISK per km	Average factor price	Average market price	Marginal factor price	Marginal market price
Costs excl.tax	35.456		17.016	
Taxes (not refundable)	6.950		5.579	
Costs incl.tax	42.406	48.871	22.596	26.041

The driving costs for vans and trucks include costs for fuel, tires, repair and maintenance, and depreciation, and the costs are split into fixed costs (given per hour) and variable costs (given per km). Delays are given an extra time value of 40%. The same method is applied here as for private cars. The salary is calculated according to Icelandic data and average annual running hours according to Danish data.

Table 11-7 Distance related costs for delivery trucks and heavy good vehicles for 2020 in 2020-prices

ISK per km	Delivery truck	Heavy good vehicles
Propellant	8.39	28.68
Tires	2.89	8.40
Repair and maintenance	14.01	13.64
Depreciation	2.20	5.80

ISK per km	Delivery truck	Heavy good vehicles
Costs excl. taxes	27.48	56.51
Taxes (not refundable)	17.12	42.97
Costs incl. tax	44.60	99.49
Costs incl. tax (market prices)	51.40	114.65

Note: All prices are in factor prices unless otherwise stated

Table 11-8 Time related costs for delivery trucks and heavy good vehicles for 2020 in 2020-prices

ISK per hour	Delivery truck	Heavy good vehicles
Depreciation	113	1,026
Salaries	4,381	4,902
Repair and maintenance	233	344
„Kapacitetsomkostninger“	820	1,148
Costs excl. taxes	5,548	7,419
Costs incl. tax (market prices)	6,394	8,551

Note: All prices are in factor prices unless otherwise stated

A.1.3 External costs

Traffic imposes negative externalities on society in the form of air pollution, noise, accidents, congestion and wear on the infrastructure.

Emissions, climate, noise and congestion

The values for air pollution, noise and congestion stated below have been converted from Danish unit prices and are primarily linked to willingness to pay. The common approach for WTP unit transfers recommended by the „Handbook on the external costs of transport“[24] consists of multiplying the unit values by the ratio of income in the policy country to income in the study country with an income elasticity of 0,8. The emission values for electric vehicles are adjusted further down due the the renewability of Iceland’s electricity production.

Table 11-9 Kilometre based external cost for 2020 in 2020-prices

ISK per km	Fuel	Capacity	Air pollution	Climate change	Noise	Congestion
Private car	Petrol	4 pers	0.25	0.50	2.92	11.95
	Diesel	4 pers	0.63	0.42	2.92	11.95

24 https://ec.europa.eu/transport/sites/transport/files/studies/internalisation-handbook-isbn-978-92-79-96917-1.pdf

ISK per km	Fuel	Capacity	Air pollution	Climate change	Noise	Congestion
	Electric.	4 pers	0.04	0.00	1.01	11.95
Van	Petrol	1.5 t	0.50	0.85	4.61	17.31
	Diesel	1.5 t	1.08	0.60	4.61	17.31
Truck	Diesel	16 t	2.75	2.18	16.83	26.91
Bus	Electric.	40 pers	0.29	0.02	3.27	22.04

The climate change or CO_2 emission costs are based on market prices for CO_2 quotas.

Accidents

Accidents costs can be divided into the following social cost categories:

- Direct public expenditures
  - Police and rescue cost
  - Medical treatment cost
- Indirect costs for society
  - Net production loss
- Loss of ”human value”
  - Value of statistical life
- Property damage costs

The various cost components are calculated separately for fatalities, severely and lightly injured in the Danish unit prices following the official European classification of accident casualties. The data on accidents costs in Iceland is limited however. Thus the direct costs are converted to Icelandic króna with price level indices from Eurostat. The Value of statistical life is calculated according to the recommendations set out in Handbook of External costs of Transport for values based on willingness to pay i.e. with a ratio of GDP-PPP per capita. The average accident costs for each component are subsequently calculated by multiplying with ratios derived from accident statistics from the Icelandic Transport Authority (Samgöngustofa).

Table 11-10 Accident cost for persons for 2020 in 2020-prices

ISK per	
Death	615,269,933
Seriously injured	96,431,653
Lightly injured	12,443,455
Average	21,325,294

Table 11-11 Accident cost for persons for 2020 in 2020-prices

ISK per	
Reported accident	6,555,936
Reported accident with injury	56,492,159
Reported injury	21,570,319

A.1.4 Prices, average tax rate and the distortion rate

All prices have to be stated in market prices i.e. consumer prices and have to be inflated from the base year to the year chosen in "Transportøkonomiske Enhedspriser":

- Price level calculations: Projections for GDP/capita and population projections are used to project values based on willingness to pay. Moreover, projection for the consumer price index are used for other unit prices.

- The average tax: The so called „net tax factor" approximates the average indirect tax burden in Icelandic society and is calculated as the ratio between GDP in market prices and factor prices. It is used throughout the analysis to convert factor prices to market prices. The average tax is calculated as 15%.

- The tax distortion rate: The rate reflects the deadweight loss of taxes and is a markup applied to the draw on public funds in Teresa. The distortion rate is calculated as 8% and is scaled down from the danish value of 10% with a ratio of taxes as a share of GDP between the two countries.

Appendix B Prerequisites for calculations

In order to calculate the socioeconomic value of Phase 1 of Borgarlína and taking into account the effect on public budgets, a series of assumptions are necessary. These are summarised in Table 11-12 below.

Table 11-12 Additional assumptions

Subject	Assumption
Price level	2020 prices, market prices
Dead weight loss	8 %
Factor for cost of public funds	1.28
Opening year	2024
Construction period	2021-2023
Year of NPV	2020
Social discount rate	4 % for the first 35 years hereafter 3 %
Annual traffic growth	1.04 %

Source: COWI, Mannvit and Vegagerdin

Appendix C Methodology for Consumer surplus and Rule of a half

THE RULE OF HALF

The Rule of Half (RoH) relies on the consideration that, without the project, non-travelling users Willingness To Pay (WTP) is lower than the (prior) generalised cost of transport. After project implementation the (new) generalised cost of transport is lowered so that some previously non-travelling people decide to travel.

Although the absolute WTP is not known, the average change in consumer surplus of the generated traffic can be estimated as half of the difference between the original and the new generalised costs of transport on the improved mode for a given origin-destination (O-D) relation. It is half because a linear demand/cost graph is assumed where new users are spread evenly between two extremes: those requiring marginal motivation to start travelling (their WTP is already on the cusp between travelling and not travelling, so they get the full benefit of the change in generalised costs) and those requiring the full benefit of the change to the transport system to be motivated to travel (they get marginal net benefit). The RoH can be therefore expressed by the following formula:

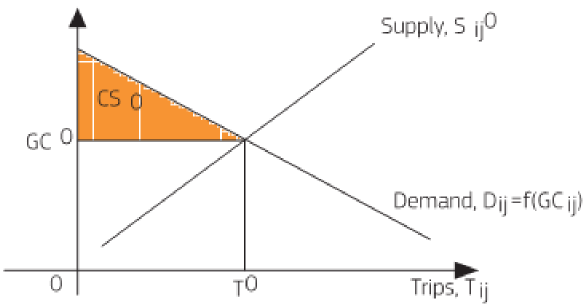
$$gc = p+z+v\tau$$

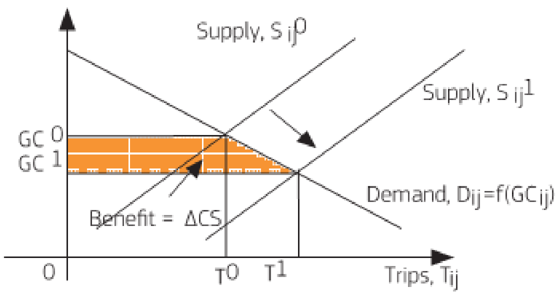
where: p is the amount paid for the trip by the user (tariff, toll); z is the perceived operating costs for road vehicles (for public transport is equal to zero);τ is the total time for the trip; v in the unit value of travel time.

Total consumer's surplus (CS^0) for a particular i and j in the Business As Usual (BAU) scenario is shown diagrammatically in the first figure. It is represented by the area beneath the demand curve and above the equilibrium generalised cost, area CS^0.

$$\text{User benefit} = \text{Consumer's surplus}_{ij}^{1} - \text{Consumer's surplus}_{ij}^{0}$$

where: 1 is the do-something scenario and 0 is the BAU scenario.





If there is an improvement in supply conditions the consumer's surplus will increase by an amount of ΔCS, due to a reduction in equilibrium generalised cost and the total user benefit (for existing and new users) can be approximated by the following function, known as the rule of a half:

$$\Delta CS = \int_{GC_1}^{GC_0} D(GC)dGC \approx \text{Rule of one Half (RoH)} = \frac{1}{2}(GC_0 - GC_1)(T_0 + T_1)$$

For the generated demand only (i.e. for new users), the benefits may be approximated by the following formula :

$$\Delta CS(\text{generated}) \approx 1/2 * (GC0-GC1) * (T1-T0)'$$

In the case of a totally new infrastructure, the RoH will not be directly applicable and the measurement of the benefits depends on the nature of the new mode, its placement in the mode hierarchy and transport network, and will often need to be derived from the users' WTP or calculated with other approaches. For example see various integration and other methods suggested in World Bank Transport Note No. TRN-11 2005.

Source: Authors

Source: *Guide to Cost-Benefit Analysis of Investment Projects, European Commission December 2014*

Appendix D Methodology for Accident assessment

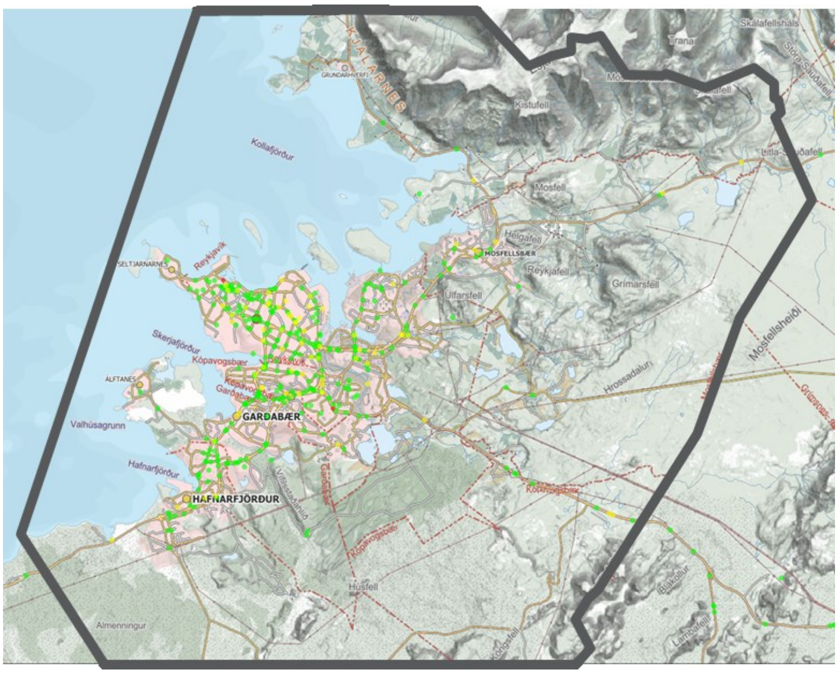
To be able to predict the development in the number of crashes with causalities in the influence area, crash data from Icelandic Transport Authority (Samgöngustofa)[25] have been used. The figures have been compared with the Road Safety Action Plan for Reykjavík where crash data from Reykjavík Municipality for the period 2000 – 2017 can be found[26].

According to the Road Safety Handbook[27] the number of vehicles in the traffic system can be reduced by transferring journeys from individual to public transport. This can limit the amount of traffic, primarily in larger cities and towns where there is a traffic base for a good public transport.

D.1 Influence area

In Figure 11-1 the influence area can be seen: Reykjavík incl. Kjalarnes, Mosfellsbær, Seltjarnarnes, Kópavogur, Garðabær og Hafnarfjörður corresponding to the Capital area (Höfuðborgarsvæðið).

Figure 11-1 The influence area



Crashes on state roads administrated by the Road Administration (Vegagerðin) have been included.

The following can be stated regarding the influence area:

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[25] http://g.map.is/k/kortasja.php?client=us
[26] UMFERÐARÖRYGGISÁÆTLUN, REYKJAVÍKUR, 2019-2023, DRÖG.
[27] TØI, Norway

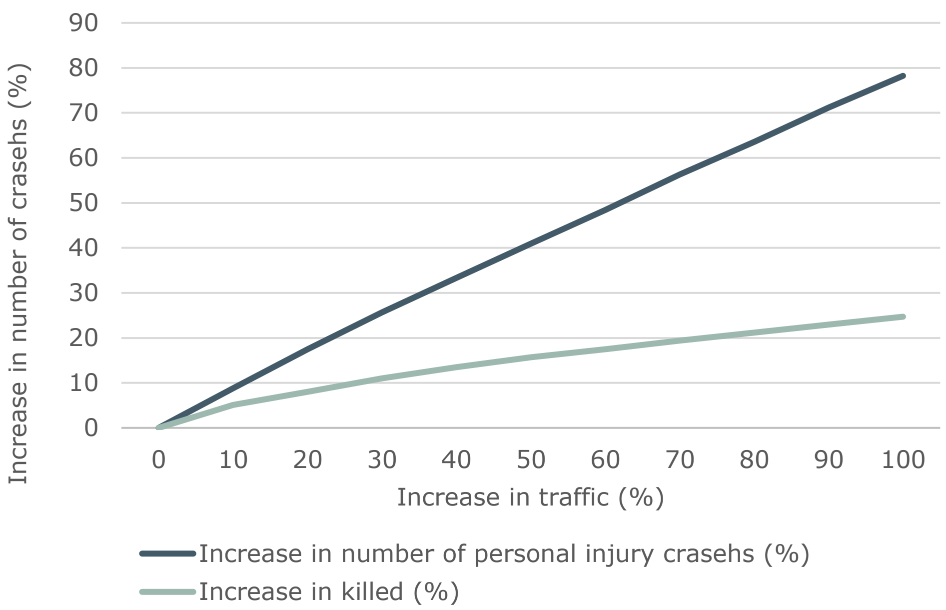
- 65% of all crashes (with and without causalities) in this area are registered in Reykjavík Municipality
- 96% of crashes with causalities are registered in urban areas
- 99% of material damage only crashes are registered in urban area.

This means that if we use an influence area that does not include rural roads, the results will be almost identical.

D.2 Relationship between traffic volume and number of crashes

An older version of the TØI Handbook shows the relationship between change in traffic volume and the change in the number of fatal crashes and the number of personal injury crashes – see Figure 11-2.

Figure 11-2 The relationship between change in traffic volume and the change in the number of fatal crashes and the number of personal injury crashes (TØI)



It is assumed that the opposite applies: decrease in traffic reduces the risk of crashes. Example: reduction in traffic volume by 1 % reduces the number of personal injury crashes by 0.88 %. When the reductions in traffic volume are very low, the relationship is almost linear. According to TØI the estimated confidence interval is [0.77%; 0.99%]) and the figures applies to all types of roads and to all traffic volumes.

The number of killed is very low in the area and will thus not be used separately in the following calculations (included in personal injury crashes also called crashes with causalities).

D.3 Scenarios

There are 4 different scenarios:

- F0_Søk: 2024 without Borgarlínan
- F1: 2024 with Borgarlínan
- F1_B: 2024 Borgarlínan with changes to parking
- F1_C: 2024 Borgarlínan with changes to car ownership.

The traffic volume for each of those scenarios has been calculated:

- F0_Søk: 5,766,295 driven km per day
- F1: 5,726,717 driven km per day
- F1_B: 5,726,105 driven km per day
- F1_C: 5,613,668 driven km per day.

The traffic volume for the basis scenario 2019 (B) is 5.146.081 driven km per day in the area.

Table 11-13 Changes in traffic volume for each scenario compared to basis

Scenario	Traffic volume [driven km. pr. day]				
	Basis 2019 (B)	Basis 2024 (F0_Søk)	Scenario 2024	Changes Basis 2019 (B)	Changes Basis 2024/scenario
F1	5,146,081	5,766,295	5,726,717	12.1%	-0.7%
F1_B	5,146,081	5,766,295	5,726,105	12.1%	-0.7%
F1_C	5,146,081	5,766,295	5,613,668	12.1%	-2.6%

The increase in traffic volume is rather high for all scenarios.

The traffic model shows an increase in traffic volume from 2019 to 2024 by 12.1 %. With Borgarlína the car traffic will be 0.7% lower in 2024 compared to if nothing is done with the F1 and F1_B scenario and 2.6% lower with the F1_C scenario.

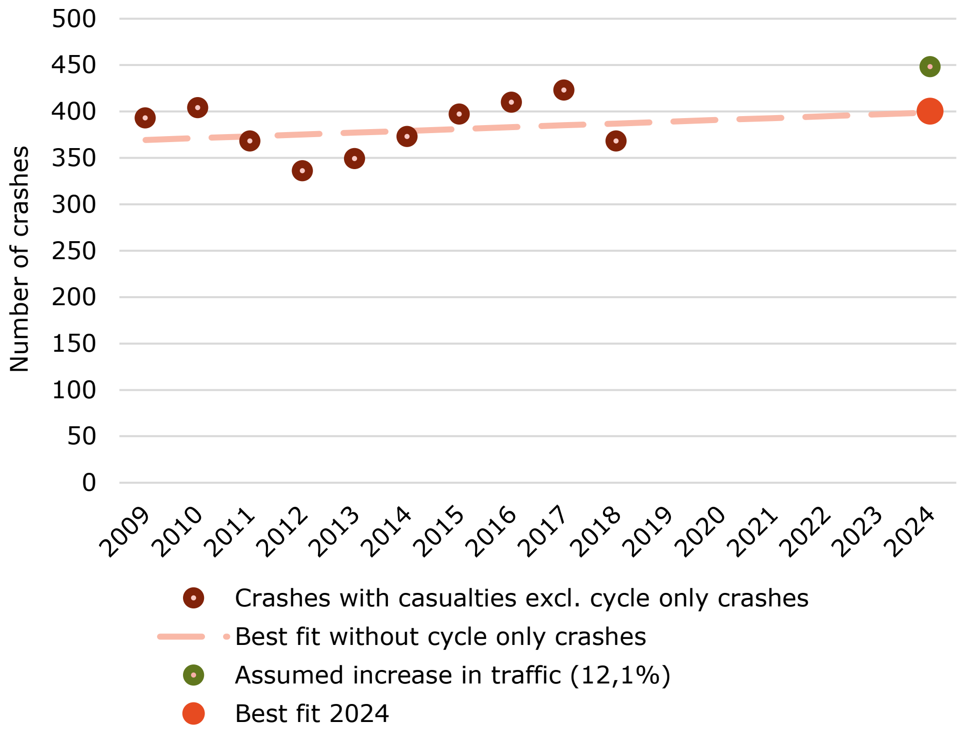
A 0.7% lower traffic volume will result in a decrease in the number of crashes with causalities by 0.5 – 0.7% according to the TØI model shown before and a 2.6% lower traffic volume will result in a decrease in the number of crashes with causalities by 2.3 – 2.6%.

D.4 Development in the number of injury crashes and causalities

In the following calculations crashes involving only cyclists are excluded as those numbers normally do not depend on car traffic volume.

Using best fit for the number of crashes with causalities in the period 2009 – 2018 we can predict around 400 crashes in 2024 (the dotted line and the orange dot) without Borgarlína – se Figure 11-3.

Figure 11-3 Development in the number of crashes with causalities in the area 2009 – 2018 and a prediction on the number in 2024.



If we use the calculations based on increase in daily traffic by 12.1% the increase in the number of crashes will be 10.7 – 12% in the period 2019 to 2024 with a maximum figure of 448 crashes with causalities pr. year (12%). This number fits well with the increase pr. year since 2012 but is higher than the best fit for 2009 – 2018. The prediction for the number of crashes with causalities in 2024 without Borgarlína and other extraordinary road safety measures is thus 400 – 448.

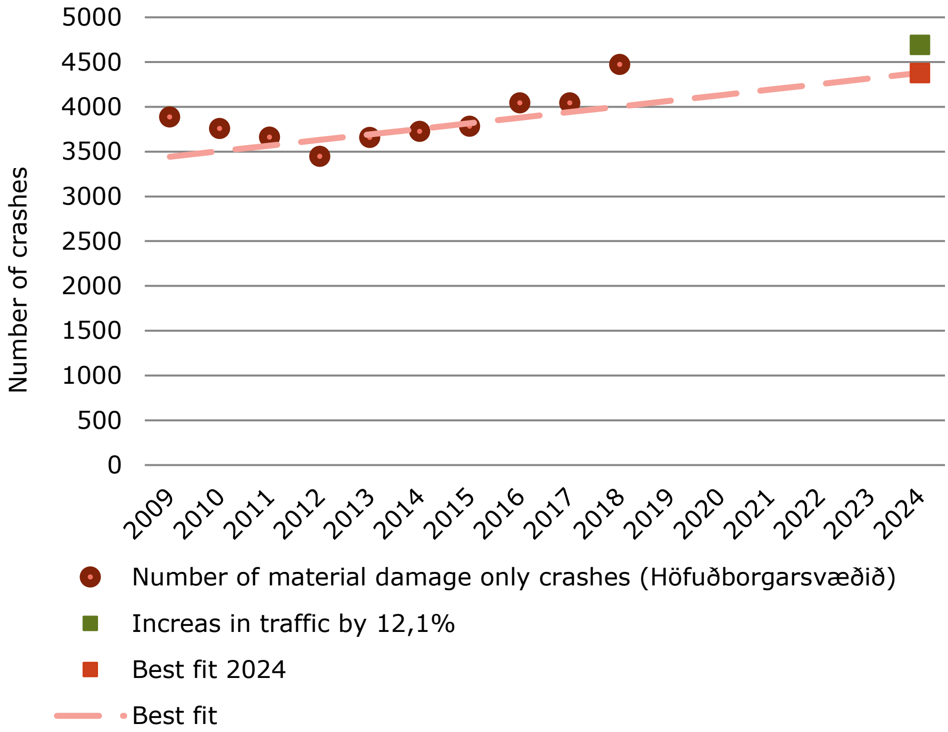
There is no information regarding the number of causalities pr. crash in Iceland, but in Denmark the figure is around 1.2 and will be used here. The prediction for the number of causalities in 2024 is thus 480 – 538 without Borgarlína and other extraordinary road safety measures.

For scenario F1 and F1_B the number of causalities will be 0.5 – 0.7% lower corresponding to 2 – 4 causalities and for scenario F1_C those figures will be 2.3 – 2.6% lower corresponding to 11 – 14 causalities. All figures have been rounded to nearest integer.

D.5 Development in the number of material damage only crashes

If nothing is done 4,379 – 4,695 material damage only crashes can be predicted in 2024 using the same method as described before and presupposing the same relationship between changes in traffic volume and number of crashes as for crashes with causalities.

Figure 11-4 Development in the number of crashes with material damage only in the area 2009 – 2018 and a prediction on the number in 2024.



For F1 and F1_B scenarios the reduction in the number of material damage only crashes can be predicted to be 22 – 33 with and for F1_C the reduction in the number of material damage only crashes can be predicted to be 101 – 122.

D.6 Reservations

The following reservations can be made:

- This is a "nothing else changed" scenario and other road safety measures in the period 2019 – 2024 are thus not included like measures included in Reykjavík Road Safety Action Plan and similar plans for the other Municipalities. Major changes in the road and street network are not included and the influence of COVI-19 virus on economy and traffic is not included
- The calculated numbers depend on the prediction on the number of causalities in 2024
- There will be a decrease on roads/streets with high reduction in traffic but no changes on roads/streets with no changes or even increase on some roads/streets compared to the scenario without Borgarlína
- The calculations should be updated when the number of crashes for 2019 is known for a more accurate prediction in the number of crashes in 2024, but this will probably only give a minor difference.

D.7 Recommendation

To be "on the safe side" 2 casualty crashes, 3 causalities and 27 material damage only crashes in 2024 should be used for F1 and F1_B scenarios for the socioeconomic analyses and 10 casualty crashes, 12 causalities and 111 materiel damage only crashes saved in 2024 for the F_C scenario for the socioeconomic analyses.