Carbon emissions study in the European Straits of the PASSAGE project

Final Report

Prepared for Département du Pas-de-Calais and the partners of the PASSAGE Project

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DISCLAIMER	The project team does not accept any liability for any direct or indirect damage resulting from the use of this report or its content. This report contains the results of research by the authors and is not to be perceived as the opinion of the partners of the PASSAGE Project.
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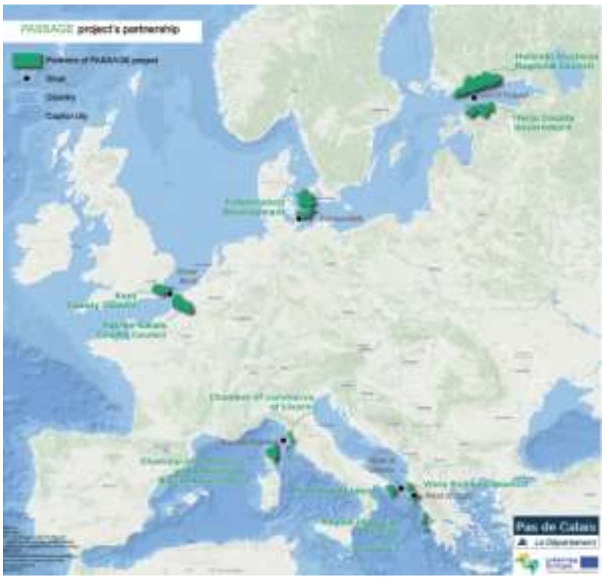
Introduction

1. Context of this study

a) PASSAGE Project



The PASSAGE (*Public AuthoritieS Supporting low-cArbon Growth in European maritime border regions*) project[1] involves 6 straits, with 11 partners from 8 countries.

It emerged from the European Strait Initiative (ESI)[2] and is co-financed by the ERDF in the framework of the Interreg Europe programme. The European Straits Initiative was launched in 2009 by Pas-de-Calais County Council and Kent County Council and now includes 24 public authorities in Europe. Experiencing the features of a strait territory and the related human, social, economic and environmental challenges, their aim is to bring together strait territories and to structure projects along their common issues.

Even if straits have apparent basic similarities (a stretch of water that is surrounded by two coastal areas which are linked to their proper hinterlands), each side of a strait might have different carbon intensive economic activities and are often subject to different governance and laws as they are from different countries.

As a result of these area features, cross-border cooperation is required. Following the "*Network Of STRAits*" (NOSTRA) project, launched in 2012, which aimed to reinforce the governance tools supporting sustainable development, the 2016-2020 PASSAGE project is the second strait-related project to be supported by the INTERREG Europe programme (formerly Interreg IV C), and is dedicated to the development of low-carbon solutions in the straits areas.

At the request of the Pas-de-Calais County Council, a carbon study was launched in January 2017 in order to support the preparation of action plans at strait level by the partners of the PASSAGE Project.

b) Straits and climate change

Straits have unique geographies, and are characterised by diversified and specific economic activities, including transportation, industrial activities, tourism, services and manufacturing. Straits are important centres of communication, commerce and culture.

[1] www.interregeurope.eu/passage
[2] www.europeanstraits.eu

Straits include cities with an important population living on coastlines, and thus particularly vulnerable to global environmental change, such as rising sea levels and coastal storms. Additionally, all these economic activities may be a significant, and growing, sources of energy consumption and account for a significant percentage of greenhouse gas (GHG) emissions. This may include not only GHG emissions from “land based” activities (ports, industries, cities, tourism), but also “sea based” activities, such as domestic or international maritime transportation. Therefore, straits may play an important role in tackling climate change and responding to climate impacts, bringing an integrated management approach, considering marine areas and hinterlands, on both sides of the strait.

As for cities, strait’s ability to take effective action on mitigating climate change and monitoring progress, begins with developing a GHG inventory; a “carbon study”. Such an inventory will first enable straits to understand the main emissions contribution of different activities taking place at strait level. It may then allow straits to determine where to best direct mitigation efforts, where to best consolidate partnerships with key stakeholders, and finally create a strategy to reduce GHG emissions.

Nevertheless, it is worth noting that state, regional, city and company level inventories are mainly carried out because of legally binding obligations. Voluntary initiatives to account for and disclose GHG emissions are quite new practices, such as *The Covenant of Mayors for Climate and Energy* or the *World Port Climate Initiative* (WPCI). Very few studies have been carried out at strait level, and it is worth mentioning that the governance of these areas is often complex, because it involves multiple levels and responsibilities, as well as administrative and cultural divisions that may hinder the implementation of common action at a strait level.

2. Objectives

The aim of this “carbon study” is to provide a first review of knowledge, experience and requirements in terms of GHG emissions at a strait level, to enable partners of the PASSAGE project, as well as relevant stakeholders, to define the strategic direction for the better integration of “low carbon measures” in these straits.

In addition, to ensure credible reporting and good consistency in GHG accounting, this study proposes a framework on how emissions sources are defined and categorised, and a specific methodology for calculating and reporting GHG emissions and scientific studies (that are built on existing methodologies), related to the definition of a strait. A detailed methodology is provided in the Annexes.

In this study a total of 6 European straits have been involved: Dover / Pas de Calais Strait, Strait of Otranto, Strait of Corfu, Gulf of Finland’s Strait, Fehmarn Belt, and Corsica Channel.

3. Overview of the general approach

This carbon study has been designed by the project team, in agreement with Pas de Calais County Council and all participating PASSAGE partners. The study was carried out with the following steps.

a) Step 1: Understanding of the local context

During the first step of this study, the project team carried out a review of all the documents and information provided by PASSAGE partners. This desk review helped the project team to better understand the various local situations and to start identifying the main characteristics of each strait. For instance, Pas-de-Calais County Council provided a report presenting the GHG inventory carried out by the "*Société d'exploitation des Ports du Détroit*", which is the unique operator for the ports of Calais and Boulogne-sur-Mer (see, for example, the charts below illustrating the GHG emissions in 2011 and 2014 for the port of Calais, in tons of CO_2 equivalent).

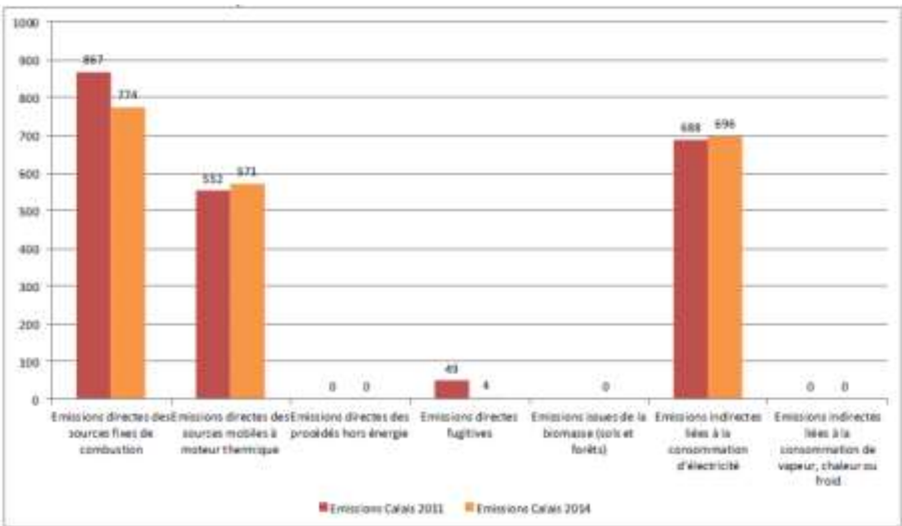


Figure 1 – Comparison of GHG emissions per sector in the Port of Calais, in 2011 and 2014 (Source: Bilan des émissions de gaz à effet de serre, Société d'exploitation des Ports du Détroit, 2016)

Other relevant reports reviewed by the project team are those prepared under the "NOSTRA" project, which were very useful in strengthening the general level of knowledge on each strait. Following this desk review, the project team organised telephone interviews with the PASSAGE partners, using a preliminary questionnaire intended to identify the primary stakeholders to involve at strait level, and to gather initial information regarding the analysis of the specificities of each strait. Additionally, the first theoretical concepts were presented to the local partners so that they could also better understand the need for additional information and prepare to send inquiries to other relevant agencies for data collection. The table below presents the members of the PASSAGE project that have been interviewed by the project team.

Table 1 - List of the PASSAGE project stakeholders interviewed

	Strait	Organisation
Liz FAGG Doug KEMPSTER	Dover / Pas de Calais strait	Port of Dover

Heidi SKINNER	Dover / Pas de Calais strait	Freight Transport Association - FTA
Antoine SURGET Colette MARIE	Dover / Pas de Calais strait	Pas-de-Calais County Council
Marc HAERINCK	Dover / Pas de Calais strait	Grand Port Maritime de Dunkerque
Mathieu SAMARCQ Karine SELLIER	Dover / Pas de Calais strait	Eurotunnel
Elina LOMPERI Kaarina RAUTIO	Gulf of Finland	Helsinki-Uusimaa Regional Council
Jesper BILLE Horst WEPPLER	Femharn Belt	Femern Belt Development Kreis Ostholstein
Anila HITAJ Mirela KOCI Nikolaos PETROPOULOS Ionnis PAPAGIANNOPOULOS	Otranto/Corfu	Regional Council of Vlora AULEDA Innopolis Innopolis

The interviews with each PASSAGE project partner increased understanding of the context and specificities of each strait. These exchanges mainly enabled additional local context information to be identified, and it was also an opportunity to briefly present the first methodological approach to calculate the GHG emissions at a strait level. The port authorities were also invited to participate to these discussions, when possible. This information served as the basis for the design of the methodological framework, and for the preparation of the data collection tool.

b) Step 2: Literature review and expert interviews

The second step of the study was mostly done in parallel with the first step: the project team carried out a literature review of relevant studies and scientific publications related to the definition of a strait, the GHG emissions methodologies and actions for specific sectors and activities taking place at strait level. This review has been consolidated through several interviews with researchers and representatives of key organisations working on these fields. The table below presents the organisations and representatives that have been interviewed.

Table 2 - List of the people interviewed by the project team

Name	Organisation	Expertise
Frédérique LOEW-TURBOUT	Université de Caen	Atlas Transmanche
Nora MAREI	CNRS (PRODIG)	Expertise on Gibraltar strait and regional economics
François LEVARLET	T33 SRL	Study cross border needs (EU, 2016)
Patrick RIGOT-MULLER	Mines PARISTECH	Low-carbon shipping

c) Step 3: Defining a methodological framework

The project team defined a common methodological framework for all the straits, based on the literature review and the interviews carried out in the previous steps. The framework includes a definition of the strait's boundary, a description of the activities accounted for in the inventory, the calculation methodologies and a categorization of the emissions by sectors and sub-sectors. The methodological framework follows the main accounting and reporting principles from the *GPC Protocol Standard*. A methodological note was written to ensure transparency and that stakeholders had a good comprehension of the calculations and methodologies used . The detailed methodological framework is described further below in this report.

d) Step 4: Data collection and complementary literature review

The data collection was led by the PASSAGE partners in each strait. To facilitate the data collection, the project team provided a draft letter to be sent to each type of stakeholder (port authority, coastguards), describing the data needed and the deadline, along with a data collection tool. However, the tool was just indicative, the cells were not expected to be filled in one by one, but the tool enabled the stakeholders to identify the data needed under the project. The stakeholders were encouraged to send any database containing the data listed, in order to facilitate the process for the data holders.

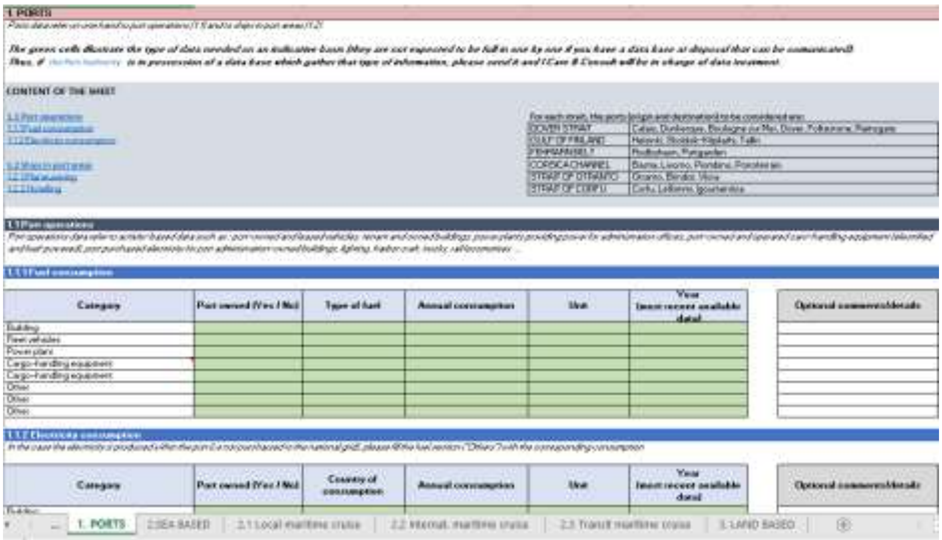


Figure 2 - Extract of the data collection tool sent to PASSAGE partners (Source: I Care & Consult)

To cope with the difficulties faced by partners to collect data and to inform the data collection tool, a complementary literature review was carried out by the project team. Based on the literature desk review, together with the information provided by PASSAGE partners, the project team was able to fill in some of the remaining data gaps in the data collection tool. Unfortunately, due to some data unavailability (“defence secret” classified data, for example), it was not possible to totally complete the GHG inventory for all the straits, and despite several hypothesis proposed by the project team, the required accuracy of the results could not be reached under this project. The main limitations of the study are presented further below in this report.

e) Step 5: Analysis at strait level and completion of individual monograph

During this step, the full information collected from both data collection tool and complementary literature review was documented in the form of an individual monograph dedicated to each PASSAGE straits. In each strait’s monograph, the current GHG emissions due to each sector and sub-sector considered in the area were presented.

f) Step 6: Transversal analysis and completion of final report and recommendations

A transversal analysis was conducted to draw the main lessons and key findings from the carbon study in each strait. Recommendations and good practices were provided to the PASSAGE partners while they were preparing their action plan. Recommendations for further work on this subject and for further actions to reduce the emissions are also presented in this final report.

4. Focus on the key elements of the approach

This section provides a detailed explanation on the methodological approaches being defined and used in the development of the GHG inventories of the Straits during this study.

a) Defining a strait: perimeter, activities

Geographers describe straits as “narrow stretches of water between two land masses joining two marine expanses” as explained by Nathalie Fau, a well-known expert on straits[3]. They can connect two oceans, or an ocean to a sea (the Strait of Gibraltar), two continents (the strait of Gibraltar, the Bosphorus), an island and a continent (Dover / Pas de Calais Strait), or two islands (Bonifacio Strait). In a paper published in 2003, the geographer Jean-Pierre Renard defines the Strait of Dover as a “terraqué” or terraqueous space, trans-border area (from the Latin words terra and aqua). Indeed, as recalled by Fau in HyperGeo, this complex space forms a maritime and terrestrial interface, and to study a strait it is necessary to consider longitudinal flows, cross-flows and the maritime space per se, since it at once constitutes the dividing line and the zone of contact in either direction.

The strait also induces several discontinuities, notably legal ones, administrative ones with different systems and competences for the local authorities across the border and, sometimes, economic ones when the two regions facing each other do not have the same level of economic activity. Cooperation is notable for maritime security and risk minimisation. The straits and the cross-border regions show and benefit from regional economic integration as documented by several OECD studies in the Oresund or Helsinki-Tallinn regions (OECD, 2013[4]).

From a geographical point of view, a strait is a narrow stretch of water between two land-masses joining two marine expanses. Unlike cities, for which we can generally base studies on administratives boundaries, a strait is a complex area comprising a maritime space and a terrestrial interface, with a spatial dimension that can be subject to discussion and interpretation depending on the purpose of this definition. Moreover, there is no administrative boundary for a strait (although there are different administrative boundaries within a strait), and thus it is necessary to take into consideration functions and activities of a strait to be able to propose and justify a specific boundary.

From a functional point of view, a strait is the crossing-point where the crossing is the shortest possible. It is thus a core node of transport and communication, with a "bridge effect" stepping up maritime connections (ferries, container transport, ro-ro ferries etc.) or fixed links (bridges and tunnels). A strait can be seen as a transportation hub organized around the main ports on both side of the strait, involving longitudinal (between the main ports of the strait) and transit flows of goods and people

[3] http://www.hypergeo.eu/spip.php?article576

[4] Nauwelaers, C., K. Maguire and G. Ajmone Marsan (2013), “The Case of Helsinki-Tallinn (Finland-Estonia) – Regions and Innovation: Collaborating Across Borders”, OECD Regional Development Working Papers, 2013/19, OECD Publishing. http://dx.doi.org/10.1787/5k3xv0lrt1r6-en

through the maritime corridor. Economic activities, as well as in-land transportation are then induced by theses flows through the maritime corridor.

A strait is thus a maritime corridor through which there are longitudinal flows and transit flows. Chorems or ("chorèmes" in French) are proposed by Marei & Baron (2014[5]) to represent the spatial functions as well as to propose four possible different engines of the territorial development along a terraqueous frontier. This type of graphic representation identifies the main representative stakeholders (institutional, economic) of a strait activity ,as well as their operational competences. An example is the port authority, with operational competences directly linked with the strait activity (notably the maritime freight between the two sides of the strait).

Finally, based on the literature review, and interviews carried with key experts and PASSAGE partners, a first schematic representation named "*chorem*" has been proposed for each strait, which represent the spatial functions and boundaries, as well as the main flows and induced economic activities to be potentially included in a GHG inventory. At a later stage, the individual straits were requested to validate the specific activities that can be found in their strait, and provide associated data for identified sectors and activities.

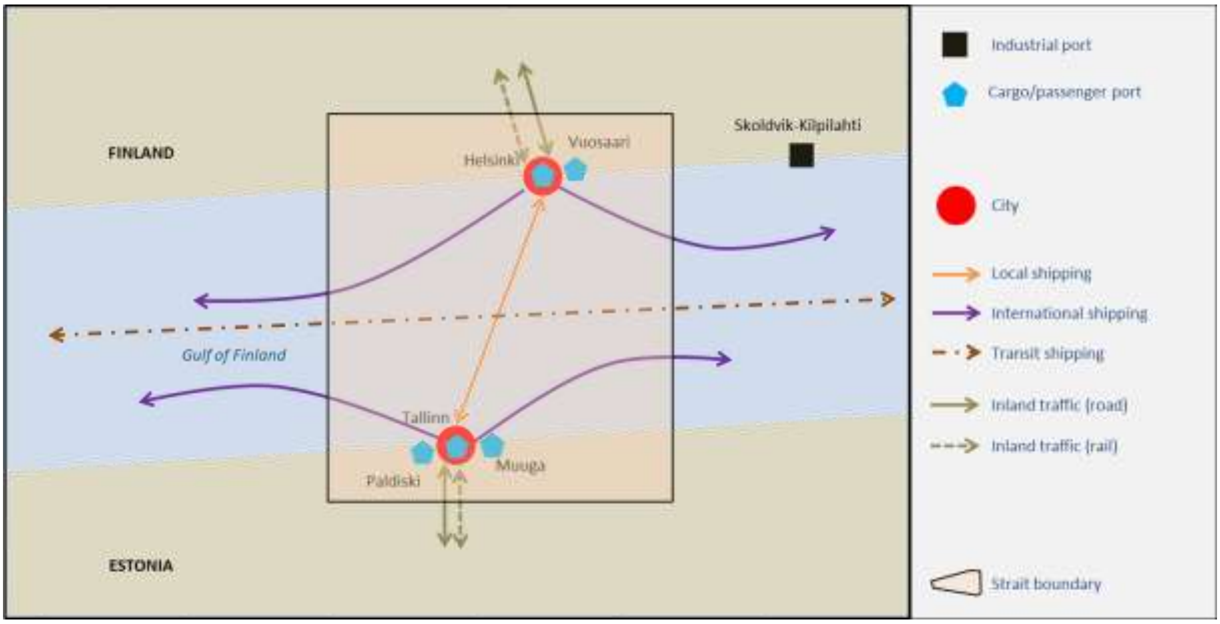


Figure 3 – Chorem representation for the Gulf of Finland (Source: I Care & Consult)

To clarify the geographic boundaries of the strait (including the hinterland distance and the maritime distance of the strait), the NUTS 3 regions corresponding to the ports taken into consideration in each strait, were considered for most of the straits (with some exceptions, described in the carbon study for each strait). The NUTS (Nomenclature of Territorial Units for Statistics) is a hierarchical system for dividing up the economic territory of the EU, for the purpose of socio-economic analysis of the regions. The NUTS 3 correspond to small regions, which allow a precise analysis.

[5] Penser le détroit de Gibraltar pour figurer l'entre-deux, Nora Mareï et Nacima Baron Yellès. https://belgeo.revues.org/10632

b) Selecting the main activities related to GHG emissions taking place in the Straits

From an economical point of view, most of the straits in Europe are characterised by **diverse economic activities**, ranging from fishery, tourism, services and manufacture to industry. According to NOSTRA[6], all these economic activities contribute directly to the local GDP and many provide essential employment opportunities for the local population as well as contributing to welfare. Additionally, as explained in the previous section, a strait can be seen as a **transportation hub** organized around the main ports on both side of the strait, involving longitudinal (between the main ports of the strait) and transit flows of goods and people through the maritime corridor. Economic activities, as well as in-land transportation are then induced by theses flows through the maritime corridor.

During this study, a focus was made on the activities that have a potential and relevant impact in terms of GHG emissions. Based on the literature review and current framework in terms of GHG calculation and reporting, a first distinction was made to distinguish three main sectors and type of activities at strait level: “port” activities, “land-based” activities, and “sea-based” activities.

A second distinction with several sub-sectors was also proposed, to enable a better understanding of what physically happens in terms of GHG emissions, especially regarding transportation activities, (considering that GHG emissions from strait activities are mainly driven by transportation activities). This distinction should also help to identify the main stakeholders involved in GHG emissions of specific sub sector. The table below presents an exhaustive list of activities taking place in all the European straits and that are considered in the scope of this study.

Ports

- **Port operations**: port-owned and leased vehicles, buildings, port-owned and operated cargo-handling equipment, port purchased electricity for port administration-owned buildings, lighting and operations
- **Ships in port areas**: In fairway channel, at anchor, in port basin, maneuvering, at berth

Sea-based

- **Local maritime cruise**: traffic between port-to-port inside the strait
- **International maritime cruise**: ships arriving / departing from the ports located in the strait
- **Transit maritime traffic**: traffing crossing the strait without calls at the straits’ ports

Land-based

- **Road-railway-fluvial traffic**: transportation of goods and persons departing and arriving at the strait’s ports
- Tunnel
- **Induced economical activities** : industries, residential and economical activities, tourism

Figure 4 – Proposed categorization of GHG emissions at strait level (Source: I Care & Consult)

It is assumed in the present methodology that ports are able to influence strait’s GHG emissions, and as a consequence, ports should be considered as an important component of a low carbon strategy at strait level. The proposed designation includes:

- **Sectors**: define the topmost categorization of the strait’s GHG sources activities, mainly driven by flows of people and goods;

[6] Baseline study of the Nostra Project: Final report

- **Sub-sectors**: this additional level of categorization enables the use of disaggregated data, and helps identify mitigation actions by partners and stakeholders.

It is important to clarify here, that the availability of data is a key factor in deciding whether to include or exclude several sub-sectors proposed above. Indeed, the GHG inventories that were built under the PASSAGE project are based on recent and easily available data, because the data collection needed to be finalized under a tight timescale.

c) Setting a methodological framework

During this study, the main accounting and reporting principles for strait GHG emissions follow the main principles from the *GPC Protocol Standard*, which enables a fair and true account of emissions:

Relevance: The reported GHG emissions shall appropriately reflect emissions occurring as a result of activities of a strait. The inventory can also serve the decision-making needs of the PASSAGE project members, taking into consideration relevant local, subnational, and national stakeholders and regulations. The principle of relevance applies when selecting data sources, and determining and prioritizing data collection improvements.

Completeness: Straits shall account for all required emissions sources within the inventory boundary. Any exclusion of emission sources should be justified and explained.

Consistency: Emissions calculations shall be consistent in approach, boundary, and methodology. Using consistent methodologies for calculating GHG emissions enables meaningful documentation of emission changes over time, trend analysis, and comparisons. Calculating emissions should follow the main methodological approaches available for GHG emissions inventory.

Transparency: Activity data, emission sources, emission factors, and accounting methodologies require adequate documentation and disclosure to enable verification. The information should be sufficient to allow individuals outside of the inventory process to use the same source data and derive the same results. All exclusions shall be clearly identified, disclosed and justified.

Accuracy: The calculation of GHG emissions shall not systematically overstate or understate actual GHG emissions. Accuracy should be sufficient to give decision makers and the public reasonable assurance of the integrity of the reported information. Uncertainties in the quantification process shall be reduced to the extent that it is possible and practical.

This methodology requires straits to measure and disclose a comprehensive inventory of GHG emissions and to total these emissions following a categorization of all emissions depending on where they physically occur.

Activities taking place within a strait can generate GHG emissions that occur inside the strait's boundary, as well as outside the strait's boundary (such as international maritime cruise for example). This methodological approach is based on an adapted application of the scopes framework used in the "*GPC Protocol Standard*", and takes into consideration the strait-induced activities and the different abilities of strait stakeholders to take effective action on mitigating climate change.

The figure below illustrates which emission sources occur solely within the geographic boundary of a strait, which occur outside the geographic boundary of a strait, and which may occur across the geographic boundary:

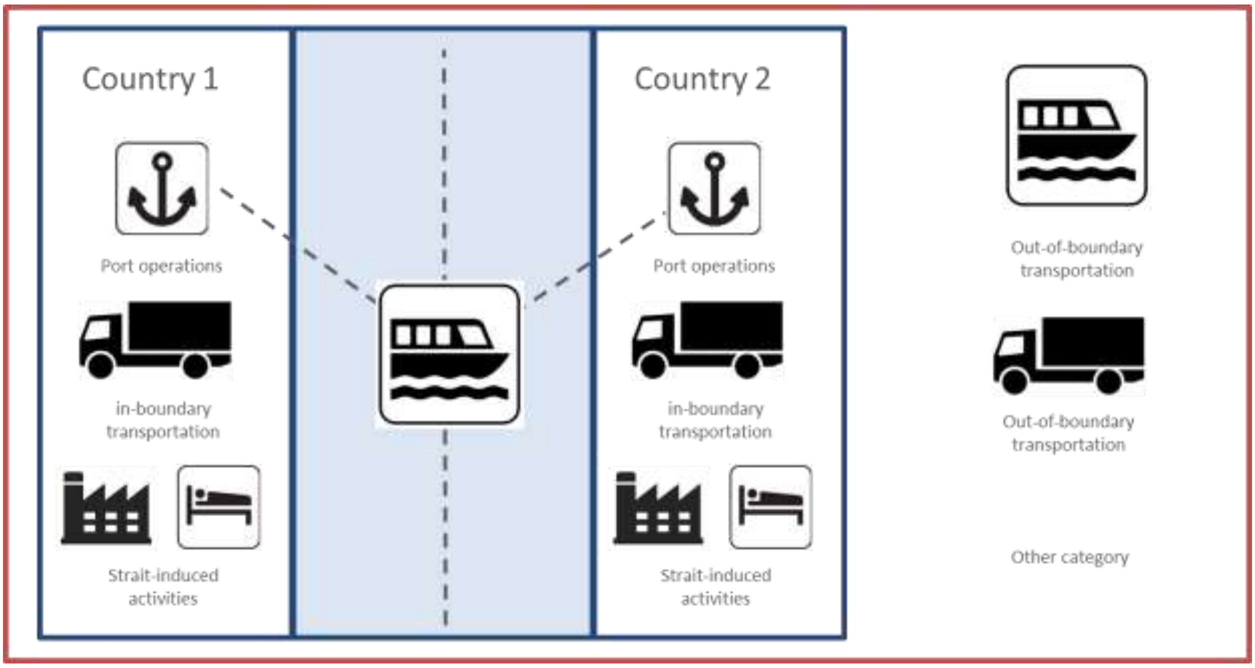


Figure 5 – Illustration of the emission sources within and outside the strait's boundary (Source: I Care & Consult)

This proposed methodological approach should enable strait inventories to be consolidated with existing available GHG inventories (for example the WPCI carbon footprint calculator[7] used by a Port Authority, the *Baseline Emission Inventory* carried out by a city involved in the Covenant of Mayors[8] or an industrial plant located inside the strait boundary that carried out a specific GHG inventory of its activity[9]), and to be compared with national GHG inventories, especially regarding international maritime traffic.

d) Calculation methodologies

The proposed methodology is based on the main purpose of a strait inventory, that is to say:

- Demonstrate leadership in climate change mitigation: stakeholders of PASSAGE project will propose a first GHG inventory of strait-induced activities, and try to engage the main relevant stakeholders, in order to promote and implement low-carbon operations and reduce GHG emissions at strait level;
- Estimate and understand the order of magnitude and the share of GHG emissions from straits activities in comparison to other territories in the European Union: this project will also enable stakeholders to estimate the consistency of the results with their country's national inventories;
- Compare with, learn from, and share best practice with other straits: the PASSAGE project brings together six straits and eleven partners in several countries, that will map and understand the emissions contribution from different activities at a strait level.

[7] http://wpci.iaphworldports.org/carbon-footprinting/
[8] http://www.covenantofmayors.eu
[9] National Emission Registry of industrial plant in France: www.georisques.gouv.fr

This approach does not require specific methodologies to be used to produce emissions data. Instead it is based on the most appropriate methodologies used by the main stakeholders involved in strait activities, and already carrying out inventories for those activities, that is to say:

- Port authorities, following the WPCI carbon footprint calculator;
- Transportation companies, following the GLEC framework;
- Cities, following the GPC Protocol Standard or the Covenant of Mayors.

For most emission sources, as for companies or cities, the strait's stakeholders will need to estimate GHG emissions by multiplying activity data by an emission factor associated with the activity being measured.

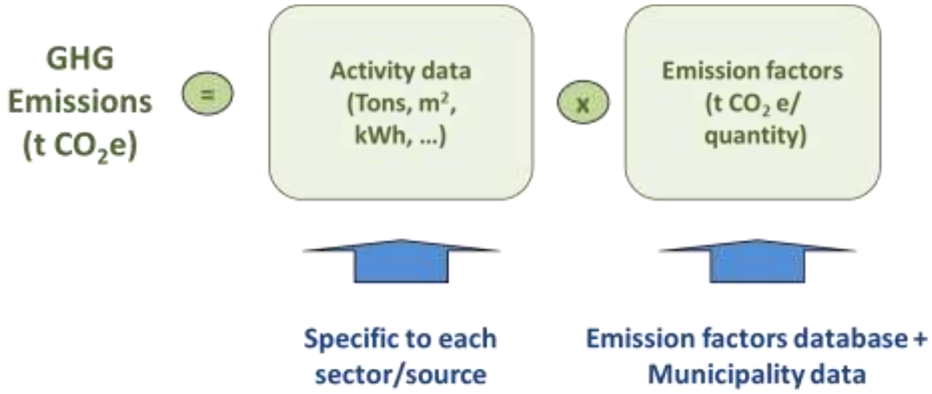


Figure 6 - Principles of calculations (Source: I Care & Consult)

- Activity data is a quantitative measure of a level of activity that results in GHG emissions taking place during a given period of time (2016 in the case of this study): For example, the electrical consumption due to port operations, or the ton-kilometers transported by trucks departing from a port, etc.
- Emission factor is a measure of the mass of GHG emissions relative to a unit of activity: For example, estimating CO_2 emissions from the use of electricity involves multiplying data on kilowatt-hours (kWh) of electricity used by the emission factor ($kgCO_2/kWh$) for electricity, which will depend on the technology and type of fuel used to generate the electricity.

Activity data will need to be gathered from a variety of sources, including national or local statistics, the country's national GHG inventory report, scientific and technical articles, or GHG emission reports carried out by a specific stakeholder (for example Eurotunnel).

The calculation methodologies per sub-sector are detailed in the annex.

5. Opportunities and benefits resulting from the carbon study

Following the NOSTRA project, the carbon study carried out for the European Straits of PASSAGE is one of the first studies on the carbon footprint at a strait level. Through the work that has been carried out, PASSAGE partners have had access to some key opportunities during the study:

- Opportunity to deepen the collaboration with the cross-border partners in each strait and with the stakeholders outside their structure;

- Opportunity to share good practices and collaborate with the PASSAGE partners.

The main benefits the PASSAGE partners could take advantage of as a result of the carbon study are:

- Awareness raising and capacity building of the PASSAGE partners on the mitigation of climate change issues;

- Analysis of the stakes at a strait level, in terms of GHG emissions, on which actions must be taken to reduce their impact on climate change;

- Awareness raising on the maritime emissions at a local level. This study aimed to allocate emissions at a local level and integrate them into the local stakeholders' responsibilities. This occurred in a favourable timing with the adoption of an MRV (Monitoring, Reporting, Verification) Shipping Regulation by the European Commission and the IMO DCS (Data Collection System). This led to a lobbying action at a European level, as well as a common answer to the European public consultation on the revision of the policy on monitoring, reporting and verification of CO_2 emissions from maritime transport.

- Completion of an original and innovative study, to increase the knowledge of the GHG impact of these specific territories, the straits, in the continuity of different studies led by universities. This study brought a global perspective of the situation and evolution of the strait, as well as the identification of some gaps in addressing key challenges for the strait. This could also lead to the publication of a scientific article.

6. Limitation of the carbon study

The main limitation was to juggle multiple straits with specific characteristics (geography, economy etc.) and the will to build a common and homogeneous methodological approach. The main limitations linked to the approach were:

- **Type of straits**: there were major differences between the straits studied, in terms of economic activities and maritime transport specifically. For example, the strait of Dover / Pas de Calais is a major hub of transport, with almost 20% of worldwide maritime traffic in 2006 and important industries, while the Strait of Corfu presents a very different economical context (mainly small-scale ports, few industries, tourism being the main economic activity).

- **Definition of the organizational perimeter**: contrary to the cities, there are no administrative boundaries to a strait. The definition of the boundaries of a strait is a research subject and there is no clear definition nowadays, specifically on the depth of the hinterland and the length of the maritime boundary. An arbitrary decision was made to consider the NUTS3[10] regions as the hinterland of the strait and as the limit of the maritime boundary. However, some boundaries differ due to local context. In some cases, there was already a defined maritime boundary (according to the IMO Separation Traffic Scheme, such as the Strait of Dover / Pas

[10] Nomenclature of territorial units for statistics (hierarchical system for dividing up the economic territory of the EU).

de Calais or the Corsica Channel). In some other cases, more relevant hinterland was considered (such as the consideration of the capital region in the Finnish shore of the Gulf of Finland’s Strait, for the economical induced activities). This led to a heterogeneity in the boundaries, to align with the local context of the strait, with arbitrary decisions that are debatable and differences between the straits.

- **Definition of the operational perimeter**: this perimeter is mainly homogeneous for all the straits, except for the inclusion of tourism in the induced economical activities of the Strait of Dover / Pas de Calais, that was not included in the other straits. A functional approach around the strait was considered, which means that not all the emission sources within the boundary are considered (such as waste or resident’s transport). Only the activities induced by the presence of the strait were considered, which led to a selection of representative activities (ports activities, in-land transport linked to the ports, maritime transport, industrial activities, residential and commercial activities). One of the limitation is that not all sources of emissions and activities are taken into account in the straits. Moreover, there might be some overlaps and double counting in the calculations of emissions from tourism in the Strait of Dover / Pas de Calais, as a part of these emissions might be included in the Residential and Commercial emissions from the cities.

- **Definition of a methodological approach**: the approach was built based on scientific works, without being able to evaluate the type of data available and needed. There was then an adjustment of the method depending on the available data, that led to some arbitrary decisions that could be debatable. For example, there is a difference in the emission factors for ferries considered in the local maritime cruise and the ferries considered in the maritime cruise with calls to the strait’s ports, depending on the availability of data such as the number of ferries and the number of passengers transported.

- **Emission factors**: the emission factors for maritime transport considered in the study are taken from the DEFRA database mainly. However, there seems to be large differences between the emission factors in the different databases available at a European level (Base Carbone in France, DEFRA in the UK, LIPASTO in Finland…). It was decided to use only the DEFRA database in all the straits, in order to be consistent in the methodology, but this impacts largely the results in some of the straits (such as the Gulf of Finland’s Strait).

- **Missing data**: due to difficulties accessing some information in the very restricted timeline, some data is missing for some of the straits. This is due to the technicality of the study and the lack of time to reinforce the capacity of the stakeholders and ensure a good comprehension of the stakes and the data to collect. Moreover, with the transit maritime transport, there is variation between the countries on the institutional cooperation and the governance, which led to data missing in some straits (Corsica Channel, Fehmarnbelt, Strait of Otranto). 95% of the data needed was not in direct possession of the PASSAGE partners, meaning that access to data depended on the connection of the partner to its stakeholders and their capacity to collect the data needed. The governance and the network of actors varied greatly between the straits and between the countries.

- **Results**: in some cases, due to missing data the GHG emissions inventories are not complete. In these cases, notation keys (NC – not communicated) were used to indicate that the source of emissions is not negligible, but that it was not accounted for as the data was not collected. This could lead to a misinterpretation of the results. Moreover, it was only possible to distinguish the emissions within and outside the strait's boundaries in two cases (Strait of Dover / Pas de Calais and Gulf of Finland's Strait). Finally, there was no inventory management plan implemented for the follow-up and the update of the inventories, even though a robust and transparent tool was provided with the calculations. Training could be provided to ensure a good comprehension of the tool and the calculations and the ability to update the inventory over time.

- **Action plans and decarbonization paths**: The action plans proposed are not always directly linked to the study due to the operational responsibilities of the partners (such as the CCI de Bastia, which has a direct operational responsibility with the Port of Bastia in the Corsica Channel, and the Pas-de-Calais County Council which doesn't have a direct link with the ports). Moreover, for the decarbonization paths, an indicative top-down logic was used, which means the trajectory was built from national and/or sectoral plans, and was not connected with the action plan.

7. Recommendations for further work

To continue the work, the main recommendations are the following:

- Ensure a translation of the deliverables in the native language of the PASSAGE partners and communicate the study to the stakeholders;

- Continue to build cooperation with the stakeholders, to sustain the data collection over time and to allow the inventories to be updated and the missing date to be obtained;

- Improve the emission factors used to reflect the local context and the specificities of each strait and actors (such as the maritime companies operating in the strait);

- Consolidate the data, specifically on transit maritime cruise, by working with the institutional organizations in charge of collecting the data and the coastguards;

- Expand the work through a university thesis or work.

1. Main GHG emission sources at strait level

As described earlier, there are 4 main emission source sectors considered in this study:

- **Ports operation**: including energy consumption of the buildings in the port and of the ships in the port areas. This emission source was included in the inventory when available (for the Strait of Dover/Pas-de-Calais). However, the information was not easily accessible in most cases and thus this emission source was incomplete in some cases (Gulf of Finland's Strait, missing the emissions from the ships in port areas in the Estonian shore, and Corsica Channel, missing the energy consumption in the port's buildings in the French shore and the emissions from the ships in port areas in the Italian shore) or not considered at all in other cases (Fehmarnbelt, Strait of Otranto and Strait of Corfu). However, the emissions are in most cases small, especially compared to the other sectors considered in this study (less than 2% in the case of the Strait of Dover / Pas-de-Calais and the Gulf of Finland's Strait).

- **Maritime transport**: including local, international (with calls to the strait's ports) and transit maritime cruise. This emission source was included in most of the inventories, depending on the local availability of data. The local maritime cruise data was collected from the ports and/or the local maritime companies. The international maritime cruise data was collected from the ports, and the transit maritime cruise was collected from the coastguards. This last one was harder to obtain due to the lack of monitoring of the ships passing through the straits in some cases (Strait of Corfu for example), or due to the difficultly accessing the data due to the institutional relationships and governance (Strait of Otranto for example). The inventory for the Strait of Otranto is incomplete on this sub-sector as no data could be collected. For the other straits, the missing data could be estimated thanks to data collected on the other shore or from publications. This emission source represents 10% to 30% of the emissions within the strait, and up to 64% of the emissions in the Strait of Corfu.

- **In-land traffic**: including road, railway, waterways transport from and to the ports and tunnel transport if appropriate. This emission source was included in all the inventories based on local and national statistics on the quantity of merchandise transported, the number of passengers passing through the ports, the mode of transport and the distance travelled. This emission source represents between 3% and 20% of the emissions within the strait. In the Gulf of Finland's Strait, the in-land traffic represents only 3%, which can be explained by the characteristics of the strait, which links two capitals with a large alternative transport offer and lower distances travelled. In Fehmarnbelt, the in-land traffic represents almost 20% of the emissions, which can also be explained by the characteristics of the strait which is far from the main cities in both countries, implying higher distances travelled.

- **Induced economical activities**: including industries and residential and commercial activities. This emission source was included in all the inventories based on European data on the emissions from industries (in the EU-ETS database), and on the emissions from residential and commercial activities per capita in each country (as reported to the UNFCCC). This is a major source of emissions representing between 20% and more than 80% of the emissions in the strait. In the straits of Dover / Pas de Calais, Corsica Channel, Gulf of Finland and Otranto, this is mainly due to the many industries in the strait region.

2. Significance of GHG emissions in straits

The emissions of the PASSAGE straits were 44.0 $MtCO_2e$ in 2016, mostly emitted by the Strait of Dover / Pas de Calais (33%). This is equivalent to the emissions of 6.5 million inhabitants in Europe[11] and to 1.1% of the European Union emissions[12].

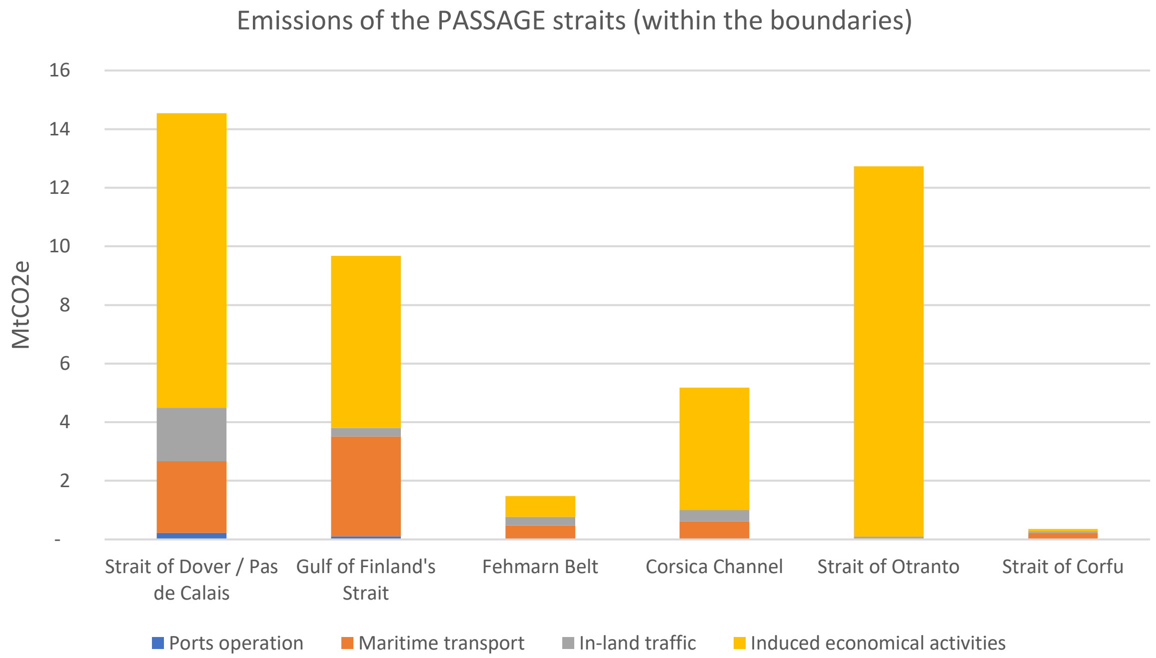


Figure 7 - Emissions of the PASSAGE straits (within the boundaries) (Source: I Care & Consult)

In most of the straits, the induced economical activities (industries & cities) represent a significative part of the GHG emissions within the strait's boundaries. This is mainly the case in the Strait of Dover / Pas de Calais, the Gulf of Finland's Strait, Corsica Channel and the Strait of Otranto, where there are many industries that influence the emissions. The cities (residential and commercial activities) are also a main source of emissions in the straits.

The maritime cruise, and specifically the transit maritime cruise, is an important source of emissions for the straits occurring mainly in the Strait of Dover / Pas de Calais and the Gulf of Finland's Strait. The maritime cruise (local, international and transit maritime cruise) represents 16% of the global emissions of the PASSAGE straits.

Finally, the on-road transportation is also an important source of emissions in the majority of the straits.

However, it's important to note that, due to data missing, some inventories are not complete (specifically concerning the ports operation and the transit maritime cruise, such as in the straits of Corfu and Otranto).

[11] Considering 6.8 tCO_2e/capita. Source: Service of Observation and Statistics in France, based on data by EDGAR, World Bank, 2015
[12] Considering emissions of 4 054 MtCO2e in the European Union in 2014. Source: CAIT Climate Data Explorer, World Resources Institute

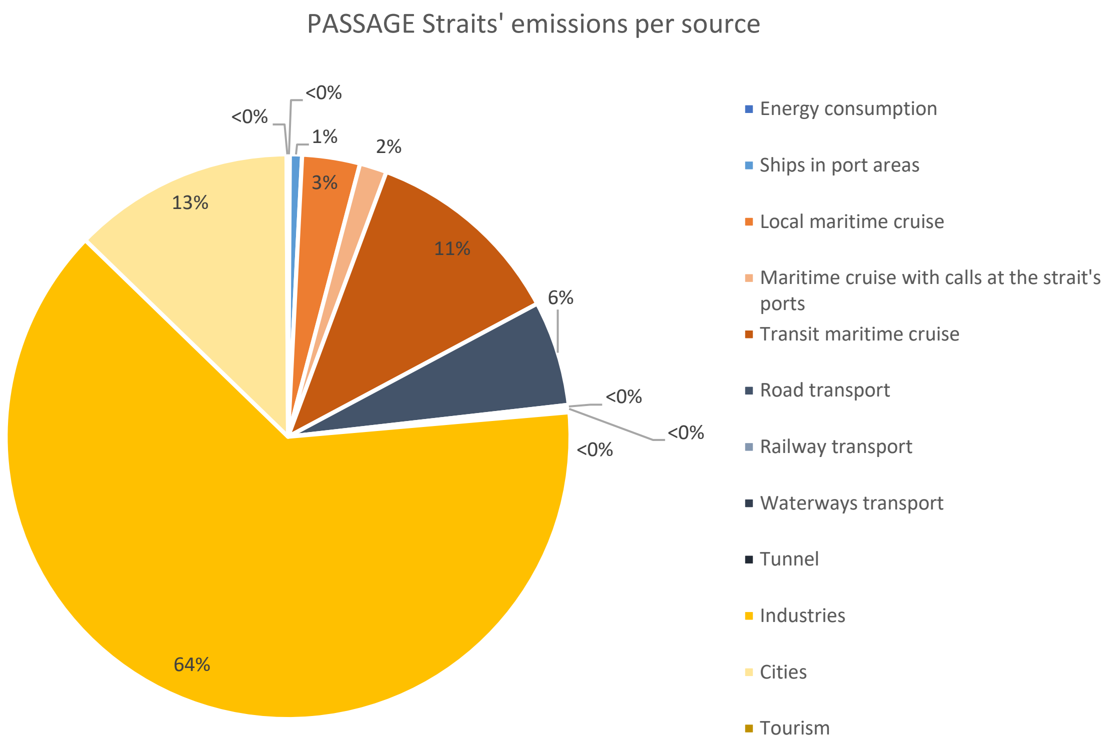


Figure 8 - Breakdown of the PASSAGE straits' emissions per sub-sector (Source: I Care & Consult)

3. Comparative table between straits

The following table show the emissions per source of each of the straits. It is important to note that the results cannot be compared between the straits, as they are influenced by the specificities of each strait and the availability of data (as not all the inventories are complete).

But, it is still interesting to note that the emissions mainly reflect the specificities of the straits. The straits with significant levels of traffic (such as the straits of Dover / Pas de Calais, Gulf of Finland or Otranto) also have significant emissions due to the industries, as well as significant road transport. This can be explained by the influence of the traffic and the main ports on the supply of materials to the industries for example.

The straits with a less significant traffic (such as Fehmarnbelt and the strait of Corfu) are mostly impacted by the emissions from the local maritime cruise, the residential and commercial activities in the cities and the in-land transport. The transit maritime cruise and maritime cruise with calls at the strait's ports are of less importance compared to the other straits.

Table 3 - Comparative table of the emissions of each strait

Emission source (within the strait's boundary) *in tCO2e*		Strait of Dover / Pas de Calais	Gulf of Finland's Strait	Fehmarnbelt	Corsica Channel	Strait of Otranto	Strait of Corfu
Port operations	Energy consumption	16 205	26 437	NC	694	NC	NC
	Ships in port areas	206 868	75 590	NC	23 138	NC	NC
Maritime transport	Local maritime cruise	725 457	190 435	248 571	73 117	55	214 443
	Maritime cruise with calls to the strait's ports	21 834	383 583	NC	229 978	31 377	16 435
	Transit maritime cruise	1 702 548	2 839 190	231 081	289 993	NC	/
In-land traffic	Road transport	1 688 671	262 653	289 190	367 205	61 466	50 308
	Railway transport	32 951	22 431	3 086	21 415	2 691	/
	Waterways transport	36 345	/	/	/	/	/
	Tunnel	64 899	/	/	/	/	/
Induced economical activities	Industries	8 346 854	4 849 287	0	3 570 531	11 163 390	1 556
	Cities & Towns	1 667 014	1 028 048	710 864	606 029	1 468 585	75 469
	Tourism	37 896	NC	NC	NC	NC	NC
TOTAL		**14 547 543**	**9 677 653**	**1 482 791**	**5 182 101**	**12 727 564**	**358 210**

4. Responses addressing key challenges for low carbon development of straits: EU policies and governance practices

The European Union emissions represent about 10% of total global emissions. Its Member States have ratified the UNFCCC's Kyoto Protocol in 1997 and the Paris Agreement in 2015, setting emission targets to limit the global emissions and keep global warming below 2°C.

In its 2050 Low-Carbon Economy Roadmap, the EU aims to cut greenhouse gas emissions to 80% below 1990 levels (with milestones to 40% by 2030 and 60% by 2040), with a contribution from all sectors (power sector, residential and tertiary, industry, transport, agriculture). The Effort Sharing Decision establishes binding annual greenhouse gas emission targets for Member States for the period 2013-2020. These targets concern emissions from most sectors not included in the EU Emissions Trading System (EU-ETS), such as transport, buildings, agriculture and waste. The national emission targets for 2020 have been agreed unanimously and are based on the relative wealth of each Member States (GDP per capita).

The international maritime transport is not included in the national inventories and the Paris Agreement. However, it represents about 2.5% of global greenhouse gas emissions according to the 3rd IMO GHG Study. Moreover, they are predicted to increase between 50% and 250% by 2050, depending on future economic and energy development, which is not compatible with the goal of keeping global temperature increase to below 2°C compared to pre-industrial levels. In order to promote the reduction of emissions by the maritime companies, the European Commission set out a strategy in 2013 to include maritime transport emissions into the EU's policy for reducing its domestic GHG emissions. The strategy consists in 3 steps:

- Monitoring, reporting and verification of CO_2 emissions from large ships using EU ports
- Greenhouse gas reduction targets for the maritime transport sector
- Further measures including market-based measures in the medium to long term

From 2018, the MRV companies (ships over 5000 gross tonnes loading/unloading cargo/passengers at EU maritime ports) are to monitor and report their related CO_2 emissions, submit to an accredited MRV shipping verifier a monitoring plan and submit the verified emissions through THETIS MRV (a dedicated European Union Information system currently under development by the European Maritime Safety Agency). In parallel, the IMO is implementing a Data Collection System. This system requires every ship of 5000 gross tonnage and above to collect consumption data for each type of fuel oil they use. The aggregated data is reported to the flag State each year and then transferred to an IMO Ship Fuel Oil Consumption Database. An annual report will then be produced by the IMO.

All these initiatives, combined with the national and sectoral plans in each country aiming to reduce greenhouse gas emissions, will impact the straits and lead them into low-carbon development.

5. Recommendations for future actions

a) At the level of the partnership

The carbon study has resulted in several key recommendations for the PASSAGE partners:

- Capitalise on this first work by deepening the knowledge of the strait's carbon footprint through academic research;
- Consider monitoring the emissions over time, through the update of the inventories;
- Consolidate the governance at a strait level;
- Bring the key findings to the attention of the European Commission.

b) At strait level

The carbon study has resulted in key recommendations that are generic at a strait level:

- **Port Authorities**: it would be interesting for all the ports of the straits to adhere to the WPCI (World Ports Climate Initiative), an initiative launched by the International Association of Ports and Harbors (IAPH) under the auspices of the C40 Cities to reduce the greenhouse gas emissions in the ports. Moreover, the Port Authorities should ask the European Commission for the MRV Shipping Regulation data for all the ships calling at their ports. This would improve and facilitate the data collection for the future update of the inventories and allow the ports to better understand their impact on climate change and their role as transportation and economic centers.
- **Port towns**: it would also be interesting for the cities and towns with a port to include the maritime transport and the port's emissions in their inventories to have a better understanding of the impact of these activities on the territory and the emissions and to ensure an inclusion of actions linked to these activities in the strategies and action plans to tackle climate change.
- **PASSAGE partners**: it is important to continue and improve the working cooperation with the different stakeholders within the strait (port authorities, coastguards, cities etc.), to facilitate the data collection and the implementation of the action plan to reduce the GHG emissions. Moreover, it is also important to continue and improve the cooperation between the two shores of the strait and between the local and regional institutions in charge of specific topics, to ensure compatible and shared strategies and actions within the strait.

Overview of the baseline study at strait level: Gulf of Finland

This chapter presents the main conclusions of the analysis carried out for the Gulf of Finland's Strait.

IDENTITY OF THE STRAIT

The strait in a nutshell

The Gulf of Finland is surrounded by three different national economies (Finland, Russia and Estonia) with different maritime transportation structures. Helsinki is regularly cited as a leading city of the low carbon transition. The eastern parts of the Gulf of Finland belong to Russia, and some of Russia's most important harbours are located near St. Petersburg, not considered in this study. However, the development of maritime transportation in the Gulf of Finland in future is mainly dependent on the development of Russian economy and transportation sector.

The strait specificities

- Both regions are capital cities and leading urban agglomerations in their countries: Tallinn-Harju's share in Estonia is 60% of GDP and 40% of population[13]; the respective figures for Helsinki-Uusimaa are 38% of GDP and 28% of population[14].
- The different levels of development between Helsinki and Tallinn result in many asymmetric flows (workers to Helsinki, tourists to Tallinn). Beyond infrastructure and labour market issues, there are interesting opportunities for joint innovation policy efforts given their shared strengths such as in ICT, a dynamic start-up environment and technologically sophisticated public services (OECD, 2013).

Main findings

- 9.7 $MtCO_2e$ were emitted within the Gulf of Finland's Strait's boundary in 2016, equivalent to the average emissions of about 1.4 million inhabitants in Europe[15], which is 16% of Finnish emissions and 44% of Estonian emissions in 2014[16]
- The industries represent the main emitter of the strait, with 50% of the emissions.
- The transit maritime cruise represents a large part of the cross-border emissions.
- The ships in port areas represent most of the emissions from the ports operation.

Decarbonization paths

- Finland and Estonia have ambitious targets of reduction of GHG emissions implemented in national strategies:
  - Reduction of emissions by 80% to 95% by 2050 compared to 1990 and become a carbon-neutral society in Finland
  - Reduction of emissions by 70% by 2030 and 80% by 2050 compared to 1990 in Estonia[17]
- The decarbonization path, based on the national targets applied to the strait's emissions, results in a reduction of the GHG emissions by 19% by 2030 compared to 2016.

[13] Based on data provided by Harju County Government
[14] Based on data by Laakso et al, 2013
[15] Considering 6.8 tCO_2e/capita. Source: Service of Observation and Statistics in France, based on data by EDGAR, World Bank, 2015
[16] Considering emissions of 59.5 $MtCO_2e$ in Finland and 22.04 $MtCO_2e$ in Estonia in 2014. Source: CAIT Climate Data Explorer, World Resources Institute
[17] http://www.envir.ee/en/news-goals-activities/climate/general-principles-climate-policy

1. Analysis of the situation at the strait level

Organizational perimeter

Helsinki-Uusimaa Regional Council in Finland and Union of Harju County Municipalities in Estonia are involved in governing the strait Gulf of Finland together with City of Helsinki, City of Tallinn, Finnish and Estonian governments and other actors.

Projects include e.g.: FinEst Link, North Sea–Baltic Connector of Regions (NSB CoRe), Baltic Energy Market Interconnection Plan (BEMIP), FinEst Smart Mobility, Twin Port 1 & 2.

The Gulf of Finland's Strait	FINLAND	ESTONIA
The PASSAGE administrative authorities	Helsinki-Uusimaa Regional Council	Union of Harju County Municipalities
Inhabitants	1 640 000	582 556
Land area (km^2)	9 097	4 333
Density (inhab./km^2)	180	134
Number of district authorities	26 municipalities	23 municipalities
Coastline (km)	300	155
Seascape area / Width	640,000 ha / narrowest distance across the Gulf is 52km from Porkkala to Rohuneeme outside Tallinn	
Main city	Helsinki	Tallinn

The boundaries of the strait were determined as follows:

- The maritime boundary is set according to the boundaries of the NUTS 3[18] region (Põhja Eesti and Helsinki-Uusimaa);
- The Finnish border boundary for economical activities is the capital region (Helsinki, Espoo, Vantaa and Kauniainen) and for the in-land transport Helsinki-Uusimaa region (NUTS3)[19];
- The Estonian border boundary is the Põhja- Eesti region (NUTS 3).

The following map shows the boundaries of the strait considered here:

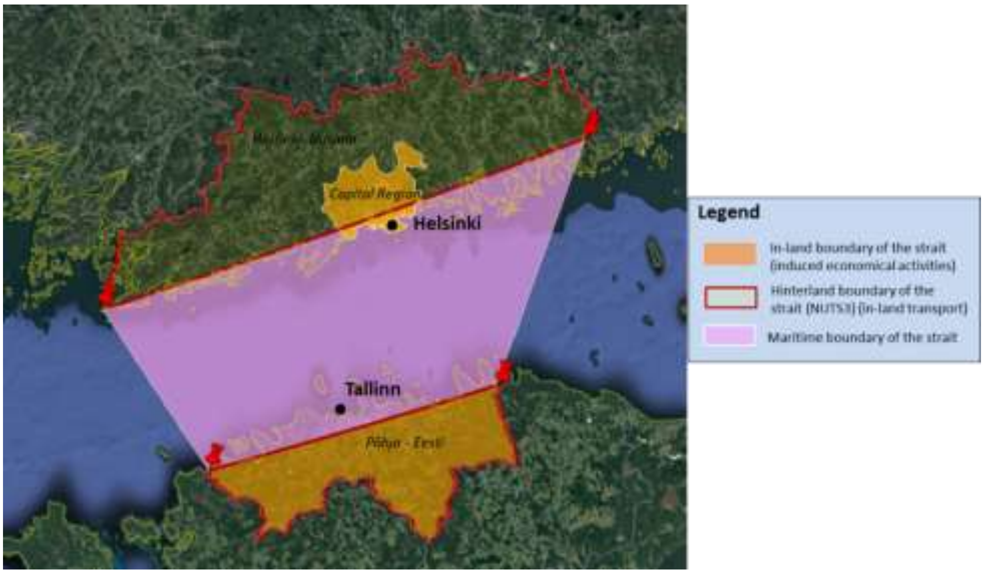


Figure 9 - Geographical boundary of the Gulf of Finland's Strait (Source: I Care & Consult)

[18] Nomenclature of territorial units for statistics (hierarchical system for dividing up the economic territory of the EU).

[19] In the Helsinki-Uusimaa Region, the in-land boundary of the strait for economical activities, i.e. industries and cities, is considered as the boundary of the Capital Region, because only data from the Port of Helsinki was available. Including industries from other parts of the Helsinki-Uusimaa Region, especially from the industrial area of Sköldvik (Kilpilahti), would have biased the study, because data wasn´t available from the Port of Sköldvik which is the main port of the area.

Functional & operational perimeter

Within the strait area, different activities take place and might generate significant GHG emissions, that are not under the control of the PASSAGE authorities. The role of the organizations deals mainly within the transport sector and interregional cooperation and their competences include regional planning (land-use) and regional development. Future scenarios of the relationship between Helsinki and Tallinn are published in the "Twin-city in Making - Integration Scenarios for Tallinn and Helsinki Capital Regions"[20].

Baltic Sea (and the Gulf of Finland) is designated as a Sulphur Emission Control Area (SECA) and will be a Nitrogen Emission Control Areas (NECA) by 2021. This will likely increase the use of green shipping technology and alternative fuels such as LNG, and in general catalyse technological innovations in the field of green shipping.

The section below aims to list the main activities within the considered perimeter.

PORTS

The Port of Helsinki (including Vuosaari harbour) and the Port of Tallinn (including ports of Muuga and Paldiski) are some of the busiest ports on the Baltic Sea.

The port of Sköldvik (Kilpilahti) (located 50 km east of Helsinki), is the biggest Finnish port by tonnage (industrial area of Kilpilahti: notably petrochemicals activity). However, due to the lack of data availability, it was not possible to include this port in the study. Share of the four biggest ports in the Finnish side of the Gulf of Finland – KotkaHamina, Sköldvik, Helsinki, Hanko – is 95 % of the cargo tonnes of the Finnish ports in the Gulf of Finland. Other ports in the Finnish side of the Gulf of Finland are minor ports.[21]

Other minor Estonian ports in the Gulf of Finland include: Sillamäe, Kunda, Miiduranna, Vene Balti, Bekker and Paldiski Northern.

In the Gulf of Finland, 17 ports handle oil and oil products: six ports in Finland, six in Estonia and five in Russia. (Holma et al. 2011). Finland's largest oil port is Sköldvik and port handles 96 % of the Finnish volumes. In Estonia, the largest port is Muuga and ports share of Estonian oil volumes is 82%. Estonia has no crude oil reserves or oil production plants or refineries of its own.

There is almost no fishing activity in the area.
The main emission sources from the ports themselves are the energy consumption, such as electricity, natural gas, gas oil, diesel etc. Each of the ports of the strait has sent the energy consumption in their facilities.

MARITIME TRAFFIC

Maritime traffic in the Gulf of Finland has grown remarkably during the 2000s. One of the main cross-border port activity is passengers maritime transport between Helsinki and Tallinn (tourists, workers weekly return trip). Growing transport volumes are connected with increasing interaction between the regions in terms of tourism, business activities, migration, cross-border work, studying and all kinds of social interaction.

As suggested by the literature review, the sea-based activity is one of the main GHG source of emissions within a strait. The key figure of the **main maritime traffic** occurring in the Gulf of Finland's Strait are reported below:

[20] Terk, Erik (ed.) (2012), Twin-city in making: Integration scenarios for Tallinn and Helsinki capital regions. Tallinn, Tallinn University Estonian Institute for Future Studies.
[21] Finnish Transport Agency (2016), Monthly statics on international shipping 12/2016.
https://www.liikennevirasto.fi/documents/20473/38366/kk_12_2016/190ce59f-b1c9-4846-8359-713fd62dbb22

- **The local maritime traffic** concerns the trips, by ferries, between Helsinki and Tallinn. This traffic represents almost 11 300 trips in 2016, according to the Finnish Transport Agency. About 8.7 million passengers were transported across the strait, as well as more than 3.8 million tonnes of freight.

- **The maritime traffic with calls at the strait's ports** (Helsinki and Tallinn) concerns all the ships arriving at and leaving from the strait's ports, except for the ferries that are included in the local maritime transport. The port call statistics of each port contains information about the type of vessel calling to the port, as well as the port of origin and destination, the weight carried and other information about the size of the ship.

  The table below presents the different types of vessels and the cargo handled in the port in 2016, based on the call statistics from the Port of Helsinki, excluding the local maritime cruise (between Helsinki and Tallinn) that is treated above.

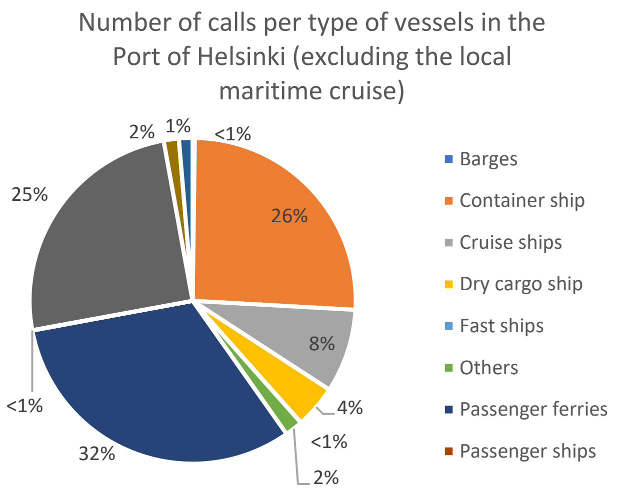


Figure 10 - Type of vessels calling at the Port of Helsinki (Source: I Care & Consult from data provided by the Port of Helsinki)

Table 4 - Total cargo handled per type of vessel in the Port of Helsinki

Type of vessel	Total cargo handled in 2016 (in tonnes)
Container ships	3 267 719
Roro	3 549 664
Dry cargo ships	896 935
Passenger ships & ferries	3 770 195
Tankers	133 860
Tugs	1 290
Barges	1 257
TOTAL	**11 620 919**

In total, the port of Helsinki handled more than 11.6 million tonnes of freight (including freight between Helsinki and Tallinn) and almost 12.4 million passengers in 2016 representing 8 481 ships calling at the port (including passengers between Helsinki and Tallinn). The main types of ships are passenger ferries, roro and container ships.

The table below presents the different type of vessels and the cargo handled in the port in 2016, based on the key figures of the Port of Tallinn, excluding the local maritime cruise between Tallinn and Helsinki that is treated above.

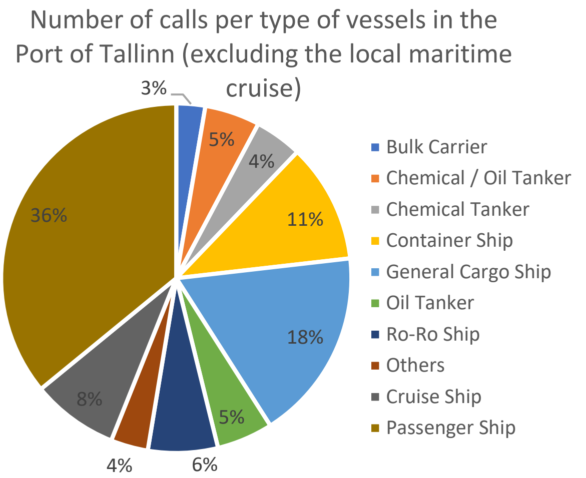


Figure 11 - Type of vessels calling at the Port of Tallinn (Source: I Care & Consult from data provided by the Port of Tallinn)

Table 5 - Total cargo handled per type of vessel in the Port of Tallinn

Type of vessel	Total cargo handled in 2016 (in tonnes)
Container ships	1 777 900
General cargo	580 900
Dry bulk	3 745 400
Liquid bulk	9 442 800
Roro cargoes	4 563 200
TOTAL	**20 110 200**

In total, the port of Tallinn handled more than 20.1 million tonnes of freight (mostly in liquid bulk, roro cargoes and dry bulk carriers, including freight between Helsinki and Tallinn) and almost 10.2 million passengers in 2016 representing 7 492 ships calling at the port.

- **The transit maritime cruise** concerns the vessels passing through the Gulf of Finland's Strait without any calls to the strait's ports. This represents more than 39 500 ships in 2016, mainly general dry cargo ships and tankers.

The Gulf of Finland is under full radar surveillance and operates under a Traffic Separation Scheme, which means that two lanes run through the strait for inward and outward-bound traffic. Vessel traffic in the area is also monitored by means of radar and the AIS-system. Estonia and Finland have also implemented mandatory ship reporting systems in their territorial waters outside their VTS area. Each vessel over 300 gross tonnes must report either to Tallinn Traffic, Helsinki Traffic or St. Petersburg Traffic before proceeding through the service area.

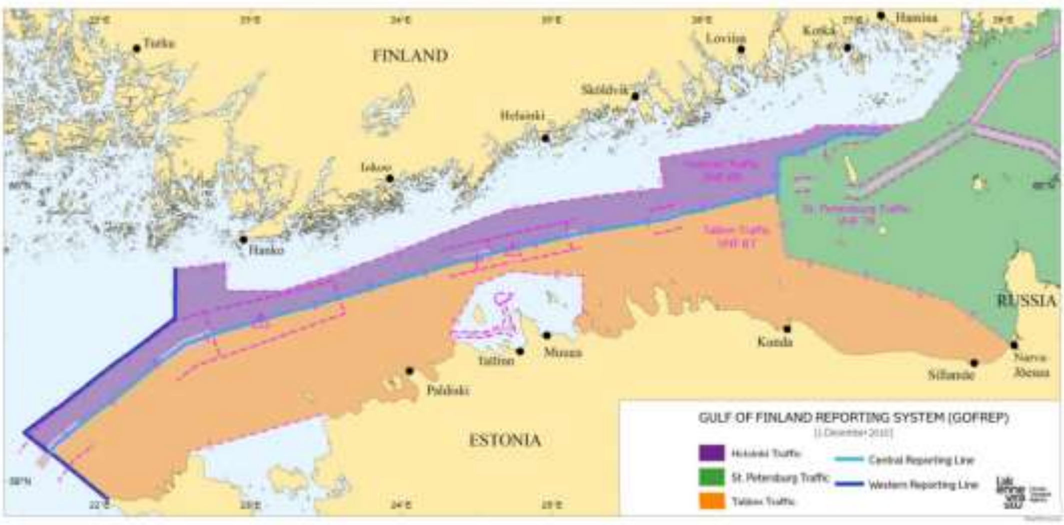


Figure 12 - GOFREP operational area (Source: Finnish Transport Agency - Liikennevirasto)

The database containing every report of vessels on the Estonian side (with information such as the type of vessel and the next port of call) was provided by the Estonian Maritime Administration. More than 39 500 vessels were reported passing through the Gulf of Finland's Strait without any calls to the strait's ports (Helsinki and Tallinn).

IN-LAND TRAFFIC

In this section, the traffic related to the ports are considered, as they induced the majority of freight and passengers induced by the strait.

Figure 13 - Map of the transport corridors

One of the feature of the Gulf of Finland is the access to Russia. There are several possible changes in transport corridors and recomposition. Rail Baltica is a greenfield rail transport infrastructure project (EU TEN-T) with a goal to integrate the Baltic States in the European rail network. It will connect Tallinn, Pärnu, Riga, Panevežys, Kaunas, Vilnius, Warsaw.

Most of the goods are transported to their next destination by road in Finland and in Estonia. The railway network is also an important infrastructure for in-land traffic in both Finland and Estonia. The national share for road and rail transport was used, as well as national statistics on distance based on Eurostat data.

However, the Helsinki Region Transport Authority HSL has made a survey in 2015 for passengers coming to the harbour in Helsinki. The results from this survey were used to estimate the modal share of passengers as well as the average distance travelled by the main type of transport.

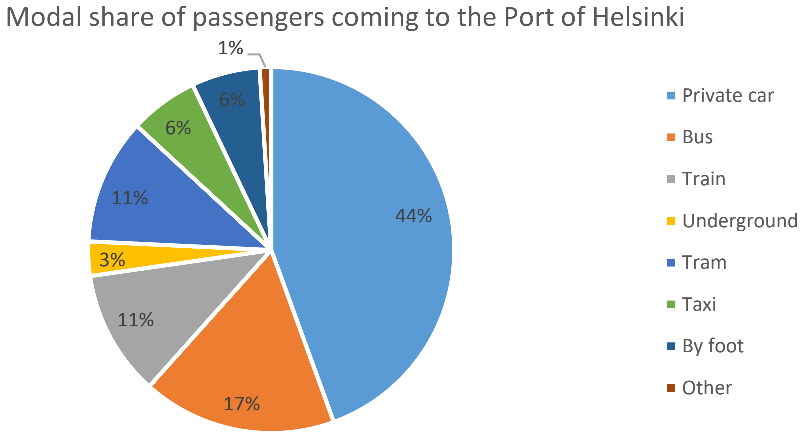


Figure 14 - Modal share of passengers coming to the port of Helsinki (Source: I Care & Consult, based on the survey by HSL)

Table 6 - Hypothesis on modal share and distance for in-land traffic based on national statistics

Mode		Country	Modal share	Distance
Road transport	Freight	Finland	74%	120 km
		Estonia	67%	90 km
	Passengers	Finland (car)	44%	88 km
		Finland (taxi)	6%	20 km
		Finland (bus)	17%	83 km
		Estonia	98%	2 km

Railways	Freight	Finland	26%	254 km
		Estonia	33%	111 km
	Passengers	Finland (train)	11%	96 km
		Finland (underground)	3%	10 km
		Finland (tram)	11%	4 km
		Estonia	2%	43 km

The following table presents the quantity of goods that were handled in the ports and transported in the hinterland, based on data provided by the ports:

Table 7 - Quantity of goods and number of passenger handled in the ports and transported in the hinterland

Port	Quantity of goods (tonnes)	Number of passengers
Helsinki	11 621 000	11 974 000
Tallinn	20 118 500	10 173 000

INDUSTRIES

Cross-border trade and production have also increased rapidly during the last 10 years, for example influenced by Finnish manufacturing enterprises that have relocated activities to Estonia. Estonia's economy is highly export-oriented. Manufacturing of machinery and equipment, the wood industry and food and beverage manufacturing have the highest share of the country's industry. Finland´s economy is also export-oriented with a share of services 70 % of GDP, industry 27 % and primary production 3 %. The main economic activities include for example wholesale and retail trade, transportation and storage, information and communication, real estate activities, electrical and electronic industry, chemical industry, metal industry and paper industry[22].

More than 2,000 vessels continuously transport different kinds of cargoes in the Baltic Sea. The biggest share of the cargo is liquid bulk, i.e. various oil products, crude oil and chemicals. The major part of the transport goes through the Russian ports and terminals, i.e. Ust-Luga and Primorsk. The annual volume of the oil transport in the Gulf of Finland is about 160 million tonnes and the oil transportation is envisaged to grow significantly [23].

The main emitting industries in Tallinn are various boiler houses and a power plant. The boiler houses are functioning with natural gas and light fuel oil as reserve, while the Tallinna Elektrijaam power plant process is based on the energy from domestic wood chips and peat. The main GHG sources in Helsinki capital area are heating 59%, traffic 24%, electricity 13%, industry and machinery 2 % and waste treatment 2%[24]. Many industries are located in Helsinki, Vantaa and Espoo. The most important emitter is the *Hanasaari B* power plant in Helsinki. The data that has been used to calculate the emissions of the industries comes from the EU emissions trading system.

Figure 15 - Tallinna Elektrijaam power plant (Source: OÜ Utilitas Tallinna Elektrijaam)

[22] Statistics Finland, Annual national accounts. http://tilastokeskus.fi/til/vtp/index_en.html

[23] Montewka, Jakub & Häkkinen, Jani & Rytkönen, Jorma & Jalonen, Risto (2016), Maritime Traffic and Its Safety. In Raateoja, Mika & Setälä, Outi (eds.), The Gulf of Finland Assessment. Reports of the Finnish Environment Insitute 27/2016.

[24] Uudenmaan kasvihuonekaasupäästöt 2015 (Greenhouse gas emissions in Helsinki-Uusimaa 2015) https://www.uudenmaanliitto.fi/tietopalvelut/uusimaa-tietopankki/alue_ja_ymparisto/kasvihuonekaasupaastot

CITIES & TOWNS

The regions of Helsinki – Uusimaa (Finland) and Põhja – Eesti (Estonia) also present emissions due to the energy consumption in the residential and commercial sectors. Those emissions are estimated based on the population of the strait's main regions and the national GHG inventory.

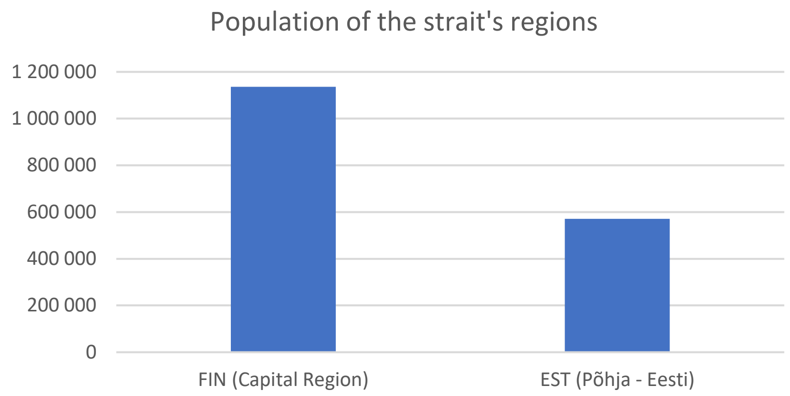


Figure 16 - Population of the main regions of the Gulf of Finland's Strait (Source: I Care & Consult from data by Eurostat – NUTS 3)

The Helsinki Capital Region includes the capital city of Helsinki and neighbouring cities of Espoo, Vantaa and Kauniainen. These municipalities have ambitious carbon neutrality goals as the cities of Espoo and Vantaa are aiming at carbon neutrality by 2030 and the City of Helsinki by 2035. In addition, the Helsinki-Uusimaa Regional Programme sets a target for the whole Helsinki-Uusimaa region to become carbon neutral by 2035. National target is to reduce GHG emissions by 80% to 95% from the year 1990 level by 2050. Phasing out coal will be especially challenging for Helsinki, as coal provides about one-third of its electricity and about 60% of the district heating[25].

In 2013, GHG emissions in Estonia totalled 21.8 million tons, which is 45.7% lower compared to the base-year level of 1990. However, Estonia is still among the top three per capita and per GDP greenhouse gas emitters in Europe – mainly due to its carbon and energy-intensive oil shale based energy generation sector, rapid growth in road freight transport and car use, low energy efficiency of the new vehicle fleet and the high energy consumption of buildings. Still, the average carbon footprint of the Estonian electricity has decreased to 0.91 kg CO_2 per kWh (Kallaste, 2014).

[25] Helen, Origin of energy https://www.helen.fi/en/company/energy/energy-production/origin-of-energy/

Schematic representation of the strait

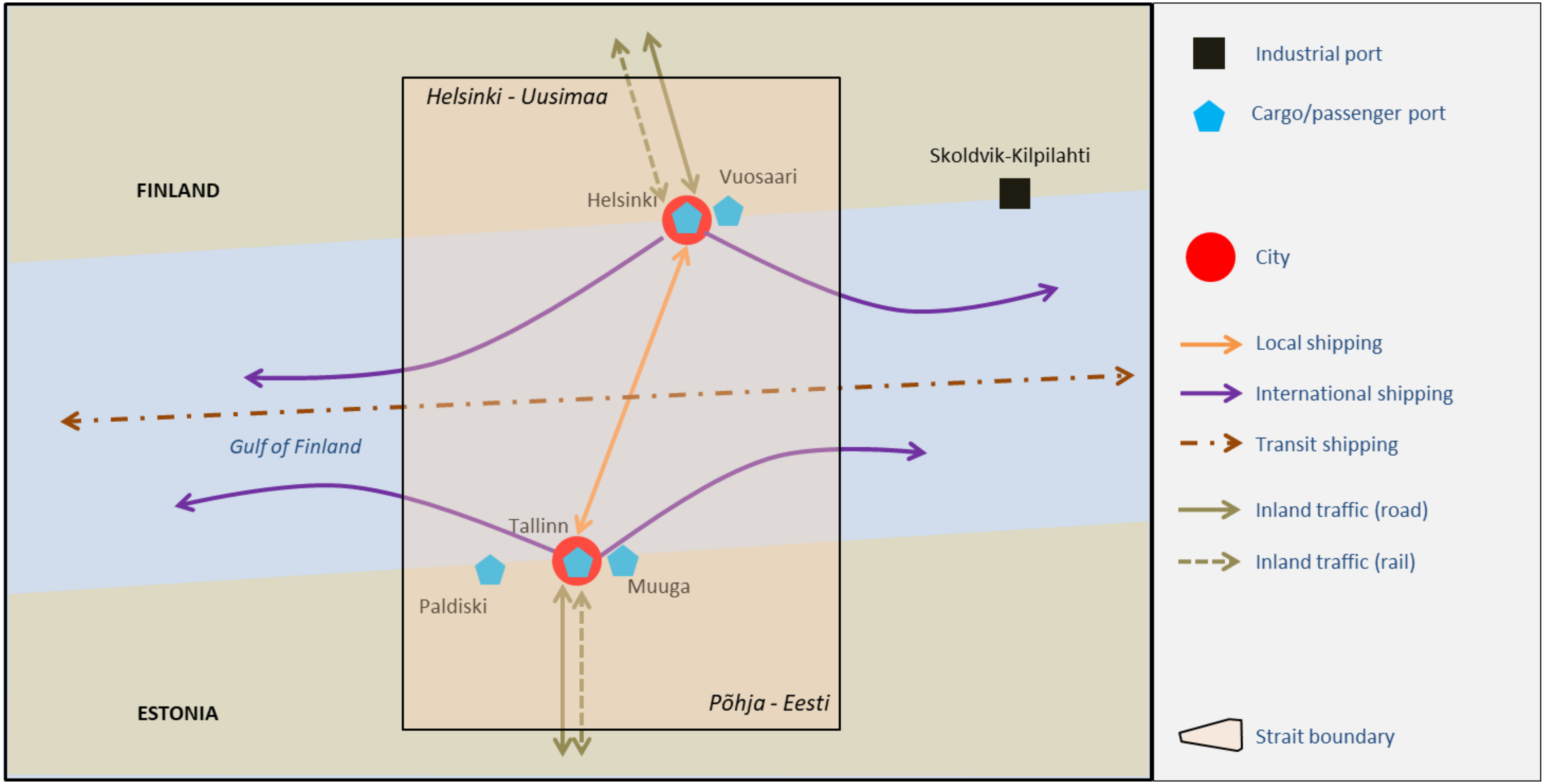


Figure 17 - Schematic “choreme” representation of the Gulf of Finland’s Strait (Source: I Care & Consult)

Geographic representation of the strait

This map presents the main distances considered within the boundary based on the geographic boundary of the strait, as defined in the methodological note. The NUTS3 regions were considered to delimit the maritime boundary of the strait.

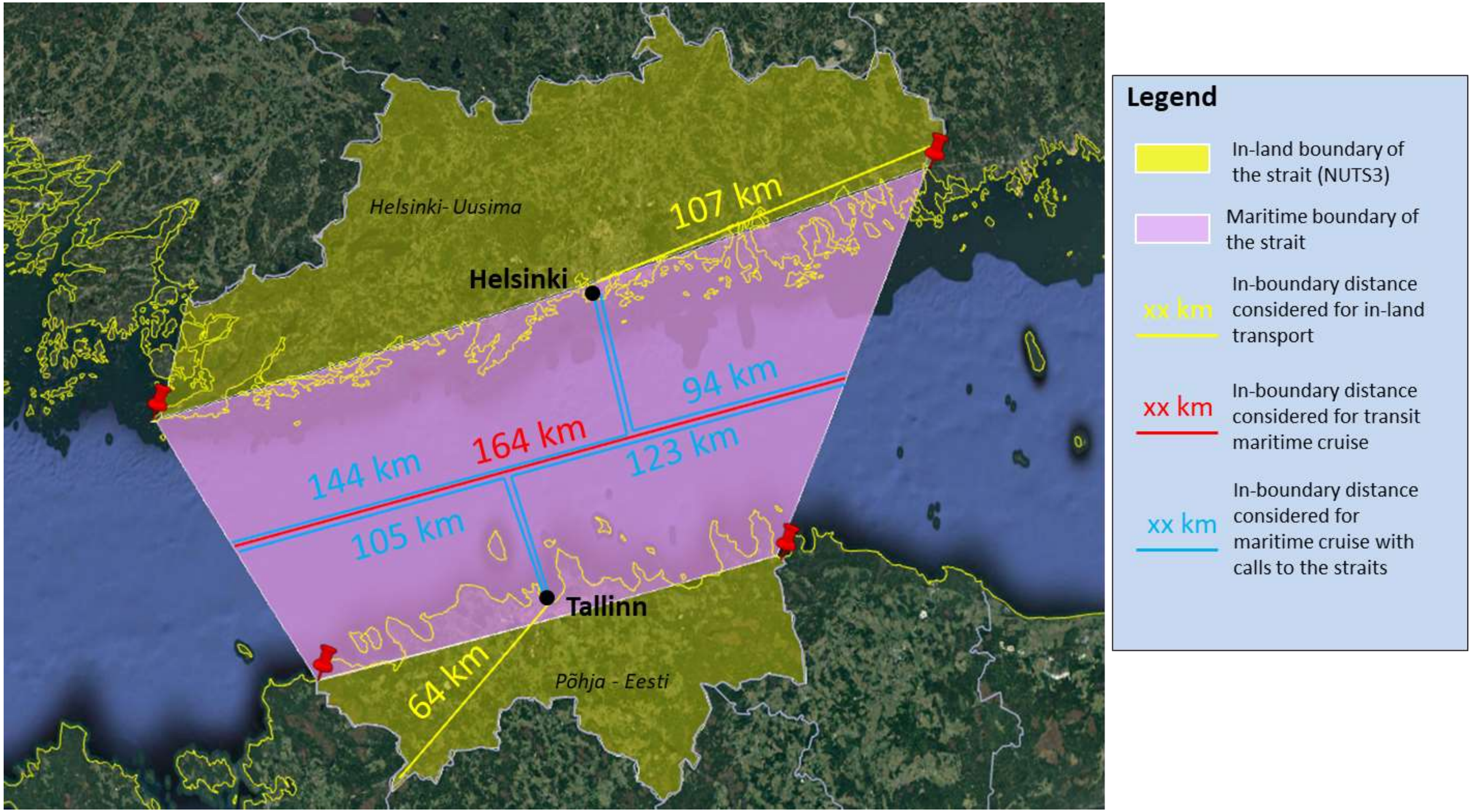


Figure 18 - Representation of the geographical boundary of the Gulf of Finland's strait (Source: I Care & Consult)

2. GHG emissions and key priorities for future actions

This section aims to gather the main GHG emissions sources **within the strait perimeter** and not all the emissions of the region. All the calculations can be seen in the Excel file linked to this study.

The latter are calculated thanks to the data collected from the local stakeholders, existing studies carried out by the Helsinki-Uusimaa Regional Council and Union of Harju County Municipalities and the literature reviews, and processed by I Care & Consult.

The Gulf of Finland's Strait emitted **9.7 MtCO_2e** in 2016. The main source of emission is the induced economical activities with 61% of the total emissions, followed by the maritime transport with 35% of the total emissions, the in-land traffic representing 3% and the port operations representing 1%. The emissions are mainly impacted by the industries and the transit maritime cruise. It is important to note that some emission sources were not estimated based on a lack of data (such as the emissions from ships in port areas in Tallinn).

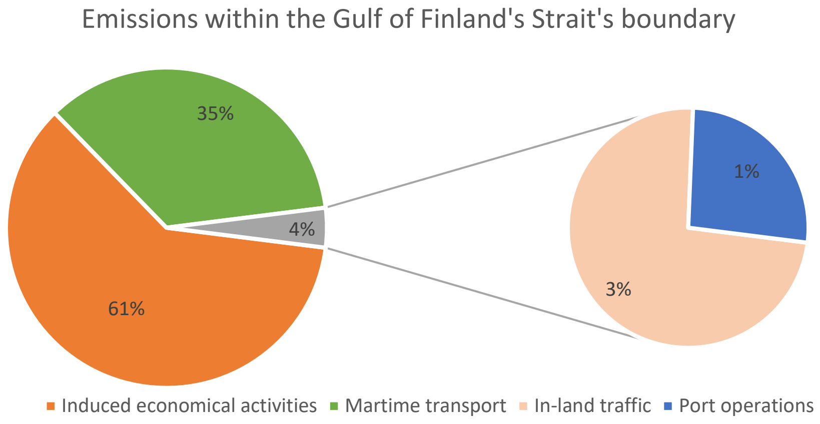


Figure 19 - Repartition of emissions from the Gulf of Finland's Strait (Source: I Care & Consult)

Table 8 - Repartition of emissions from the Gulf of Finland's Strait, per source

Emission source (within the strait's boundary) ***in tCO_2e***		**Finland**	**Cross-border**	**Estonia**
Port operations	Energy consumption	14 819		11 618
	Ships in port areas	75 590		NC
Maritime transport	Local maritime cruise		190 435	
	Maritime cruise with calls to the strait's ports		383 583	
	Transit maritime cruise		2 839 190	
In-land traffic	Road transport	178 520		84 132
	Railway transport	12 279		10 152
Induced economical activities	Industries	4 631 624		217 663
	Cities	786 120		241 928
TOTAL		**5 698 953**	**3 413 207**	**565 492**

It is important to note that pan-European emission factors were used, as described in the methodological note. However, the Finnish emission factors[26] could also be used. In this case, the emissions are equal to 7.1 $MtCO_2e$ (instead of 9.7 $MtCO_2e$), meaning a reduction of 27%, mainly due to a reduction of the emission factors of tankers and cargo ship in the transit maritime cruise. This means that the share of the maritime transport in the inventory is reduced to 12%. Nevertheless, the order of magnitude is still the same.

The emissions due to the strait's activity but emitted outside of the boundary (due to in-land and maritime transport outside of the boundary) were also estimated. Considering these indirect emissions, the strait is responsible for the emissions of 15.1 $MtCO_2e$, from which 64% are emitted within the boundary. It is important to note that some of the indirect emission sources could not be estimated due to lack of information (such as the out-boundary emissions from transit maritime cruise). The main emitter outside of the boundary is the out-boundary emissions from the maritime cruise with calls to the strait's ports (Helsinki and Tallinn).

Table 9 - Direct and indirect emissions from the Gulf of Finland's Strait, per source

Emission source (within and outside the strait's boundary) ***in*** tCO_2e		**Within the strait's boundary**	**Outside the strait's boundary**
Port operations	Energy consumption	26 437	
	Ships in port areas	75 590	
Maritime transport	Local maritime cruise	190 435	
	Maritime cruise with calls to the strait's ports	383 583	5 381 055
	Transit maritime cruise	2 839 190	NC
In-land traffic	Road transport	262 653	43 439
	Railway transport	22 431	15 985
Induced economical activities	Industries	4 849 287	
	Cities	1 028 048	
TOTAL		**9 677 653**	**5 440 479**

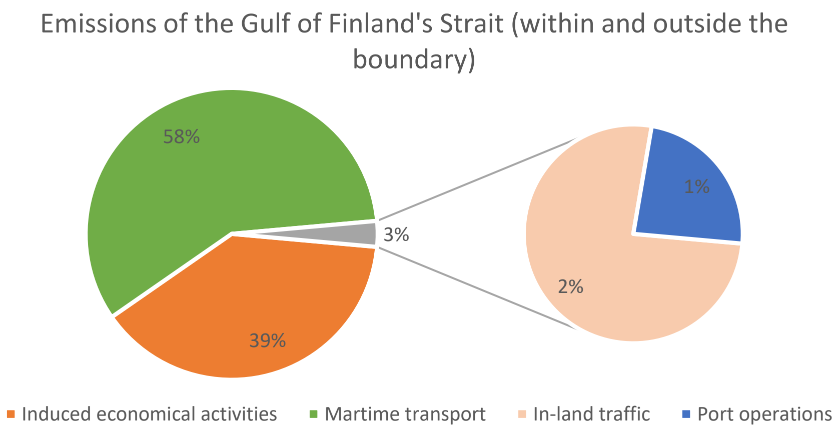


Figure 20 - Repartition of emissions from the Gulf of Finland's Strait (direct and indirect emissions) (Source: I Care & Consult)

[26] http://lipasto.vtt.fi/yksikkopaastot/indexe.htm

PORTS

These emissions concern the emissions from the energy consumption of the ports and from the ships in port areas (manoeuvring and at berth, consuming energy for the main and auxiliary engines). These emissions are occurring within the strait's boundary. They represent 1% of the total emissions within the strait's boundary.

- **Energy consumption**

The energy consumption is the source of **26.4 ktCO_2e**, which represents 26% of the emissions from ports operation.

The Port of Helsinki is the main emitter of GHG with 14.8 ktCO_2e in 2016, mainly because of the consideration of various emission sources such as the working machines and the rubber wheeled traffic in the port. The main source of emission is the electricity consumption in the port of Tallinn, representing more than 90% of the emissions, the emission factor for electricity in Estonia being more important than in Finland (mainly because of the use of coal to produce electricity in Estonia).

The main source of emission in the Port of Helsinki are the rubber wheeled traffic and the working machines, followed by electricity and heating.

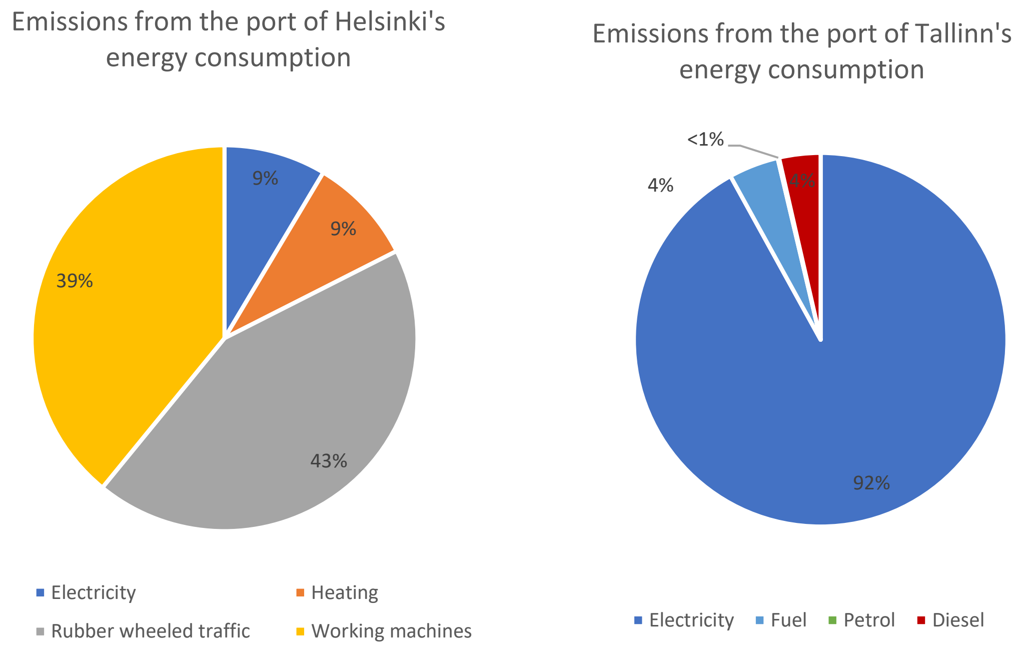


Figure 21 - Repartition of emissions from the energy consumption in the ports of Helsinki and Tallinn (Source: I Care & Consult based on data provided by the port)

- **Ships in port areas**

The emissions from ships in port areas represent **75.6 ktCO_2e** for the Port of Helsinki, which represents 74% of the emissions from ports operation. It is important to note that, as no information were provided on time spent in the port areas by the Port of Tallinn, the emissions from the ships in port areas were not estimated.

The Port of Helsinki estimated the GHG emissions produced in the port area, based on information on the ship type, the fuel, the engine type, the utilization of the main engines, the time spent on berth with auxiliary engines and whether the vessel uses onshore electricity while on berth or not. The ships while in port areas are an important source of emissions for the Port of Helsinki. They represent more than 80% of the emissions in the port area of Helsinki (compared to the rubber wheeled traffic and the working machines, included in the energy consumption of the port).

MARITIME TRAFFIC

These emissions concern the emissions from the maritime transport within the strait's boundary. They represent 35% of the total emissions.

- **Local maritime cruise**

This source of emissions concerns the ferries and other maritime cruise navigating between Helsinki and Tallinn and occurs only within the strait's boundary. It represents **190 ktCO₂e**, 6% of the emissions from maritime transport. In 2016, more than 8.7 million passengers travelled between the ports of Helsinki and Tallinn and more than 3.8 million tonnes of freight.

- **Maritime cruise with ships calling at the strait's ports**

This source of emissions concerns all the ships calling at each of the strait's ports (Helsinki and Tallinn) travelling to a port outside of the strait. It represents **383.6 ktCO₂e**, 11% of the total emissions from maritime transport. This only includes the part of the trip that is realized within the strait's boundary. It is important to note that the part of the trip occurring outside the strait's boundary represents more than 90% of the emissions from maritime cruise with ships calling at the strait's ports (including the part within and outside the strait).

Most of the emissions come from the Port of Tallinn (more than 6 600 vessels arriving to or departing from the port, excluding the local maritime cruise). Most of the emissions from the ships calling at the Port of Tallinn are the passenger ships, the cruise ships and the roro ships, as well as the oil tankers and chemical/oil tankers. The main emissions from the Port of Helsinki (more than 5 600 vessels) come from the passenger ferries, the cruise ships, the roro ships and the container ships.

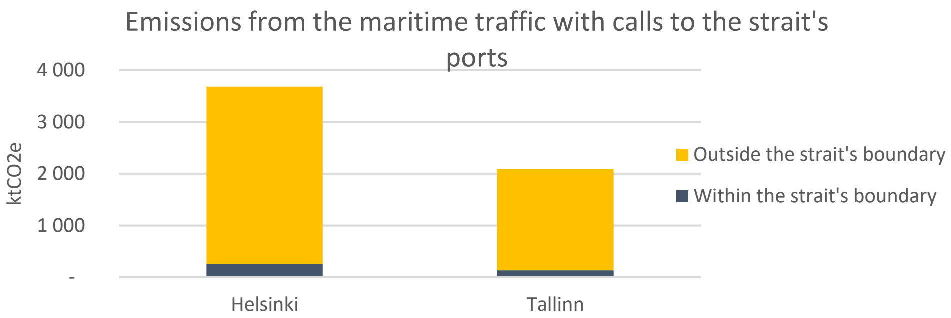
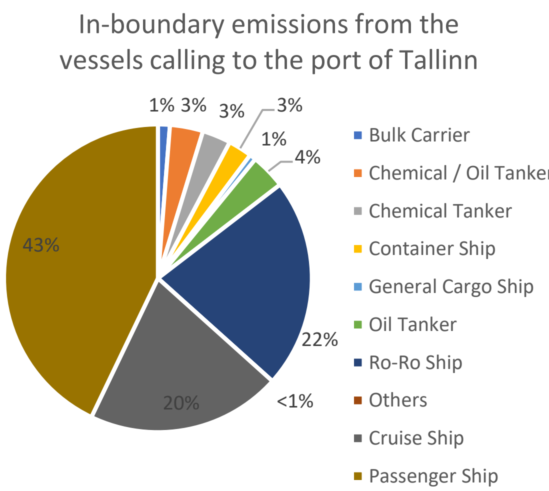


Figure 22 - Repartition of emissions from maritime transport with calls to the strait's ports (Source: I Care & Consult, based on data provided by the ports)



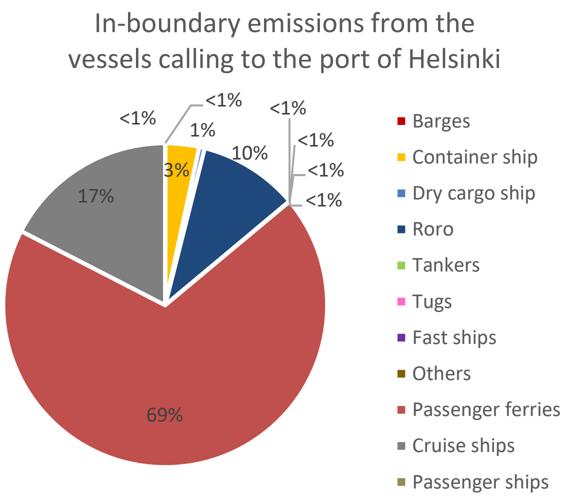
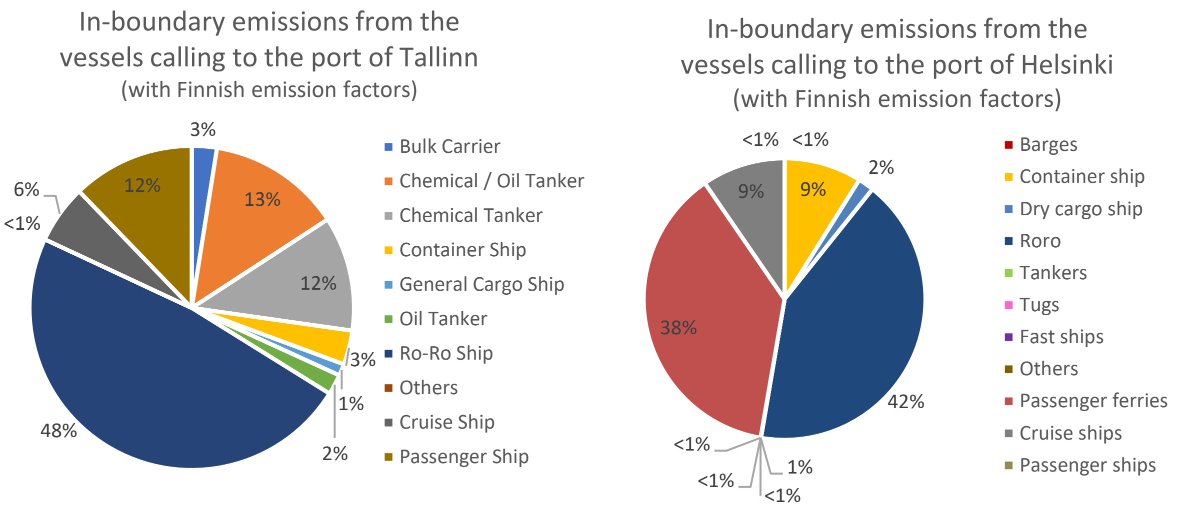


Figure 23 - Repartition of emissions from maritime transport with calls to the strait's ports per type of ship (Source: I Care & Consult, based on data provided by the ports)

It is important to note that, with the Finnish emission factors, the results are quite different. In this case, the emissions from the maritime cruise with calls at the ports of Helsinki and Tallinn are quite similar (about 71 ktCO_2e for each port). In the port of Helsinki, emissions are mainly due to the roro ships and the passenger ferries and in the port of Tallinn, emissions are mainly due to the roro ships, as shown in the figures below. This is mainly due to the hypothesis used to estimate the emission factors, depending on the consumption rate of the ship and the average number of passengers and/or tonnage considered on board.



- Figure 24 - Repartition of emissions from maritime transport with calls to the strait's ports per type of ship, calculated with Finnish emission factors (Source: I Care & Consult, based on data provided by the ports)**Transit maritime cruise**

The transit maritime cruise is one of the most important source of emissions within the Gulf of Finland's Strait's boundary. It represents **2 839 ktCO_2e** in 2016, which is 83% of the maritime emissions and 28% of the total emissions. It is important to note that, due to lack of information, the out-boundary emissions from transit maritime cruise could not be estimated. It is also important to note that only the Estonian Maritime Administration provided information, which means that the vessels reporting to the Finnish side of the strait were not taken into account. To provide a complete inventory, the figures from the Estonian Maritime Administration were doubled to account for the Finnish side of the strait. A publication from the Finnish Environment Institute indicates that 36 444 vessels passed through the mid-point of the Gulf of Finland in 2014, which is coherent with the data received by the Estonian Maritime Administration (39 500 ships).

Figure 25 - Maritime traffic in the Gulf of Finland (Source: Finnish Environment Institute)

Most of the emissions come from the cargo ship, the passenger ships and the tankers, representing more than 90% of the emissions from the transit maritime cruise

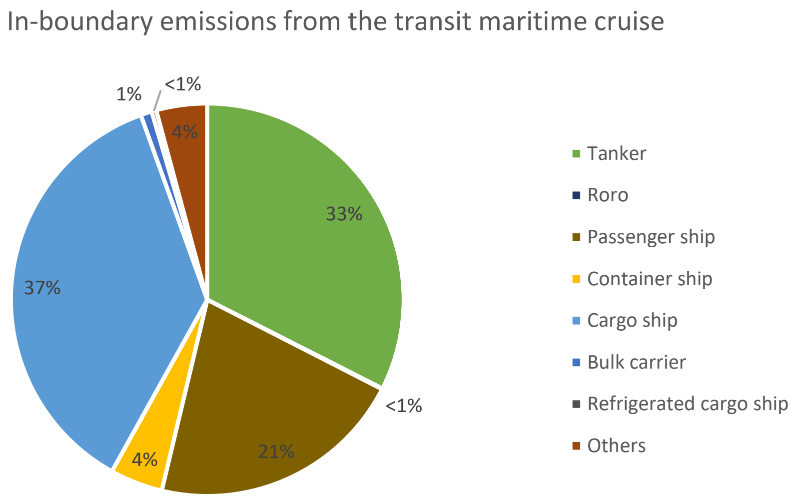


Figure 26 - Repartition of emissions from transit maritime transport per type of ship (Source: I Care & Consult, from data provided by the Estonian Maritime Administration)

IN-LAND TRAFFIC

These emissions concern the emissions from the in-land transport (road and railway transport) within the strait's boundary. They represent 3% of the total emissions.

The road transport is the most important source of in-land traffic emissions and represents about **263 ktCO_2e**. The road transport represents 92% of the emissions from in-land traffic. The railway transport (including tramways) is the second source of in-land traffic emissions and represents **22.4 ktCO_2e**.

Concerning the freight traffic, even though the Port of Tallinn handled almost twice as many goods as the Port of Helsinki, the emissions are similar because of a shorter travel distance in Estonia. The road transport is the most important source of emission and most of the emissions occur within the strait's boundary.

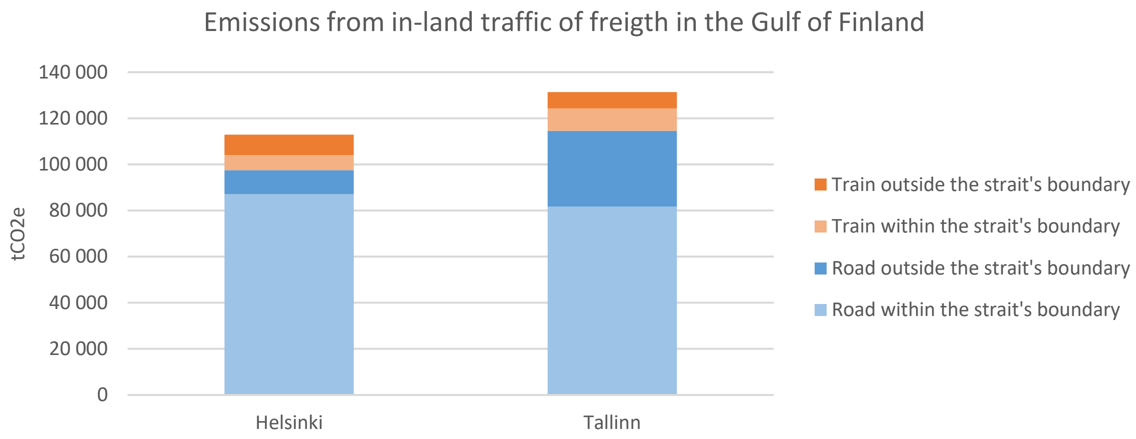


Figure 27 - Emissions from in-land traffic of freight in the Gulf of Finland's Strait (Source: I Care & Consult)

Concerning the passenger traffic, the Port of Helsinki welcomed more passengers than the Port of Tallinn, and consequentially, the emissions are higher. Moreover, the distance travelled for the Port of Tallinn is lower due to the distance to the capital figure used in the methodology. In the case of the port of Helsinki, data from a survey was considered, to ensure the distance better reflected the reality. The road transport (cars) is the most important source of emission in Finland.

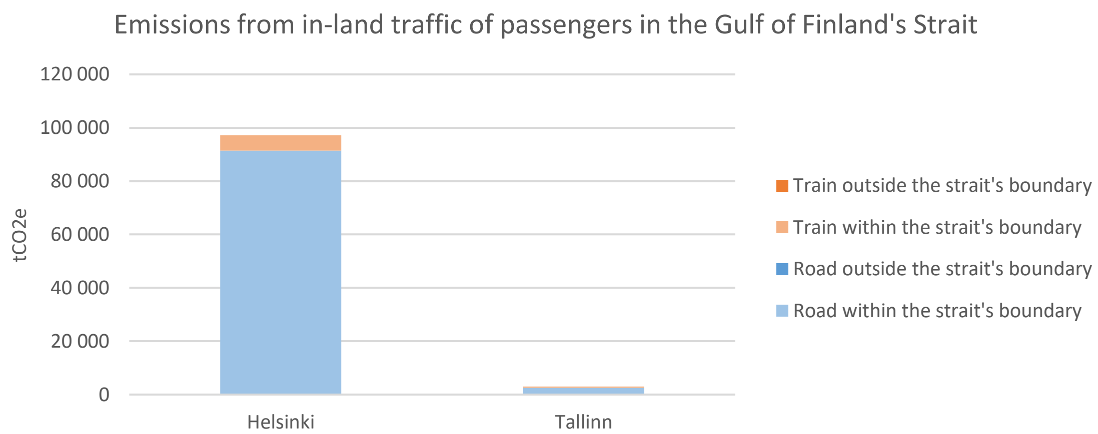


Figure 28 - Emissions from in-land traffic of passengers in the Gulf of Finland's Strait (Source: I Care & Consult)

INDUCED ECONOMICAL ACTIVITIES

This source concerns the emissions from the industries and from the cities (residential and commercial emissions from energy consumption) which occur only within the strait's boundary. It represents **5 877 ktCO$_2$e**, which represents 61% of the total emissions.

- **Industries**

Many industries were identified close to the Ports of Tallinn and Helsinki. They emitted **4 849 ktCO$_2$e** in 2016.

The most important emitter of GHG on the Finnish side of the strait is the *Hanasaari B* power plant, producing electricity and heat from coal and wood pellets in Helsinki.

The most important emitter of GHG on the Estonian side of the strait is the *Mustamäe Katlamaja* site, the most important boiler house in Tallinn. It represents more than 46% of the emissions from industries within the strait's boundary.

Figure 29 - Hanasaari B Power Plant (Source: Wikipedia)

- **Cities**

The emissions from the cities were estimated based on the number of inhabitants in the NUTS 3 region which shore correspond to the strait (Helsinki Capital Region and Põhja – Eesti). They emitted about **1 028 ktCO$_2$e** in 2016.

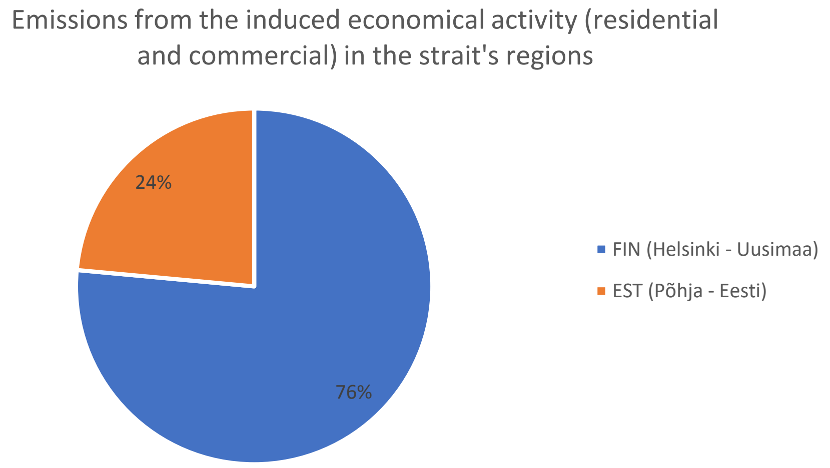


Figure 30 - Emissions from the Gulf of Finland's Strait's regions (Source: I Care & Consult)

3. Decarbonization paths

In the last years, the threat of climate change is being addressed globally by the United Nations Framework Convention on Climate Change (UNFCCC). The EU emissions represent about 10% of total global emissions and its Member States have ratified the UNFCCC's Kyoto Protocol in 1997 and the Paris Agreement in 2015, setting emission targets to limit the global emissions and keep global warming below 2°C. The EU aims to decarbonize its energy system and cut its greenhouse gas emissions by 80% to 95% by 2050. To achieve this goal, it has set a binding target of reducing emissions by at least 40% compared to 1990 levels by 2030. Many European countries have adopted national programs aimed at reducing emissions.

FINLAND

Finland has an active role in climate policy and already published many National climate and energy strategies (2001, 2005, 2008, 2013, 2016), as well as an Energy and Climate Roadmap 2050 (in 2014), a Climate Change Adaptation Plan 2022 (in 2014), a Climate Change Act (in 2015), etc.

The Climate Change Act (609/2015) that entered into force in June 2015 established a framework for the long-term and cost-effective planning and monitoring of climate policy in Finland with the aim of reducing anthropogenic emissions of greenhouse gases into the atmosphere, mitigating climate change, and adapting to climate change through national actions. The act sets as the long-term target reducing greenhouse gas emissions by a minimum of 80% by 2050 compared to 1990 levels.

Finland's binding target is to cut emissions by 39% in the non-ETS sector by 2030 compared to 2005 and a reduction of 43% in the emissions trading sector is agreed in the EU's 2030 package. The National Energy and Climate Strategy specifies the objectives and the key measures to achieve the binding emission reduction targets in the effort sharing sector by 2030.

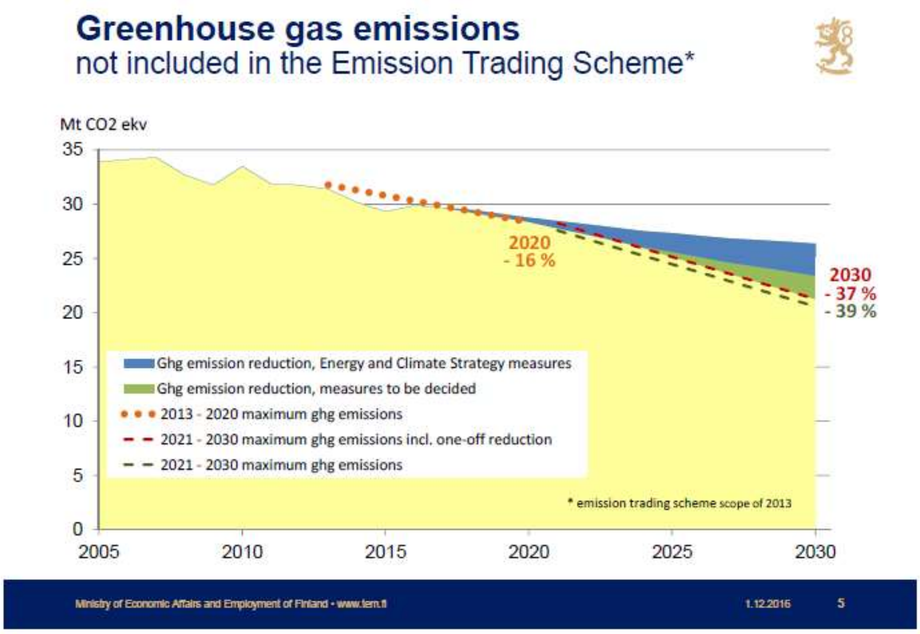


Figure 31 - Predicted evolution of greenhouse gas emissions of Finland between 2005 and 2030 (Source: Finnish Climate Policy – towards a low-carbon and energy-efficient future, Ministry of the Environment, Ministry of Agriculture and Forestry and Ministry of Employment and the Economy, 2015)

The Government Programme of Prime Minister Sipilä also set ambitious targets in the energy sector. It aims for increasing the share of renewable energy to over 50% of end consumption, increasing self-sufficiency to over 55%, phasing out coal use in energy production, halving the domestic use of imported oil, and bringing the share of renewable transport fuels up to 40% (23.5% of the fuel energy content). An effort will be made to achieve all this by 2030. In the case of the transport sector, this means a reduction of the traffic emissions by some 50% by 2030 compared to the situation in 2005.

Moreover, Finland has set an ambitions long-term goal of a carbon-neutral society.

Finally, the Government Report on the National Energy and Climate Strategy for 2030, published in 2017, emphasizes the crucial role of the municipalities in attaining the emissions targets in the effort sharing sector. The municipalities' decisions related to land use, transport and services, business policy, energy issues and procurement have an impact on greenhouse gas emissions. Sustainable public procurement both supports cutting emissions and offers possibilities for developing the domestic market.

As a result, the Helsinki-Uusimaa Regional Council published in 2018 their Regional Programme 2.0, covering a period from 2018 to 2021. The Helsinki-Uusimaa Region aims to become a carbon-neutral region by 2035 as part of the vision "Helsinki Region 2050 – Cool & the most vibrant region in Europe". The work includes drafting of a Roadmap for a Carbon-neutral Helsinki-Uusimaa Region began in 2018. The Region proposes to reduce the greenhouse gas emissions by 80% and offset the remaining 20% through other projects to reduce emissions or increase carbon sinks. The three biggest cities of the region, Helsinki, Espoo and Vantaa have set the goal of achieving carbon-neutrality by 2035 or earlier.Porvoo, Lohja, Hyvinkää, Hanko, Raasepori, Inkoo and Siuntio are part of the Hinku project which has the objective to reduce GHG emissions in their area by 80% by 2030 compared to the GHG emissions for 2007. These ten municipalities cover 80% of the population of the entire Helsinki-Uusimaa. The municipalities of Helsinki, Espoo and Vantaa, have also signed the Covenant of Mayors, with an objective of reduction of 20% by 2020. Helsinki-Uusimaa Regional Council takes part in the Compact of States and Regions.

The City of Helsinki has already achieved a reduction of 25% of its GHG emissions between 2015 and 1990.

ESTONIA

The Resolution of the Riigikogu, signed in 2017, presents the General Principles of Climate Policy until 2050. The long-term target of Estonia is to reduce the emissions of greenhouse gases by 2050 by 80% in comparison with the emission levels of 1990. As the country moves towards this target, emissions will be reduced by about 70% by 2030 and by 72% by 2040 in comparison with the 1990 emission levels.

A National Renewable Energy Action Plan was also published, in 2010, establishing a target of 25% of renewable energy in final consumption by 2020.

In 2013, GHG emissions in Estonia were 45.7% lower than the base-year level of 1990, which means that Estonia is well ahead of the Kyoto target.

The projections made in Estonia's Second Biennal Report under the UNFCCC give an indication of future trends in GHG emissions in Estonia, given the policies and measures implemented and adopted within the current national climate policies (scenario with additional measures):

Table 10 - Estonian sectoral objectives in 2030, compared to 2013

Sector	Emissions 2013	Emissions 2030	Evolution
Energy production and manufacturing industries	16 086.5 $ktCO_2e$	11 142.6 $ktCO_2e$	-31%
Transport	2 241.9 $ktCO_2e$	1 437.9 $ktCO_2e$	-36%
Other sectors (commercial, residential, agriculture)	672.0 $ktCO_2e$	602.2 $ktCO_2e$	-10%

A total reduction of 26% is projected between 2013 and 2030 with the actual policies (including the additional measures).

The City of Tallinn joined the Covenant of Mayors in 2009 and a Sustainable Energy Action Plan 2011-2021 was established. The objective is to reduce the CO_2 emissions in Tallinn by 20% by 2021 compared to 2007. The objective established in Tallinn Environmental Strategy 2030 is to reduce CO_2 emissions by 40% in comparison to 2007.

INTERNATIONAL SHIPPING SECTOR

Maritime transport emits around 1 000 $MtCO_2e$ annually and is responsible for about 2.5% of global greenhouse gas emissions (3rd IMO GHG Study). Shipping emissions are predicted to increase between 50% and 250% by 2050, depending on future economic and energy developments. According to the 2nd IMO GHG Study, ship's energy consumption and CO_2 emissions could be reduced by up to 75% by applying operational measures and implementing existing technologies. The EU and its Member States have a strong preference for a global approach led by the International Maritime Organization (IMO) to reduce the energy consumption and GHG emissions of the shipping sector[27]. The European Commission's 2011 White Paper on transport suggests that the EU's CO_2 emissions from maritime transport should be cut by at least 40% from 2005 levels by 2050, and if feasible by 50%. However international shipping is not covered by the EU's current emissions reduction targets.

In 2013, a strategy was set out by the Commission to include maritime emissions into the EU's policy for reducing its domestic GHG emissions. The strategy consists in three steps:

- Monitoring, reporting and verification of CO_2 emissions from large ships using EU ports
- Greenhouse gas reduction targets for the maritime transport sector
- Further measures including market-based measures in the medium to long term

From 2018, the MRV companies (ships over 5000 gross tonnes loading/unloading cargo/passengers at EU maritime ports) are to monitor and report their related CO_2 emissions, submit to an accredited MRV shipping verifier a monitoring plan and submit the verified emissions through THETIS MRV (a dedicated European Union Information system currently under development by the European Maritime Safety Agency).

[27] Reducing emissions from the shipping sector, European Commission https://ec.europa.eu/clima/policies/transport/shipping_en

At the strait level, the application of the national objectives (disaggregated by sector) results in a reduction of the emissions **by 19% by 2030**, compared to 2016. The following table presents the main hypothesis made to estimate the decarbonization path of the Gulf of Finland's Strait.

Table 11 - Hypothesis for the estimation of the decarbonization path of the Gulf of Finland's Strait

Emission source (within the strait's boundary)	Source of hypothesis	% of reduction	Emissions 2016 (tCO_2e)	Emissions 2030 (tCO_2e)
Port operations	European Commission's target on CO_2 emissions from maritime transport	-40% between 2005 and 2050 (corresponding to -12.3% between 2016 and 2030)	102 027	89 478
Maritime transport	European Commission's target on CO_2 emissions from maritime transport	-40% between 2005 and 2050 (corresponding to -12.3% between 2016 and 2030)	3 413 207	2 993 383
In-land traffic	Transport target in Finnish National Energy and Climate Strategy for 2030 and Estonia's Second Biennal Report under the UNFCCC	FI: -50% between 2005 and 2030 (corresponding to -27.5% between 2016 and 2030) EE: -36% between 2013 and 2030 (corresponding to -29.0% between 2016 and 2030)	285 083	205 271
Industries	Industry target in EU Emission Trading Sector for Finland and Estonia's Second Biennal Report under the UNFCCC	FI: -43% between 2005 and 2030(corresponding to -23.7% between 2016 and 2030) EE: -31% between 2013 and 2030 (corresponding to -25.1% between 2016 and 2030)	4 849 287	3 696 959
Buildings	Finnish global reduction in the non-ETS sector and Estonia's Second Biennal Report under the UNFCCC	FI: -39% between 2005 and 2030 (corresponding to -21.5% between 2016 and 2030) EE: -10% between 2013 and 2030 (corresponding to -8.2% between 2016 and 2030)	1 028 048	839 194
TOTAL			**9 677 653**	**7 824 284**

This reduction is due to the actions implemented at all the levels (national, regional, local) and corresponds to the path that is being taken with the actual strategies. The emissions can also be reduced by implementing new actions specifically on the strait's boundary.

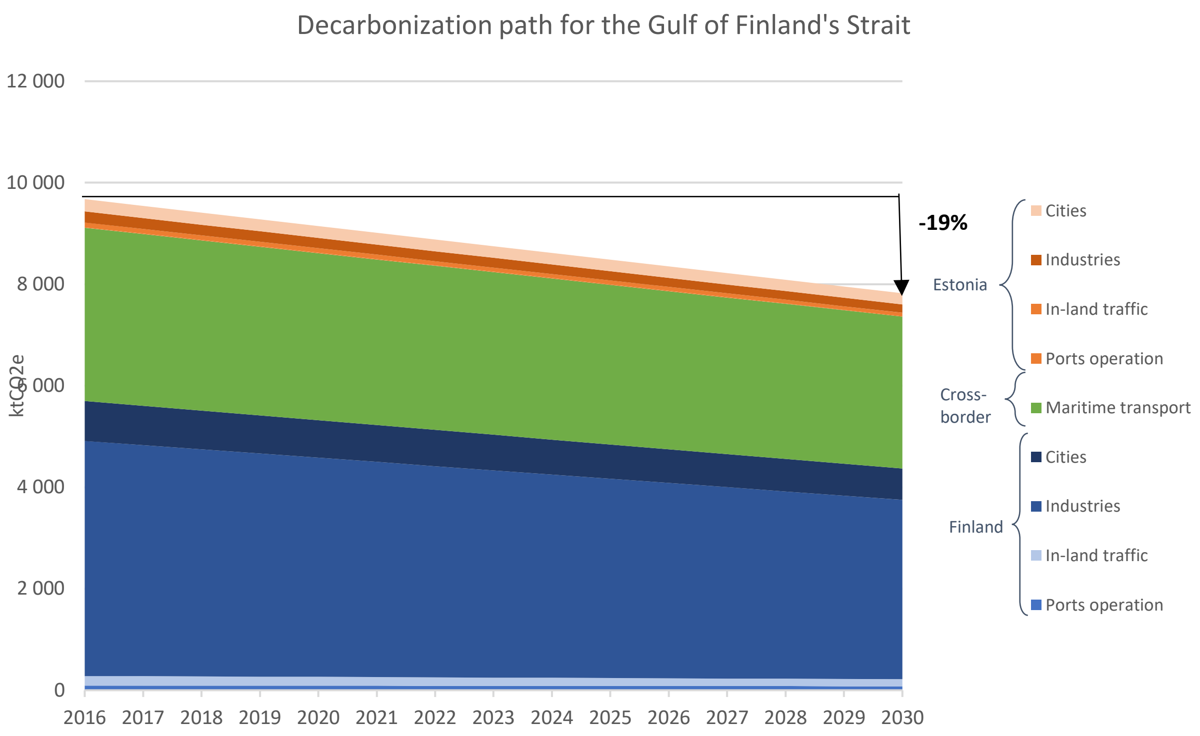


Figure 32 - Decarbonization path for the Gulf of Finland's Strait, based on the national sectorial targets (Source: I Care & Consult)

4. Towards the implementation of action plans

The Gulf of Finland's Strait developed an action plan contributing to the reduction of the strait's emissions. The action plan has 4 main actions. These actions are mainly cross-border actions to strengthen the cooperation between the two regions:

- "Policy change and impact: towards fewer carbon emissions": this action aims to influence the programme Interreg Central Baltic to include low-carbon objectives.
- "Ensuring low-carbon transport": this action aims to implement the E-ticketing project to develop a common ticketing system and e-ticketing in Helsinki and Tallinn. This should result in a reduction of the in-land traffic emissions with a stronger use of the public transport.
- "Deepening of the cooperation": this action aims to enforce the cooperation within the strait, with the signature of a new Memorandum of Understanding between Finland and Estonia.
- "Communication: broadening the awareness of a low carbon Gulf of Finland": this action aims to communicate about the project, presenting the results, to sensitize the managing authorities and the public.

The following table presents the actions reducing emissions from each source.

Table 12 - Impact of the actions of the Gulf of Finland's Strait on each source of emissions

Thematic axes	Cross-border
Maritime traffic	• Ensuring low-carbon transport
In-land traffic	• Ensuring low-carbon transport
Induced economical activities	• Policy change and impact towards fewer carbon emissions

Annexes

1. Carbon footprint methodologies and key studies

a) Cities and hinterland activities

The GHG protocol for Cities[28] (Global Protocol for Community-Scale GHG Emission Inventories – GPC) has similar strait hinterland issues, as these territories have different types of economic activities (cities, industries, transportation, etc.) and possibly different ways to account their GHG emissions.

It provides reporting and accounting principles at a territorial scale, for instance, to define the inventory boundary. It also brings global and sector-specific accounting and reporting guidance. Furthermore, the methodology enables stakeholders to understand how a GHG inventory can be used to set mitigation goals and track performance over time. The "GPC protocol" is an accounting-reporting standard for cities, which has been developed by World Resources Institute, C40 Cities Climate Leadership Group and ICLEI – Local Governments for Sustainability (ICLEI). It is one of the standard coming from the GHG Protocol Initiative, a partnership launched at the end of 1990's between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD).

In *The role of sea ports in end-to end maritime transport chain emissions* (Gibbs and al. 2014), the road traffic emissions, which might be considered as hinterland activities, are assessed.

It is demonstrated that the road GHG annual emissions (138 kt of CO_2) of the UK's busiest container port of Felixstowe are twice higher than the port ones (71.5 kt of CO_2).

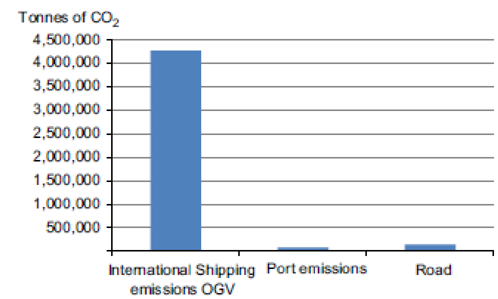


Fig. 1. Comparison of CO_2 emission sources at Felixstowe port (tonnes of CO_2).

Figure 33 - Comparison of CO2 emission sources at Felixstowe port (Source: Gibbs and al. 2014)

In comparison, the International Shipping OGV (Ocean Going Vessels) emissions seem to be huge, but it is worth noting that they are assessed for the overall origin-destination distance of the journey.

Other in-land activities are also generating GHG emissions within a strait area, like cities, industries or companies. These stakeholders carry out GHG inventories due to legal obligation or on voluntary bases.

For instance, through the Covenant of Mayors for Climate & Energy and the setting of its Sustainable Energy Action Plan (SEAP), the Livorno municipality (Corsica Channel) has carried a GHG inventory.

[28] http://www.ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

In the industry sector, company emissions could be registered in on-line data base, like in France in the IREP data base which collect pollutant emissions from the main industrial companies.

CARBONE FOOTPRINT

Other types of companies operating at a strait level might also achieve out GHG inventory, like the Getlink Group (formerly Eurotunnel Group) Eurotunnel Group. At cross-border scale (UK + France) and every two years, Carbon Trust Standard realizes a GHG inventory audit, and the Getlink Group also discloses for the same perimeter the GHG emissions in the yearly registration document. The Port of Dover is also a Carbon Trust Standard holder and aims to become a carbone neutral port.

On the French shore, Eurotunnel has achieved a legally obligated carbone footprint in 2012 and 2015. Since the first GHG inventory has been carried out at cross-border scale (2006, sea breakdown in the chart opposite), Eurotunnel has set several measures to reduce their GHG emissions.

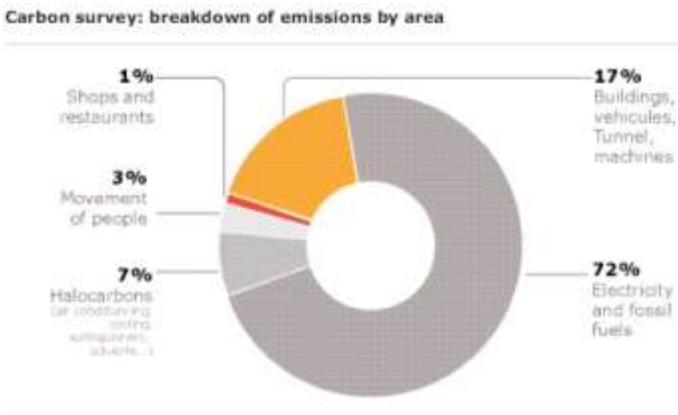


Figure 34 - Eurotunnel GHG emissions (Source: Eurotunnel, Environmental Report 2007)

2. Calculation methodologies

a) Port operations

i. Energy consumptions

The energy consumptions (such as electricity, natural gas, diesel, petrol, propane…) are provided by the Port Authority. The emission factors are taken from the national databases when available:

- France: ADEME Base Carbone[29] (Environment and Energy Management Agency), last updated in 2016, except for the electricity emission factor which was updated in 2014.
- UK: DEFRA / DECC[30] (Department for Environment Food & Rural Affairs and Department of Energy & Climate Change), last updated in 2016.
- Finland: Motiva[31], last updated in 2017 and Helsinki-Uusimaa Regional Council[32], last updated in 2015.

[29] www.bilans-ges.ademe.fr
[30] https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting
[31] https://www.motiva.fi/ratkaisut/energiankaytto_suomessa/co2-laskentaohje_energiankulutuksen_hiilidioksidipaastojen_laskentaan/co2-paastokertoimet
[32] https://www.uudenmaanliitto.fi/tietopalvelut/uusimaa-tietopankki/aineistot/alue_ja_ymparisto

For the other countries, where no national database was found, the IEA (International Energy Agency) factors specific to the country are used for electricity consumption and the DEFRA or IPCC (Intergovernmental Panel on Climate Change) standard factors are used for fuel consumption.

ii. Ships in port areas

To estimate the annual emissions from the ships in port areas (manoeuvring, at berth, etc.), the following equation is used (from the publication "*Estimating GHG emissions of marine ports – the case of Barcelona*" by Gara Villalba and Eskinder Demisse Gemechu):

$$Emission\ (tCO2e) = N\ \times PO\ (kW) \times t\ (hours) \times LF\ (\%) \times EF\ (tCO2e/kWh)$$

With:
N = Number of ships calling to the port
PO = power output in KW
t = time spent in the port in the mode considered in hours
LF = load factor
EF = emission factor in tCO_2e/kWh

This equation is used to estimate the emissions from the main engine and the auxiliary engine in the different modes (manoeuvring, at berth, etc.).

- **Number of ships per type**

The number of ships calling to the port for 2016 is provided by the Port Authority, per type of ship if available.

- **Power output**

The power output of each engine depends on the type of ship and the size (gross tonnage). When local data is available, it is directly used to estimate the emissions. When no local data is available, the European Environment Agency (EEA) provides, in the "*EMEP/EEA air pollutant emission inventory guidebook*" from 2002, a table with the estimated main engine power and auxiliary engine power by ship type and gross tonnage. As the gross tonnage is not always known, the average for all ships is taken into account, as indicated in the table below:

Table 13 - Estimated power of engines per ship type (Source: European Environment Agency, 2002)

Ship type	Estimated main engine power (kW) – total power of all engines	Estimated auxiliary power kW (medium speed)
Liquefied gas tanker	5 900	300
Chemical tanker	5 700	300
Other tanker	7 900	300
Bulk dry cargo	9 100	380
General cargo	3 300	175
Container	16 300	1 400
Passenger/ Ro-ro	12 800	1 000

- **Time spent in port areas**

This data is provided by the Port Authority, per type of ship when available.

- **Load factor**

As engines are not operating at their maximum tested power, the load factor needs to be considered. When local data is available, it is used directly to estimate the emissions. However, when no data is available, two modes are considered: manoeuvring and in port (including the un-loading, loading and hoteling phases). The following hypothesis, from the report "*Quantification of emissions from ships associated with ship movements between ports in the European Community*" by the European Commission (2002), are taken into consideration:

Table 14 - Load factor per engine and mode (Source: European Commission, 2002)

Mode	% load of MCR for Main Engine operation	% load of MCR for Auxiliary Engine operation
Manoeuvring	20%	50%
In port	20%	40%
At sea	80%	30%

- **Emission factors**

As recommended in the publication "*Estimating GHG emissions of marine ports – the case of Barcelona*" by Gara Villalba and Eskinder Demisse Gemechu, the following emission factors are considered (taken from ICF International, 2009[33]):

- For primary engine at intermediate speed: 677.91 gCO_2/kWh and 0.004 gCH_4/kWh, corresponding to 678 gCO_2e/kWh;
- For auxiliary engine: 722.54 gCO_2/kWh and 0.004 gCH_4/kWh corresponding to 722.6 gCO_2e/kWh.

b) Maritime transport

i. Local maritime cruise

The number of trips by ferries between the two shores in 2016 is provided by the Port Authorities or the Maritime Companies. The distance travelled is estimated with the websites "searoutes.com" and "sea-distances.org".

The emission factor used is taken from the Base Carbone (ADEME, France): 419 kgCO2e/km for Ro-Pax cargoes – passengers.

[33] ICF International, 2009. *Current methodologies in preparing mobile source port related emission inventories*. US EPA

ii. Maritime cruise with calls to the strait's ports

The Port Call Statistics in 2016 are provided by the Port Authorities, containing if possible the type of ship, the weight transported by each ship and the origin/destination. When all the information is available, the following equation is used to estimate the emissions:

$$Emissions\ of\ one\ ship\ (tCO2e) = d(km) \times w\ (tonnes) \times EF\ (tCO2e/t.km)$$

With:
d = distance travelled by the ship. This distance is disaggregated between the distance within the strait's boundary and outside the strait's boundary.
w = weight transported by the ship.
EF = emission factor

- **Distance**

The distance is estimated based on the country of origin/destination following "*the CERDI-seadistance database*" (by Bertoli S., Goujon M. and Santoni O. in 2016).

The distance within the strait's boundary is determined with Google Earth, based on the distance of the strait (see figures in the preceding chapter), the location of the port within the strait and the direction of the vessels. The distance was determined as showed in the following figure (in blue), with the distance from the port (here Tallinn) to the centre of the strait added to the distance from the centre to the limits of the boundary:

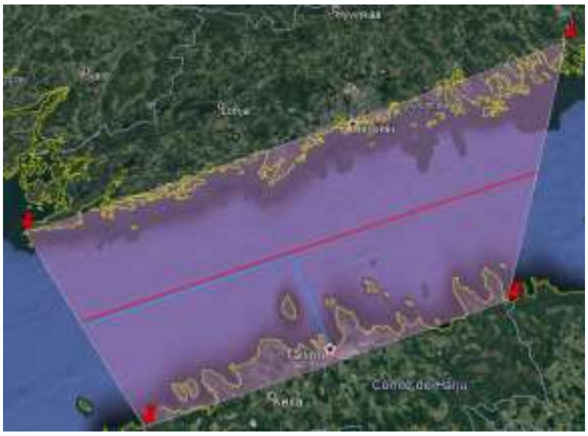


Figure 35 - Example of the determination of the distance within the strait's boundary (Source: I Care & Consult)

The following table presents the distances for each port, depending on the direction of the vessel. Those distances can also be seen in the figures of the geographic strait boundary.

Table 15 - Distances within the strait's boundary for each port (Source: I Care & Consult)

Strait	Ports	Distance from North / East (km)	Distance from South / West (km)
Dover / Pas de Calais Strait	**Calais**	47	78
	Boulogne-sur-Mer	87	50
	Dunkirk	45	122

	Dover	62	81
Gulf of Finland	**Helsinki**	94	144
	Tallinn	123	105
Corsica Channel	**Bastia**	79	40
	Livorno	63	114
Strait of Otranto	**Vlorë**	150	75
	Durres	95	200
	Brindisi	94	130
Strait of Corfu	**Sarandë**	50	/
	Igoumenitsa	/	26
	Corfu	/	43

The distance outside the strait's boundary is determined by subtracting the distance within the strait's boundary to the total distance between the two ports (on within the strait and the other anywhere in the world).

- In the case of the strait of Corfu, given the geography of the strait, almost no ships travel towards the north/east side of the strait, from the ports of Corfu or Igoumenitsa and no ships travel towards the south/west side of the strait from the port of Sarandë. Therefore, the distances linked to those sides are not considered here.**Emissions factors**

The following emission factors are used (from DEFRA/DECC, updated in 2016):

Table 16 - Emission factors per type of ship (Source: DEFRA/DECC, 2016)

Type of vessel	Emission factor (in $kgCO_2e/t.km$)
Bulk carriers	0.0042
Container	0.0190
Gas carriers	0.0136
General dry cargo	0.0156
Passengers ships	0.4581
Roro	0.0607
Tankers	0.0106
Other (average emission factor)	0.0123

The weight is usually provided in the Port Call Statistics, however if this information is missing the weight can be estimated in some cases (based on information provided by the Port Authority or based on the average weight of the other ships of the same type). In other cases (for passenger ships), the weight transported is not known but the number of passengers is provided. In this case, the emission factor (in $kgCO_2e/pass.km$) is taken from the Base Carbone (ADEME), updated in 2016:

Table 17 - Emission factor for passenger ship (Source: ADEME, 2016)

Type of vessel	Emission factor

	(in $kgCO_2e$/pass.km)
Ferries / Cruise ships	0.468

iii. Transit maritime cruise

The Ships databases in 2016 are provided by the Coastguard Agencies (where existing). They contain, when available, the type of ship, the weight transported by each ship and the previous port of call and the next port of call. When all the information is available, the following equation is used to estimate the emissions:

$$Emissions\ of\ one\ ship\ (tCO2e) = d(km) \times w\ (tonnes) \times EF\ (tCO2e/t.km)$$

With:
d = distance travelled by the ship. This distance is disaggregated between the distance within the strait's boundary and outside the strait's boundary.
w = weight transported by the ship.
EF = emission factor

- **Distance**

The distance is estimated based on the country of origin/destination following "*the CERDI-seadistance database*" (by Bertoli S., Goujon M. and Santoni O. in 2016).

The distance within the strait's boundary is determined with Google Earth, based on the limits of the strait (as defined in the previous chapters), including the main ports identified:

Table 18 - Distance within the strait's boundary (Source: I Care & Consult)

Strait	Distance of the strait (km)
Dover / Pas de Calais Strait	100
Gulf of Finland	164
Fehmarnbelt	30
Corsica Channel	55
Strait of Otranto	130
Strait of Corfu	102

The distance outside the strait's boundary is determined by subtracting the distance within the strait's boundary to the total distance between the two ports.

- **Emissions factors**

The following emission factors are used (from DEFRA/DECC, updated in 2016):

Table 19 - Emission factors per type of ship (Source: DEFRA/DECC, 2016)

Type of vessel	Emission factor (in $kgCO_2e$/t.km)

Bulk carriers	0.0042
Container	0.0190
Gas carriers	0.0136
General dry cargo	0.0156
Passengers ships	0.4581
Roro	0.0607
Tankers	0.0106
Other (average emission factor)	0.0123

When no information is available on the weight transported, an emission factor in $kgCO_2e$/veh.km can be used (from the Base Carbone, ADEME, updated in 2016):

Table 20 - Emission factors per type of ship (Source: ADEME, 2016)

Type of vessel	Emission factor (in $kgCO_2e$/veh.km)
Tankers	264
General cargo	145
Passenger ship	495
Other (average)	250

c) Induced economical activities

i. Industry

To calculate the GHG emissions due to industry in each strait, the following methodology is used.

Only the industries participating to the EU emissions trading systems are considered. These industries are identified by cities of the straits on the EU emission trading system website[34]. All the industries with an address in a city of the straits are taken into account.

For each industry identified, the “verified emissions” stated on the EU emission market for 2016, in tons of CO_2 are used. This data is available on the EU emission trading system website. If no emission is stated for 2016 for an industry, emissions for the most recent year are considered.

The emissions of all the industries identified are then summed by strait.

ii. Cities

To estimate the annual GHG emissions due to the residential and economical activities in the cities of the strait, the following methodology is used:

$$Emissions\ (tCO2e) = \frac{Emissions_{National}}{Population_{National}} \times Population_{Local}$$

[34] http://ec.europa.eu/environment/ets/napMgt.do;EUROPA_JSESSIONID=g-XI_tEdLcXzpzAnMq_2ayWUZgqc7WTsxueOiGYcOiCF6INAaes1!1777535239?languageCode=en

The national emissions from residential and economical activities are taken from the national inventories submitted to the United Nations Framework Convention on Climate Change (UNFCCC)[35] (1.A.4 Energy - Fuel combustion - Other sectors, including commercial/institutional, residential and agriculture/forestry/fishing). Most of the European countries are included in the Annex I Parties and need to report their emissions every year. The latest reporting year is 2014. For the countries (such as Albania) that are not part of the Annex I Parties, the inventory need to be submitted every four years. The latest submission was taken into account (2009 for Albania). However, it is considered that it is still representative for the year of reporting (2016).

The emissions (in tCO_2e) are then divided by the population of the country, in the reporting year when available (if the population in the reporting year is not available, the closest available year is taken into account). The population number are taken from the national statistics institute of each country:

- France: INSEE[36] (2014)
- UK: Office for National Statistics[37] (2014)
- Estonia: Statistics Estonia – Eesti Statistika[38] (2017)
- Finland: Statistics Finland – Tilastokeskus[39] (2016)
- Denmark: Statistics Denmark / Statbank Denmark – Danmarks Statistik / Statistikbanken[40] (2014)
- Germany: Statistische Ämter des bundes und der länder[41] (2014)
- Italy: Istat – Instituto nazionale di Statistica[42] (2014)
- Albania: Instat – Instituti i Statistikave[43] (2009)
- Greece: Hellenic Statistical Authority[44] (2011)

Finally, the regions considered for the residential and commercial activities are the NUTS 3 regions which shore correspond to the strait. The information on the population in the NUTS 3 regions is given in Eurostat[45], last updated in 2015.

Exceptions:

- For Dover / Pas de Calais Strait, the NUTS3 areas Pas-de-Calais and Nord include the Lille Metropolis and the Mining Basin, which are not linked to the strait's activities. It was then decided to include only the population of the "Pôle Métropolitain Côte d'Opale"[46].

[35] http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9492.php
[36] https://www.insee.fr/fr/accueil
[37] https://www.ons.gov.uk/
[38] https://www.stat.ee/en
[39] http://tilastokeskus.fi/index_en.html
[40] http://www.statbank.dk/statbank5a/default.asp?w=1366
[41] http://www.statistik-portal.de/Statistik-Portal/
[42] http://www.istat.it/en/
[43] http://www.instat.gov.al/al/home.aspx
[44] http://www.statistics.gr/en/greece-in-figures
[45] http://ec.europa.eu/eurostat/cache/RCI/#?vis=nuts3.population&lang=en
[46] http://www.pm-cote-opale.fr/

- For the Gulf of Finland's Strait, the Helsinki-Uusimaa Region is much larger than the area of the Port of Helsinki, it was then decided to consider only the capital region (i.e. Helsinki, Espoo, Vantaa and Kauniainen)[47].
- For Albania, as it is not part of EU, there are no NUTS 3 regions. Then, it was decided to take into account only the main cities on the shore[48] (Vlora and Durres for the strait of Otranto and Saranda, Konispol, Himarë and Delvinë for the strait of Corfu).

iii. Tourism

To estimate the GHG emissions due to the tourism activities in the cities of the strait, the following methodology is used:

$$Emissions\ (tCO2e) = N \times EF\ (tCO2e/night)$$

with:
N = Number of tourist nights in the areas
EF = emission factor for a hotel night (in tCO_2e/night)

The number of tourist nights in the areas is provided by the stakeholders.

The emission factor is estimated based on an average energy consumption for one hotel night, multiplied by the country's emission factors for energy consumption (for example: Base Carbone, 2016 for France and DEFRA, 2016 for the UK). The average energy consumption is taken from a study by ADEME, EU Ecolabel and AFNOR, which give the following data for a two stars hotel: an electricity consumption of 74.8 kWh/night and a water consumption of 335 l/night (last update in 2012).

d) Inland transport

i. Passengers transport

This paragraph presents the methodology used to quantify the annual GHG emissions due to the transport of the passengers that land and board in the ports of the studied straits in 2016. Two different transport modes are considered: rail and road.

For these two modes, the data needed for the calculation are the following:
- Number of passengers who travel by the transport mode
- Average distance achieved with this transport mode
- Emission factor to convert the distance in GHG emission

The following equation is then used to calculate the GHG emission by port:

$$Emissions\ (tCO2e) = N\ \times d\ (km) \times EF\ (tCO2e/km)$$

with:
N = Number of passengers landing and boarding in the studied port
d = Average distance
EF = Emission factor (tCO_2e/pass.km)

[47] http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__vrm__vaerak/statfin_vaerak_pxt_028.px/?rxid=30517e03-c548-45ac-a2d7-6ec0fa5cabe9
[48] http://pop-stat.mashke.org/albania-cities.htm

For each mode of transport, assumptions used to obtain the necessary data are presented below.

Road

➢ **Number of passengers who travel by road**

To obtain the number of passengers who land or board in the studied port and travel by road, the total number of passengers who land and board in the ports and the modal share of the port is used:

$$N = Np \times MS$$

with:

N = Number of passengers travelling by road and landing or boarding in the port (and Channel Tunnel in the case of the Dover / Pas de Calais Strait)

Np = Number of passengers landing or boarding in the port (in total)

MS = Modal share for road (in %)

The number of passengers who land or board in the ports in total is given by the port's authorities, as well as the modal share, if available.

If no information is available on the real modal share in the studied ports, the average national modal shares for 2015 are used. They are obtained on the Eurostat website[49] for all the European countries.

➢ **Average distance**

The average distance is considered equal to the distance between the port and the capital of the port's country. The average distance is then different for all the cities, even in the same strait. This distance is estimated thanks to Google Maps and the shortest itinerary is chosen.

Exception: the islands

For islands (ports of Bastia, Corfu and Lefkimi), the distance to the capital is not relevant.

Therefore, the average distance arbitrary chosen is the distance between the port and the furthest cost of the island, divided by 2.

This distance is disaggregated between the distance within the strait's boundary and outside the strait's boundary, in order to provide a complete picture of the emissions directly emitted in the strait's boundary, and the emissions induced by the strait but emitted outside of the boundary.

The strait's boundaries that are considered are the ones of the port region (NUTS3) and the distance between the port and the region boundary is estimated (named "NUTS3 Distance") (see schema below). To know the boundary of the region (NUTS3), the Eurostat website[50] is used and GoogleMaps is then used to estimate the distance. The disaggregation is then done as presented in the schema below, depending on the comparison between the average distance and the NUTS3 distance.

If Average distance > NUTS3 Distance

Distance within the strait = NUTS3 Distance

Distance outside the strait = Average distance – Distance within the strait

[49] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_psmod&lang=fr

[50] http://ec.europa.eu/eurostat/cache/RCI/#?vis=nuts3.population&lang=en

If Average distance < NUTS3 Distance
Distance within the strait = Average distance
Distance outside the strait = 0 km

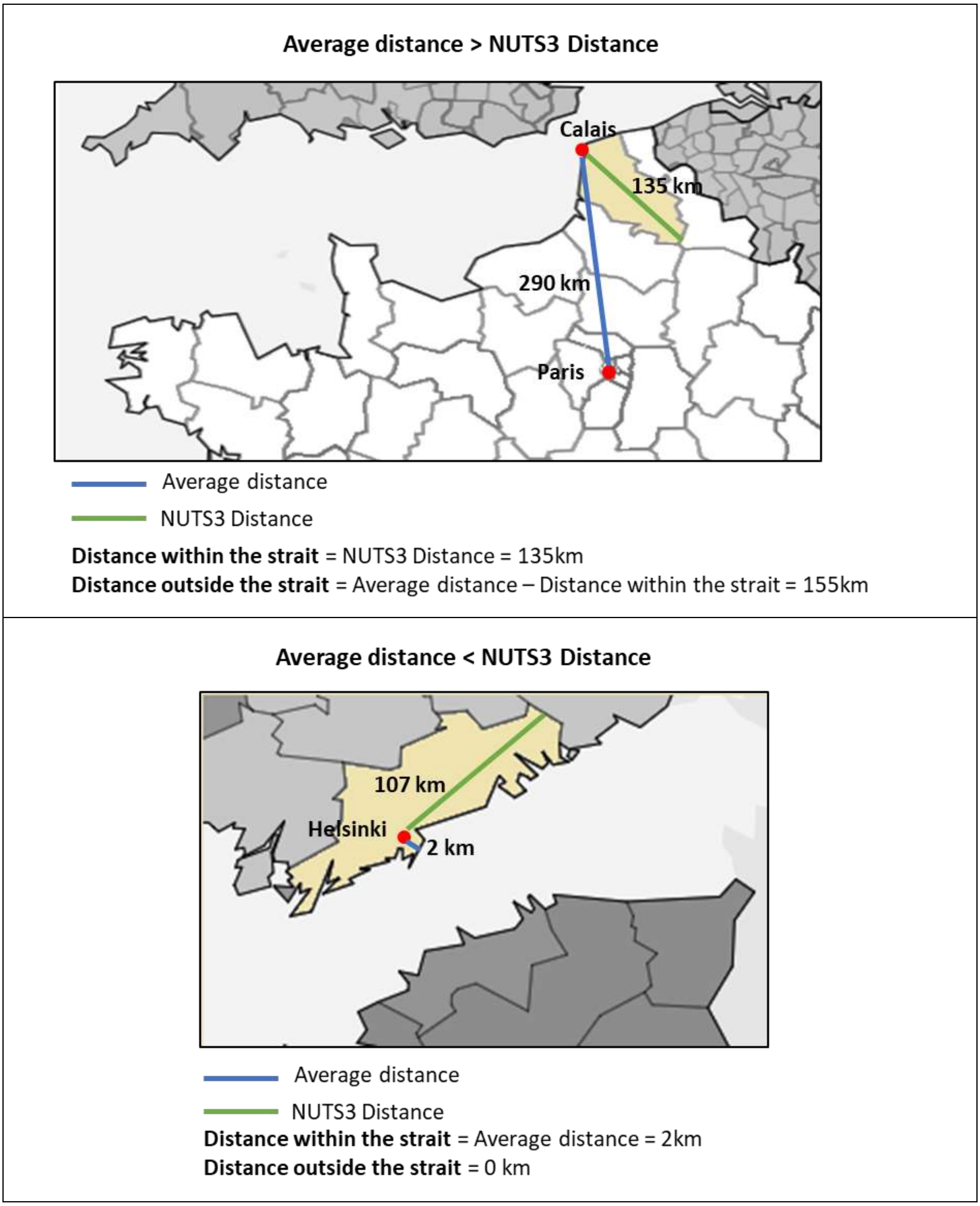


Figure 36 - Examples of estimation of the distance travelled (Source: I Care & Consult)

- **Emission factor**

The emission factor used is "Voiture particulière – Puissance fiscale moyenne, motorisation moyenne" ("Private car, Average fiscal power, Average motorization"), from the ADEME database "Base Carbone"[51] (updated in 2016). It is considered to be the same for all the countries.

The average load factor considered is two persons per car, considering the higher value of the European Environment Agency for travel and leisure[52].

As the unit of the emission factor is $kgCO_2e/km$, it is divided by two to take into account the load factor.

Table 21 - Example of calculations for on-road passenger transport

Example: Gulf of Finland – Passenger transport - Road

[51] http://www.bilans-ges.ademe.fr/fr/basecarbone/donnees-consulter/liste-element/categorie/151
[52] https://www.eea.europa.eu/publications/ENVISSUENo12/page029.html

The steps for the calculation of the GHG emissions due to transport passenger by cars in Gulf of Finland are presented below:

- **Number of passenger for each port (landing and boarding):**

Port	Passengers
Helsinki	11 974 000
Tallinn	10 173 300

Pieces of data obtained through port authorities.

- **Modal share:**

National data used.

Country	Modal share
Finland	0.95
Estonia	0.98

Pieces of data available on Eurostat.

- **Average distance**

Country	Average distance (km) = distance to capital
Helsinki	2
Tallinn	2

Results are rounded to the nearest km.

- **Emission factor**

The emission factor used is 0.127 $kgCO_2$/pass.km

- **Results**

$$\frac{\text{Number of passengers } \times \text{Modal share } \times \text{Average distance (km)} \times \text{Emission factor } (\text{kg}CO_2\ /\text{pass.km})}{1000} = \text{Emissions } (\text{t}CO_2)$$

Port	Passengers	Modal share	Average distance (km)	Emission factor ($kgCO_2$/pass.km)	Emissions (tCO_2)
Helsinki	11 974 000	0.95	2	0.127	2 878
Tallinn	10 173 300	0.98	2	0.127	2 522

Rail

- **Number of passengers who travel by train**

To obtain the number of passengers who land or board in the port and travel by train, the same equation than for road is used.

$$N = Np \times MS$$

with:
N = Number of passengers who travel by train and landing or boarding in the port (or travelling through the Channel Tunnel in the case of the Dover / Pas de Calais Strait)
Np = Number of passengers landing or boarding in the port (in total)
MS = Modal share for train (in %)

The number of passengers who land or board in the ports in total are given by the port's authorities, as well as the modal share, if available.

If no information is available on the real modal share in the studied ports, the average national modal shares for 2015 are used. They are obtained on the Eurostat website[53] for all the European countries.

- **Average distance**

The distance travelled in average by the passengers is calculated by country. Thus, the distance is the same for all the ports in a same country (for example Dunkirk, Calais and Boulogne-sur-Mer in France).

To obtain it, a ratio between passengers.km completed in 2015 in the whole country and the number of passengers who travelled in the whole country is calculated. These pieces of data are available on Eurostat[54] for the European countries.

Exception: the islands
For islands (ports of Bastia, Corfu and Lefkimi), the national average distance can be irrelevant. That is why, specific assumptions are used:

- For Bastia, as the national average distance seems relevant as it is almost entirely included in the NUTS 3 region, this data is then used.
- For Corfu and Lefkimi, it is considered that there are no railways on the island.

In the same way as road transport, this distance is disaggregated between the distance within the strait's boundary and outside the strait's boundary, in order to provide a complete picture of the emissions directly emitted in the strait's boundary, and the emissions induced by the strait but emitted outside of the boundary. The strait's boundaries that are considered are the ones of the port region (NUTS3) and the distance between the port and the region boundary is estimated (named "NUTS3 Distance"). The disaggregation is done depending on the comparison between the average distance and the NUTS3 distance.
If Average distance > NUTS3 Distance
Distance within the strait = NUTS3 Distance
Distance outside the strait = Average distance – Distance within the strait

[53] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_psmod&lang=fr
[54] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rail_pa_total&lang=fr

If Average distance < NUTS3 Distance
Distance within the strait = Average distance
Distance outside the strait = 0 km

➢ **Emission factor**

Emission factors used are those from the ADEME database "Base Carbone"[55] (last update in 2016). If the emission factor is available for the port's country, this factor is used. If the emission factor is not available for the country of the port, an average factor is used, based on all the emission factors available (0,0629 $kgCO_2$/km.pass)[56].

For France, numerous factors are available, thus the emission factor "Train Grandes Lignes" is used.

Table 22 - Example of calculations for rail passenger transport

Example: Gulf of Finland – Passenger transport - Rail

The steps for the calculation of the GHG emissions due to transport passenger by train in the Gulf of Finland are presented below:

➢ **Number of passenger for each port (landing and boarding):**

Port	Passengers
Helsinki	11 974 000
Tallinn	10 173 300

Pieces of data obtained through port authorities.

➢ **Modal share:**

National data used.

Country	Modal share
Finland	0.05
Estonia	0.02

Pieces of data available on Eurostat.

➢ **Average distance**

National data used.

Country	Thousands pass.km	Thousands pass.	Average distance (km)
Finland	4 114 000	75 952	54.2
Estonia	286 000	6 659	43.9

Pieces of data available on Eurostat.

➢ **Emission factor**

Country	Emission factor ($kgCO_2$/pass.km)
Finland	0.0452
Estonia	0.0629

[55] http://www.bilans-ges.ademe.fr/fr/basecarbone/donnees-consulter/choix-categorie/categorie/176
[56] Average emission factor used for Albania and Estonia

National emission factor available for Finland on the ADEME's database. Average emission factor used for Estonia.

➢ **Results**

$$\frac{\text{Number of passengers } \times \text{Modal share } \times \text{Average distance (km)} \times \text{Emission factor } (\text{kg}CO_2 \text{ /pass.km})}{1000} = \text{Emissions } (\text{t}CO_2)$$

Port	Passengers	Modal share	Average distance (km)	Emission factor ($kgCO_2$/pass.km)	Emissions (tCO_2)
Helsinki	11 974 000	0,05	54	0.0452	1467
Tallinn	10 173 300	0,02	43	0.0629	549

ii. Freight transport

This paragraph presents the methodology used to quantify the annual GHG emissions due to freight transport (loaded and unloaded goods in the ports of the strait in 2016). Two different modes of transport are considered: rail and road[57].

For these two modes, data needed for the calculation is the following:

- Tonnage of goods transported by the transport mode
- Average distance achieved with this transport mode
- Emission factor to convert the distance in GHG emissions

The following equation is then used to calculate the GHG emissions by port:

$$Emissions\ (tCO2e) = T\ (t)\ \times d\ (km) \times EF\ (tCO2e/t.km)$$

with:

T = Tonnage of goods going transporting by the transport mode

d = average distance

EF = Emission factor (tCO_2e/t.km)

For each mode of transport, assumptions used to obtain these pieces of data are presented below.

Road

➢ **Tonnage of good transported by road**

To obtain the tonnage of goods passing through studied ports and transported by road, the total tonnage of goods passing through studied ports and the modal share of the port is used:

$$T = Tp\ \times MS$$

with:

T = Tonnage of good passing through the port and transported by road

Tp = Total tonnage of good passing through the port (and in the Channel Tunnel, in the case of the Dover / Pas de Calais Strait)

MS = Modal share for road (in %)

[57] Except for the port for which data on waterway transport is available (case of Dunkirk)

The tonnage of good passing through the port in total is given by the port's authorities, as well as the modal share, if available.

If no information is available on the real modal share in studied ports, the average national modal shares for 2015 are used. They are obtained on the Eurostat website[58] for all the European countries.

- **Average distance**

The average distance is calculated by country.

For each European country, the breakdown of tonnage by range of distance is available on Eurostat for national and international traffic. Data for 2016 are used.

The ranges considered are:
- Range 1: <50km
- Range 2: 50-149km
- Range 3: 150-499km
- Range 4: >500km

These pieces of data are available in tonnage and are then converted in percentage.

The average distance is calculated by using the middle mileage for each range with the following equation:

$$M\,(km) = 25km \times \%Range1 + 100km \times \%Range2 + 325km \times \%Range3 + 600km \times \%Range4$$

These calculated average distances are also used for islands.

As for passenger's transport, this distance is disaggregated between the distance within the strait's boundary and outside the strait's boundary, in order to provide a complete picture of the emissions directly emitted in the strait's boundary, and the emissions induced by the strait but emitted outside of the boundary. The strait's boundaries that are considered are the ones of the port region (NUTS3) and the distance between the port and the region boundary is estimated (named "NUTS3 Distance"). The disaggregation is done depending on the comparison between the average distance and the NUTS3 distance.

If Average distance > NUTS3 Distance
Distance within the strait = NUTS3 Distance
Distance outside the strait = Average distance – Distance within the strait

If Average distance < NUTS3 Distance
Distance within the strait = Average distance
Distance outside the strait = 0 km

- **Emission factor**

[58] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frmod&lang=fr

The emission factor used is "Ensemble articulé – marchandises diverses – PTRA 40T" ("Articulated 40T, Diverse goods"), from the ADEME database "Base Carbone"[59] (updated in 2016). It is considered to be the same for all the countries

Table 23 - Example of calculations for on-road freight transport

Example: Gulf of Finland – Freight transport - Road

The steps for the calculation of the GHG emissions due to freight transport by road in Gulf of Finland are presented below:

- **Tonnage for each port:**

Port	Tonnes
Helsinki	11 621 000
Tallinn	20 118 500

Pieces of data obtained through port authorities.

- **Modal share:**

National data used.

Country	Real modal share
Finland	0.74
Estonia	0.67

Pieces of data available on Eurostat.

- **Average distance**

National data used.

Finland				
Range	<50km	50-149km	150-499km	>500km
Middle km	25	100	325	600
thousands tonnes	146936	67290	49541	1060
%	53.6 %	24.5%	18.1%	3.9%
Average distance (km) = 25 x 53.6% + 100 x 24.5% + 325 x 18.1% + 600 x 3.9% = **119.8 km**				

Estonia				
Range	<50km	50-149km	150-499km	>500km
Middle km	25	100	325	600
thousands tonnes	15738	7903	3989	6
%	57.0%	28.6%	14.4%	0.02%
Average distance (km) = 25 x 57% + 100 x 28.6% + 325 x 14.4% + 600 x 0.02% = **89.9 km**				

Pieces of data available on Eurostat.

- **Emission factor**

Country	Emission factor ($kgCO_2/t.km$)
Finland	0,0946
Estonia	0,0946

[59] http://www.bilans-ges.ademe.fr/fr/basecarbone/donnees-consulter/liste-element/categorie/104

➢ **Results**

$$\frac{\text{Tonnage transported (t)} \times \text{Modal share} \times \text{Average distance (km)} \times \text{Emission factor } (\text{kg}CO_2/\text{t.km})}{1000} = \text{Emissions } (\text{t}CO_2)$$

Port	Tonnage	Modal share	Average distance (km)	Emission factor (kgCO₂/t.km)	Emissions (tCO₂)
Helsinki	11 621 000	0.74	119.8	0,0946	97 459
Tallinn	20 118 500	0.67	89.9	0,0946	114 636

Rail

➢ **Tonnage of good transported by rail**

To obtain the tonnage of goods passing through the ports and transported by rail, the same equation than for road is used.

$$T = Tp \times MS$$

with:
T = Tonnage of goods passing through the port and transporting by train
Tp = Total tonnage of goods passing through the port (and the Channel Tunnel in the case of the Dover / Pas de Calais Strait)
MS = Modal share for train (in %)

The tonnage of goods passing through the port in total is given by the port's authorities, as well as the modal share, if available.

If no information is available on the real modal share in the ports, the average national modal shares for 2015 are used. They are obtained on the Eurostat website60 for all the European countries.

➢ **Average distance**

The average distance is calculated by country.

To obtain it, a ratio between the tonnes.km completed in 2015 in the whole country and the tonnage transported in the whole country is calculated. These pieces of data are available on Eurostat[61] for the European countries.

Exception: the islands
For the islands (ports of Bastia, Corfu and Lefkimi), the national average distance is not relevant. Therefore, the national average for road freight transport is used.

This distance is disaggregated between the distance within the strait's boundary and outside the strait's boundary, in order to provide a complete picture of the emissions directly emitted in the strait's boundary, and the emissions induced by the strait but emitted outside of the boundary. The strait's

[60] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tran_hv_frmod&lang=fr
[61] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=rail_go_grpgood&lang=fr

boundaries that are considered are the ones of the port region (NUTS3) and the distance between the port and the region boundary is estimated (named “NUTS3 Distance”). The disaggregation is done depending on the comparison between the average distance and the NUTS3 distance.

If Average distance > NUTS3 Distance
Distance within the strait = NUTS3 Distance
Distance outside the strait = Average distance – Distance within the strait

If Average distance < NUTS3 Distance
Distance within the strait = Average distance
Distance outside the strait = 0 km

➢ **Emission factor**

Emission factors used are those from the ADEME database “Base Carbone”[62] (updated in 2016).

If the emission factor is available for the country of the port, this factor is used.
If the emission factor is not available for the country of the port the average factor for Europe (available on the data base) is used[63].

For France, numerous factors are available, the emission factor “Train de marchandises - motorisation mixte électricité / gazole - marchandises denses” (“Freight train – mixed power – dense goods”) is used.

Table 24 - Example of calculations for rail freight transport

Example: Gulf of Finland – Freight transport - Rail

The steps for the calculation of the GHG emissions due to freight passenger by rail in Gulf of Finland are presented below:

➢ **Tonnage for each port (landing and boarding):**

Port	Tonnes
Helsinki	11 621 000
Tallinn	20 118 500

Pieces of data obtained through port authorities.

➢ **Modal share:**

National data used.

Country	Modal share
Finland	0.26
Estonia	0.33

Pieces of data available on Eurostat.

➢ **Average distance**

National data used.

Country	Thousand tonnes	Thousand tonnes.km	Average distance (km)

[62] http://www.bilans-ges.ademe.fr/fr/basecarbone/donnees-consulter/liste-element/categorie/127
[63] Average emission factor used for Albania and Estonia

Finland	33 392	8 468 000	253.6
Estonia	286 000	3 117 000	111.2

Pieces of data available on Eurostat.

- **Emission factor**

Country	Emission factor ($kgCO_2/t.km$)
Finland	0.0201
Estonia	0.0226

National emission factor available for Finland on the ADEME's database. Average European emission factor used for Estonia.

- **Results**

$$\frac{\text{Tonnage transported (t)} \times \text{Modal share} \times \text{Average distance (km)} \times \text{Emission factor (kg}CO_2\text{/t.km)}}{1000} = \text{Emissions (t}CO_2\text{)}$$

Port	Tonnage	Modal share	Average distance (km)	Emission factor ($kgCO_2/t.km$)	Emissions (tCO_2)
Helsinki	11 621 000	0.26	253.6	0.0201	15 401
Tallinn	20 118 500	0.33	111.2	0.0226	16 685

Exception: Waterways transport

In cases where national modal share's data is available for other transport modes, such as waterway transport, it is considered to be non-material, because the modal share is negligible (mostly inferior to 1%). As such, only the modal shares of road and rail transport are taken into account to breakdown tonnages data.

However, if the real modal share of the ports is known and if the share of waterways transport mode is important, this transport mode is considered[64].The methodology used is exactly the same than for rail mode (same pieces of data are available on Eurostat for waterways).

Exception: Airports

It was considered that airports are not influenced by the presence of the strait. As such, the airports are not taken into account in the in-land transport or in the induced economical activities.

[64] Case of Dunkirk port