



# Domestic vs. international navigation

Definitions in relation to national greenhouse gas  
emission inventories

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# Innehåll

<b>INNEHÅLL</b>	<b>4</b>
<b>SAMMANFATTNING</b>	<b>6</b>
<b>SUMMARY</b>	<b>7</b>
<b>BACKGROUND</b>	<b>8</b>
<b>PURPOSE</b>	<b>9</b>
<b>METHOD</b>	<b>10</b>
<b>2006 IPCC GUIDELINES</b>	<b>11</b>
<b>METHODOLOGY USED BY SWEDEN AND NEIGHBORING COUNTRIES TO ESTIMATE EMISSIONS FROM NAVIGATION</b>	<b>13</b>
Sweden	13
Domestic navigation	13
International navigation	13
Consumption in port	14
Norway	14
Domestic navigation	14
International navigation	14
Consumption in port	14
Finland	15
Domestic navigation	15
International navigation	15
Consumption in port	15
Denmark	16
Domestic navigation	16
International navigation	16
Consumption in port	16
Germany	16
Domestic and international navigation	16

Consumption in port	17
<b>THE CONSUMPTION OF LNG BY NAVIGATION</b>	<b>18</b>
<b>SHIPAIR</b>	<b>20</b>
<b>CONCLUSIONS</b>	<b>21</b>
Swedish methodology in comparison	21
LNG – a transboundary problem	22
Domestic vs. international navigation	22
Consumption in port	23
<b>REFERENCES</b>	<b>25</b>

# Sammanfattning

I 2006 IPCC Guidelines (GL) definieras inrikes sjöfart som en rutt mellan två hamnar i samma land, medan utrikes sjöfart definieras som en rutt mellan nationell hamn och första utländska hamn. Samtidigt slår GL fast att principen att försålt bränsle ska användas för utsläppsstatistiken ska ha företräde framför en strikt applicering av landsgränser.

Olika länder har tolkat detta på olika sätt vilket medför en risk att utsläpp kan dubbelräknas eller inte räknas med alls i ländernas nationella utsläppsstatistik.

Denna studie har visat att våra grannländer med få undantag använder försäljningsstatistik för att beräkna utsläpp från sjöfart. Taxeringskoder används i stor utsträckning för att särskilja mellan bränsle sålt till inrikes respektive utrikes sjöfart. I vissa fall används enkäter till sjöfartsaktörer för att verifiera eller komplettera statistiken.

Förbrukning i hamn ska vara inkluderat i sjöfart och GL ger instruktioner för hur dessa utsläpp ska beräknas. För de länder som använder försäljningsstatistik för att beräkna utsläppen från sjöfart, så ingår bränsle för hjälpmotorer med största sannolikhet här. Men fördelningen mellan inrikes samt utrikes sjöfart kanske inte blir helt korrekt.

Shipair-modellen, som används för att uppskatta bränsleförbrukningen för svensk inrikes sjöfart, kommer att förbättras under det kommande året. Dels kommer bränsleförbrukningen för LNG-fartyg inkluderas i modellen, vilket för närvarande saknas, dels kommer modellen troligtvis även kunna uppskatta bränsleförbrukning för internationell sjöfart. Denna senare funktionen kommer sannolikt endast att användas för LNG fartyg samt för att verifiera leveransdatastatistiken.

# Summary

SMED is short for Swedish Environmental Emissions Data, which is a collaboration between IVL Swedish Environmental Research Institute, SCB Statistics Sweden, SLU Swedish University of Agricultural Sciences, and SMHI Swedish Meteorological and Hydrological Institute.

In the 2006 IPCC Guidelines (GL), domestic navigation is defined as a voyage between two ports in the same country, and international navigation is defined as a voyage between a domestic port and the first port abroad.

At the same time, the GL also states that the amount of fuel sold should prevail over strict application of national borders when fuel consumed by navigation is estimated. Countries have interpreted this differently with the risk that bunker fuel is accounted for twice or left out altogether.

The study shows that, with few exceptions, the countries included in this study use sales statistics to estimate the emissions from navigation. Taxation codes are often used as a way to split sales data into a domestic and an international fraction. In some cases, surveys are used for some bottom-up calculation, e.g. the estimation of the fuel consumption by ferries in Denmark, or to verify the results.

The fuel consumption in port (i. e. by auxiliary machinery) should be included in navigation but is not mandatory due to the relatively small contribution to total emissions. The GL have instructions of how this should be done.

The Shipair model is used to estimate the fuel consumption by Swedish domestic navigation. It will be improved in the coming year to include the fuel consumption by LNG ships, which is missing in the model at present. The ability to estimate fuel consumption by international navigation will also be added in the model, but this feature will most likely only be used to verify delivery data statistics.



# Background

The fuel consumption by domestic navigation in Sweden is based on the ShipAir model<sup>1</sup>, which estimates the total fuel consumption by domestic navigation, as well as two different surveys to private and state owned shipping operators<sup>2</sup>. The fuel consumption by international navigation is estimated as the difference between national fuel deliveries for navigation and the estimated fuel consumption by domestic navigation.

The two surveys have different purposes. The reason for the first survey is to determine the type of fuel used, as Shipair only makes an assumption about the fuel type based on the size of the vessels. The reason for the second survey is to determine the consumption of LNG by both national and international navigation, as only a fraction of the LNG used by navigation is included in the national energy statistics. This is because the largest proportion of LNG has so far been bunkered from bunkering vessels at sea.

The 2006 IPCC Guidelines (GL) states that domestic navigation is defined as emissions from fuels used by vessels of all flags that depart and arrive in the same country and international navigation is defined as emissions from vessels that depart in one country and arrive in a different country. Sweden took note of this and included the LNG used according to these definitions in the Swedish inventory, even though the fuel was not included in the Swedish delivery statistics. This method was approved by a Swedish expert reviewer<sup>3</sup>.

The method used to estimate the emissions from LNG ships consequently differs from the method used for other fuels, which raised the question whether this method also should apply to other fuels, i. e. should the actual route of the ship or the Swedish fuel delivery statistics be the determining factor for which fuels to include in the Swedish inventory?

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<sup>1</sup> <https://www.smhi.se/nyhetsarkiv/smhis-metod-shipair-visar-utslappsstatistik-fran-sjofart-1.147353>.

<sup>2</sup> EN0118 Transportsektorns energianvändning Rederiundersökningen.

<sup>3</sup> Tomas Gustafsson, IVL. 2020.

# Purpose

The purpose of this project is, with the discussion above in mind, to analyse the definition of domestic and international navigation respectively. The analysis will be based on both the suggested methods in the 2006 IPCC GL on how to estimate the emissions from navigation and how to separate domestic from international navigation as well as the methods used by the Nordic countries and Germany.

The project also aims to clarify whether fuel consumption in port should be included in navigation, which method to use to estimate these emissions and if this consumption should fall within the boundaries of stationary combustion. According to a spokesperson from a shipping company<sup>4</sup>, the fuel consumption by auxiliary engines in port represents a small but significant part of the total fuel consumption.

The ShipAir model will be developed and improved in the coming year. The expected outcome of this will be looked into and documented within this project.

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<sup>4</sup> Referens till denna person

# Method

In order to clarify the methodology used by Denmark, Norway, Finland, Iceland and Germany to estimate the emissions from navigation and to split the emissions between national and international navigation, the National Inventory Report (NIR) of each country was examined.

To further elucidate the methodology used by our Nordic neighbouring countries, bilateral meetings were held with Finland and Norway. The topic was then further discussed at the Nordic Workshop in May 2021. In both the bilateral meetings and in the Nordic Workshop, the definition of domestic and international navigation in the 2006 IPCC Guidelines was also discussed and analysed as well as the allocation of fuel used by auxiliary engines.

# 2006 IPCC Guidelines

According to the 2006 IPCC Guidelines, domestic navigation is defined as a voyage between two ports in the same country and international navigation is defined as a voyage between a domestic port and the first port of destination in another country. This applies regardless of the ship's nationality.

Section 1.6.4 in the GL5 states on the other hand that the principle of using data of fuel sales should prevail over strict application of national boundaries for several reasons:

- Data on fuels moving across borders in vehicle fuel tanks is unlikely to be available at all, and if it were it is likely to be much less accurate than national fuels sales data.
- It is important that emissions from fuel sold appear in only one country's inventory. It would be nearly impossible to ensure consistency between neighboring countries.
- In most cases the net effect of trans-boundary traffic will be small since most vehicles will in the end return to their own country with fuel in their tanks. Only in cases of "fuel tourism" this might not be the case.

The GL section 3.5.1.3<sup>6</sup> lists possible sources of data on consumed fuel in order of decreasing reliability:

- National energy statistics from energy or statistical agencies
- International Energy Agency (IEA) statistical information
- Surveys of shipping companies (including ferry and freight)
- Surveys of fuel suppliers (e.g. quantity of fuels delivered to port facilities)
- Surveys of individual port and marine authorities
- Surveys of fishing companies
- Equipment counts, especially for small gasoline powered fishing and pleasure craft
- Import/export records
- Ship movement data and standard passenger and freight ferry schedules
- Passenger counts and cargo tonnage data

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<sup>5</sup> [https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2\\_Volume2/V2\\_1\\_Ch1\\_Introduction.pdf](https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf)

<sup>6</sup> [https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2\\_Volume2/V2\\_3\\_Ch3\\_Mobile\\_Combustion.pdf](https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf)

- International Maritime Organisation (IMO), engine manufacturers, or Jane's Military Ships Database
- Ship movement data derived from Lloyds Register data

According to section 3.5.1.1 in the GL, activity data based on ship movement can be used if detailed data on ship movement and technical properties of the vessels is available, and if they can be used to distinguish between domestic and international navigation. The Swedish ShipAir model fulfils these criteria.

Furthermore, the GL states that since every country uses different sources for activity data, no fixed rules can be applied as to how domestic and international navigation should be distinguished from each other.

# Methodology used by Sweden and neighboring countries to estimate emissions from navigation

## Sweden

### Domestic navigation

Sweden uses an AIS-based model known as Shipair to estimate the fuel consumption from domestic navigation<sup>7</sup>, which is defined as vessels of all flags which moves between Swedish ports (excluding fishing and military ships). However, Shipair only makes a rough assumption about fuel types based on vessel size. Therefore, a survey to state owned operators (such as road ferries etc) and the biggest private operators for passenger traffic is used to complement the fuel data from Shipair<sup>8</sup>. The fuel used by cargo ships is defined as the difference between the estimated fuel consumption by Shipair and this survey.

There is also a second survey to determine the consumption of LNG by both national and international navigation, as only a fraction of the LNG used by navigation is included in the national energy statistics. This is because the largest proportion of LNG has, so far, been bunkered from bunkering vessels at sea. Shipair cannot estimate the fuel consumption by LNG vessels yet and these vessels are consequently excluded from the model.

### International navigation

The fuel consumption by international navigation is estimated as the difference between national fuel deliveries for navigation<sup>9</sup> and the estimated fuel consumption by domestic navigation as well as the LNG consumption from the LNG survey for international navigation.

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<sup>7</sup> <https://www.smhi.se/nyhetsarkiv/smhis-metod-shipair-visar-utslappsstatistik-fran-sjofart-1.147353>

<sup>8</sup> EN0118 Transportsektorns energianvändning Rederiundersökningen.

<sup>9</sup> Monthly fuel, gas and inventory statistics. Statistics Sweden.

## **Consumption in port**

The fuel consumption by auxiliary engines in ports is included in the Shipair model. The model assumes different degrees of usage of the auxiliary engines depending on the type of ship, i.e. the assumption of a 20% usage of the auxiliary engines for RoRo (roll-on/roll-off) cargo ships and 40% for tankers.

If a ship moves between Stockholm-Helsingborg and then moves on to Rotterdam, half of the time in the port of Stockholm and Helsingborg is included in national navigation. The other half of the time in Stockholm is included in the preceding journey and the other half of the time in the port of Helsingborg is included in international navigation.

## **Norway**

### **Domestic navigation**

Norway defines domestic navigation as emissions from fuels used by vessels, which travel between Norwegian ports, regardless of flag or whether the final destination is outside the country's borders.

The activity data (fuel consumption) for domestic navigation is based on annual sales statistics for petroleum products, such as marine gas oil, heavy distillates and heavy fuel oil. The amount of marine gas oil used by navigation is equal to total sales figures (except bunkers), after deducting the estimated stationary use; mainly by oil and gas extraction but also by manufacturing industries and construction.

The consumption of liquefied natural gas (LNG) by navigation in Norway was introduced in 2003 and is based on sales figures reported to Statistics Norway from the distributors of LNG. Hence, if there are vessels which enters Norwegian ports but bunker LNG from bunkering ships, this fuel might be excluded.

### **International navigation**

The fuel consumption for international navigation is also based on oil sales statistics, just as for national shipping. The split between domestic and international navigation is done according to the tax registry.

### **Consumption in port**

No information on consumption in port is found in Norway's NIR. However, since Norway bases its statistics on sales data, emissions from consumption in port is likely to be included in those data although not separately calculated.

# Finland

## Domestic navigation

Finland defines domestic navigation as emissions from fuels used by vessels of all flags, which depart and arrive in Finnish ports as long as the final destination is *not* outside the country's borders. If the final destination is outside the Finnish borders, the whole trip is considered international navigation regardless of preceding stops in Finnish harbors.

The emissions from domestic navigation are estimated by the Finnish emission model MEERI. The Finnish Transport Infrastructure Agency keeps a detailed database on every ship visit in Finnish ports and includes data on ship type, age, size, engine power, speed, engine load, port, previous port, destination etc. and this information feeds into the MEERI model.

The database has detailed information about ship movements, which enables the calculation of emissions from domestic transportation based on this data. But as this is a regional model, which doesn't extend outside the Finnish economic border, emissions from international shipping cannot be obtained from this model.

The results of MEERI (gasoil and RFO) was crosschecked against fuel tax data once when the model was created, to verify the data. There were some differences, but the magnitude was close enough according to the Finnish experts.

## International navigation

The estimated energy consumption for international navigation is based on sales statistics and verified using the taxation system.

The whole voyage from the first port of departure in Finland is included in international navigation, regardless of intermediate port calls in Finland before leaving the country.

LNG consumed by Viking Grace is not included in international navigation, since the LNG fuel always is bunkered in Sweden and thus not included in the sales statistics of Finland.

## Consumption in port

For calculating emissions in ports, the time (h) of maneuvering and berthing is determined. Using engine power (kW), engine load (%) and time (h) taken for maneuvering and berthing, the total energy use in ports (kWh) is calculated for every ship type. Total emissions are obtained by multiplying the total energy



use (kWh) of ships by the emission factors (g/kWh) of different engine types (2-stroke and 4-stroke and auxiliary engines) (g/kWh)<sup>10</sup>.

## Denmark

### Domestic navigation

Denmark calculates the fuel consumption by domestic ferries through known factors such as port of departure and arrival, number of voyages and engine size. Other domestic navigation is calculated as the difference between annual sales statistics for petroleum products to domestic navigation and the fuel consumption by domestic ferries.

Fuel sales are compiled by the Danish Energy Agency and based on reports from the oil companies. Thus, Denmark uses a bottom-up approach for its' ferries but a top-down approach for the rest of domestic navigation.

### International navigation

Oil companies report data on fuel sales to the Danish Energy Agency, regarding ships with the destinations outside of Denmark. The Energy agency compiles and stores this information.

### Consumption in port

For ferries, auxiliary engine size is one of the factors used to calculate fuel consumption. For international and other domestic navigation than ferries, Denmark uses sales data to estimate emissions. Thus, consumption in port is likely included in those data although not separately calculated.

## Germany

### Domestic and international navigation

The activity data for Domestic water-borne navigation is based both on fuel sales data in the energy balance and an estimated fuel consumption based on AIS data.

The total fuel sales for IMO seagoing vessels in the Energy balance include both national and international fuel consumption.

The fractions between domestically operating seagoing IMO and non-IMO vessels, are calculated in an AIS model as well as the fraction between national and international seagoing IMO vessels.

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<sup>10</sup> Finland's NIR. Section 3.2.5.6

### **Consumption in port**

No information on consumption in port is found in Germany's NIR. However, since activity data consists of fuel bunkered to different categories of vessels, it is likely that fuel consumed in port is included. It is not known how Germany's AIS model (BSH), which is used to distinguish between domestically and internationally operated sea-going ships, handles consumption in port.

# The consumption of LNG by navigation

The consumption of Liquefied Natural Gas (LNG) by navigation was not included in the Swedish energy statistics before submission 2020. This was due to the reason that LNG vessels mostly bunker their LNG from bunkering vessels at sea or abroad. This data doesn't reach the Swedish statistical system, as the LNG is not formally imported to Sweden. Currently, there are only two land-based terminals in Sweden, which can provide ships with LNG. Furthermore, ShipAir is unable to calculate LNG consumption due to limitations in the model.

To compensate for the lack of LNG data in the energy statistics, the data has been manually collected from shipping companies which own or lease LNG ships. LNG is a relatively new fuel type in shipping, and this is reflected in the different ways that the Nordic countries handle the issue:

- Sweden performs a query to shipping companies. The query covers both domestic and international navigation.
- Finland bases its consumption of LNG for domestic navigation on fuel tax data. International navigation is calculated as total sales to navigation minus domestic navigation. Total sales to navigation are based on a company-specific enquiry, which (most likely) covers total sales to ships from the two LNG terminals, including terminal-to-ship and terminal-to-truck-to-ship delivery chains. These fuels are included in Finland's LNG balance, as they are delivered from terminals. Ship-to-ship bunkering is not covered.
- Denmark only has one ferry that runs on LNG. Data is collected directly from the ferry company.
- Norway bases the LNG consumption by navigation on a survey to "users" of LNG. The survey gives information about the amount of LNG used and if the LNG has been used for national or international navigation.
- Iceland has no sales of LNG to navigation.

A good example of the confusion regarding LNG is the ro-ro ferry Viking Grace, which travels between Sweden and Finland, but only bunkers LNG in Sweden. Finland does not include the LNG used by Viking Grace in their inventory, since Finland bases the fuel consumption by navigation on their sales figures.

Sweden only includes half of the LNG used by Viking Grace on the round-trip to Finland as international navigation since Sweden follows the definition of international navigation in 2006 IPCC guidelines. Sweden expects the other half of the LNG to be part of the Finnish inventory. Thus, half of the emissions from Viking Grace currently go uncounted for. Next year will see the maiden voyage of Viking's new LNG ferry, Viking Glory. Glory will travel between Stockholm and Åbo and may add to this problem.

# Shipair

The Shipair model, which estimates the fuel consumption by Swedish domestic navigation, is currently being updated and improved. The expected outcomes of this process are:

- Fuel consumption factors for LNG will be introduced in the model. This will allow for the model to estimate the fuel consumption for LNG ships. The current survey to LNG ship operators will thus become obsolete (for domestic navigation), facilitating data collection and reducing workload on the operators. This improvement is expected to be ready for the next submission (2022).
- The updated version of Shipair will include more AIS data, to cover a larger sea area than at present. This entails the possibility of calculating the fuel consumption for international shipping, which so far has been limited to the Baltic Sea. Due to difficulties in demarcating between national and international shipping, as discussed in this report, this feature will only be used to verify sales statistics with the exception of the LNG consumption by international shipping.

# Conclusions

## Swedish methodology in comparison

According to the 2006 IPCC Guidelines, sales statistics should be the primary source of activity data for navigation since it is the most reliable source on an international level and because strict adherence to national borders entails the risk of double counting. All Nordic countries except Sweden use sale or delivery statistics as their main source of data, in regard to total sales to shipping and the split between domestic and international shipping. Sweden uses delivery statistics for estimations of total emissions from national and international navigation.

Sweden previously used delivery statistics to estimate emissions from both domestic and international navigation but found this source unreliable with regard to the domestic/international split. The method used today is instead based on both delivery statistics and AIS modelled fuel data. The Shipair model, which is used to estimate the fuel consumption by domestic navigation, is based on AIS data in combination with specific technical ship data. The fuel delivery statistics provide information on all fuel delivered to shipping, national and international. The consumption by international navigation is estimated as the difference between the two data sources.

The issue whether trips between national ports should be regarded as national or international navigation when the final destination is outside the country emerged during the project. The GL states as following:

*“Most shipping movement data are collected on the basis of individual trip segments (from one departure to the next arrival) and do not distinguish between different types of intermediate stop.”*

This could however be tricky if sales statistics is used and the ship is destined abroad but have intermediate stops before leaving the country. Then the fuel sales will probably be defined as fuel used by international shipping. If AIS data is used on the other hand, every trip segment is defined as domestic or international regardless if the final destination lies within or outside the country.

## LNG – a transboundary problem

The matter of LNG continues to be an issue, not only for Sweden but also for our neighbouring countries. For example:

- Should ship-to-ship bunkering of LNG be included in the inventory of a country, as Sweden do, although the data is not included in the national fuel statistics?  
The LNG consumption could be estimated by:
  - A survey
  - AIS data
- It is also known that a substantial part of the LNG that is being bunkered ship-to-ship in Skagerrak, Kattegat and the southern Baltic Sea originates from Norwegian oil fields. Despite this, it is uncertain whether Norway counts this LNG as an export or as international navigation, when it first is sold to and then by LNG bunkering vessels.

## Domestic vs. international navigation

When sales data is used in one country and AIS data is used in a nearby country, there are two potential problems which can arise:

1. When a vessel leaves a country, which uses sales data as activity data (AD), with a destination abroad, the fuel sales to the vessel is counted as international navigation. But, if the fuel lasts for several trips within the next country, which uses AIS data as AD, the fuel will also be included in domestic navigation for the next country and the fuel will be double counted. To be clear, there will be no double counting for the national totals, but on a global scale where international bunkering is included together with all domestic shipping.
2. When a vessel leaves a country, which uses AIS data, only the stretch between the departing port in the first country and port of arrival in the next country is defined as international navigation. But if the fuel last for the round-trip and the second country uses sales data, the fuel for the return trip will not be included in either country's inventory. This is the case of Viking Grace mentioned above.

With sales or delivery statistics, it's more than likely that international navigation is overestimated for individual vessels, if the fuel is also used between domestic ports in the arriving country and this country use AIS data as base for the fuel consumption.

The 2006 IPCC Guidelines specifically mention that this issue probably has low impact on total emissions on a global scale, since most vessels eventually

return to their home region and on average carry the same amount of fuel with them as they carried on their way out<sup>11</sup>.

Yet another issue which have been discussed, is the question whether the stops between national ports before a vessel leaves the country should be considered domestic or international navigation. The definition varied between the countries, partly depending on if sales data or AIS data is used as data source. According to the 2006 IPCC Guidelines, domestic navigation is defined as a voyage between two ports in the same country and international navigation is defined as a voyage between a domestic port and the first port of destination in another country. This applies regardless of the ship's nationality. But section 1.6.4 in the GL states on the other hand that the principle of using data of fuel sales should prevail over strict application of national boundaries.

## Consumption in port

The 2006 IPCC Guidelines<sup>12</sup> state that fuel consumption in port should be included in navigation. However, the GL do not give any details as to whether the emissions should be included in the preceding or the following journey. In ShipAir, the fuel consumption in port is calculated using standard values. Degree of usage of auxiliary machinery is applied depending on ship type. Half of the consumption during a port call is then allocated to the preceding voyage and half to the following voyage.

This is true for both domestic and international navigation but since ShipAir only applies to domestic traffic, only half of the consumption is counted for a port call followed by a voyage to an international port. How the fuel is allocated to the preceding and the following journey has no importance for domestic navigation. For international navigation, there is no problem as long as the statistics are based on sales or delivery statistics. However, if Sweden would start to rely on AIS data (as in the ShipAir model) for international navigation while other countries use sales or delivery statistics, there would be a risk of double counting fuels.

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<sup>11</sup> Section 1.6.4. [https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2\\_Volume2/V2\\_1\\_Ch1\\_Introduction.pdf](https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf)

<sup>12</sup> [https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2\\_Volume2/V2\\_3\\_Ch3\\_Mobile\\_Combustion.pdf](https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf) sida 3.51



## The way forward

The method currently used by Sweden to calculate shipping's fuel consumption is considered to be of good quality, based on the review that has been carried out within this project. The following conclusions have been reached:

- AIS data should continuously be used to estimate the fuel consumption by domestic navigation, but *not* for international navigation. Oil sales data should decide the total fuel consumption for shipping, as a double counting on a global level could take place otherwise. However, AIS data should be used to verify the fuel consumption for international shipping, so the level is reasonable.
- Estimation of LNG use in shipping is problematic and there should be a continued dialogue regarding this fuel type with our Nordic neighbours, especially with Finland regarding Viking Grace. In the future, when the Shipair model is updated and fuel consumption factors for LNG is introduced in the model, AIS data should be used to estimate the fuel consumption of LNG. This should apply for both domestic and international navigation, as LNG data is not complete in the Swedish fuel statistics.

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