

A standardized tool to calculate Carbon Footprint in ports



USER GUIDELINES

A standardized tool to calculate Carbon Footprint in ports



UNIVERSITAT POLITÈCNICA DE CATALUNYA

1. Introduction

One of the significant environmental threats in recent years in ports is carbon dioxide emissions generated by different activities in these areas which lead to Climate Change. In a survey conducted by the European Sea Port Organization (ESPO) in 2019, Climate Change occupies the 3rd position in the ranking of ten environmental priorities in ports (ESPO, 2019). This shows that the topic of Climate Change in the maritime industry is getting more critical every day.

In order to calculate, control and reduce CO₂ emissions, an indicator was developed: the Carbon Footprint. This concept is defined as the total amount of Greenhouse Gases emissions that are emitted directly and indirectly by an activity.

In the recent years, many ports have started to calculate their Carbon Footprint and report it. However, generally each Authority or Operator uses its own method which makes the comparison of results very difficult and there is no single or unified method to calculate Carbon Footprint in ports.

Therefore, the development of a practicable, user-friendly and free available tool with a standardized method for the calculation of Carbon Footprint in ports is needed and it has been demanded by the port sector (e.g. Greenport conference, 2018). In this regard, a standardized tool has been developed. This tool is specifically designed so that port authorities can calculate their Carbon Footprint and report it accordingly.

The tool provides options to select the scopes and boundaries that are more suitable and applicable to each port. In addition, the tool allows normalizing (standardize to a common ground) the total annual emissions in terms of total tons of cargo handled or annual TEUs. This is basically done to allow a comparison of the results of different ports on the same ground.

All the emission sources gathered in the standard guidelines (i.e. IPCC, GHG protocol and WPCI) are taken into account in this tool. The sources of GHG emissions in ports are divided into four categories:

- Mobile sources such as cargo handling equipment, transport vehicles, vessels and construction equipment
- Stationary sources such as power plants, boilers, emergency generators, incineration plants and wastewater treatment plant
- Purchased electricity includes buildings, lighting, reefer power demand, electrified cargo handling equipment, other terminal electrical demands, etc.
- Employees' commuting includes emissions from the transportation of employees between their homes and their worksites

According to the World Ports Climate Initiative (WPCI, 2010), the GHG inventory is categorized into three emission scopes:

- Scope 1: Port Direct Sources. These emission sources include all the emissions generated by all port authority related buildings, equipment, vehicles, etc.
- Scope 2: Port Indirect Sources. These sources include port purchased electricity for port administration owned buildings and operations.
- Scope 3: Other Indirect Sources. These sources are typically associated with tenant operations and the commuting of port and tenant employees.

2. How to start calculation?

The development of the tool has been done by using Excel software and visual basic. The completion of this excel based tool is expected to be around 20 minutes (if data are available) and it is divided into three steps:

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- Step1: General data such as the port name, the country and the port total cargo are required.
- Step 2: The port should select the different scopes to be included in the calculation and the required data should be filled in order to get the final result.
- Step 3: By pressing the result button, a report is produced with the total CO₂ equivalent emissions, CO₂eqemissions by total cargo of the port (Carbon Footprint) as well as CO₂eq emissions by scope. This report can be saved as a pdf file.

It is important to mention that Universitat Politècnica de Catalunya (the tool developer) does not have access to any provided data. The tool is totally confidential. This document will guide you through all the tool steps.

The first screen of the tool presents a brief explanation about Climate Change and the different emissions scopes considered in the standard guidelines (Figure 1).

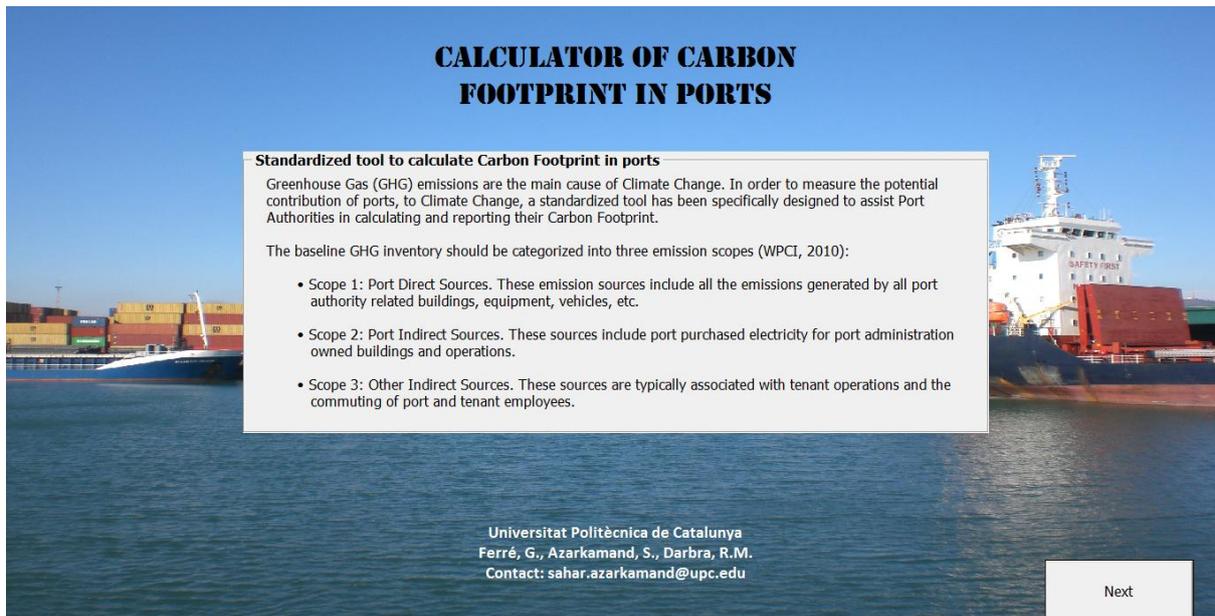


Figure 1: Introductory screen

If you press the “next” button of this screen you will continue to the next stage, which includes a description of the different steps of the tool (Figure 2). By clicking on the “Instructions” button, you will be directed to these Guidelines (pdf document). In addition, if you press the “Video tutorial” box you will be able to get the instructions through a video. When you are ready, you can click the “Start calculation” button to proceed with the tool and calculate the GHG emissions of your port.

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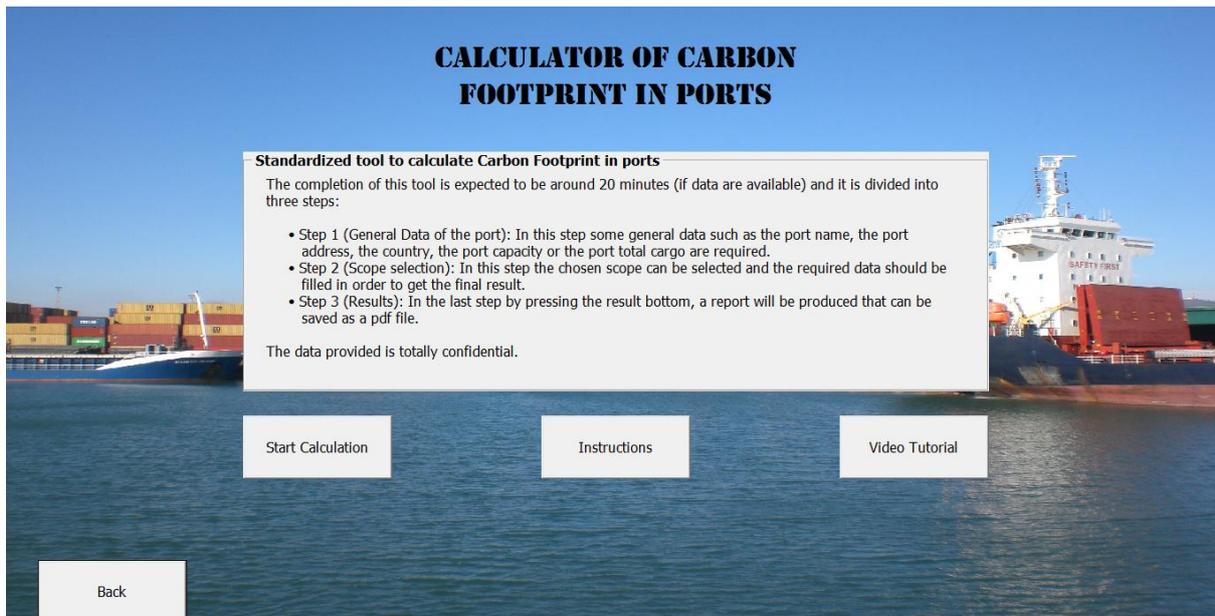


Figure 2: Steps of the tool

The first step of the tool includes the completion of the port general data as it can be seen in Figure 3. Here, you should insert some specific information of your port before calculating the emissions. These general data, which are optional, are:

- Port name
- Port address
- Country
- Capacity (TEU/ Year) or Total Cargo (Million tonnes/ Year)

Figure 3: General data of the port

As it is explained in the note 1 present in Figure 3, if data are not available for some of the sources or if any of the issues or activities are not applicable to your port, it is not necessary to fill in the boxes. The program will work in any case and you can continue filling in the rest of the tool.

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In addition, as mentioned in note 2, the boundaries of the tool are the port area and therefore all the emissions calculated should be the ones that are related to those occurring in this area, not outside.

To proceed to the next step of the tool, you should click on the 'Next' button. Once you have done that you will find a new screen where you should select the scope you want to start with (Figure 4).

In order to have a realistic overview of the Carbon footprint of your port, it is recommended to calculate all three scopes emissions.

It should be mentioned that you could save the project at each stage by clicking on the 'Save Project' button. In addition, you can clear all data by clicking on the 'Clean Project' button.

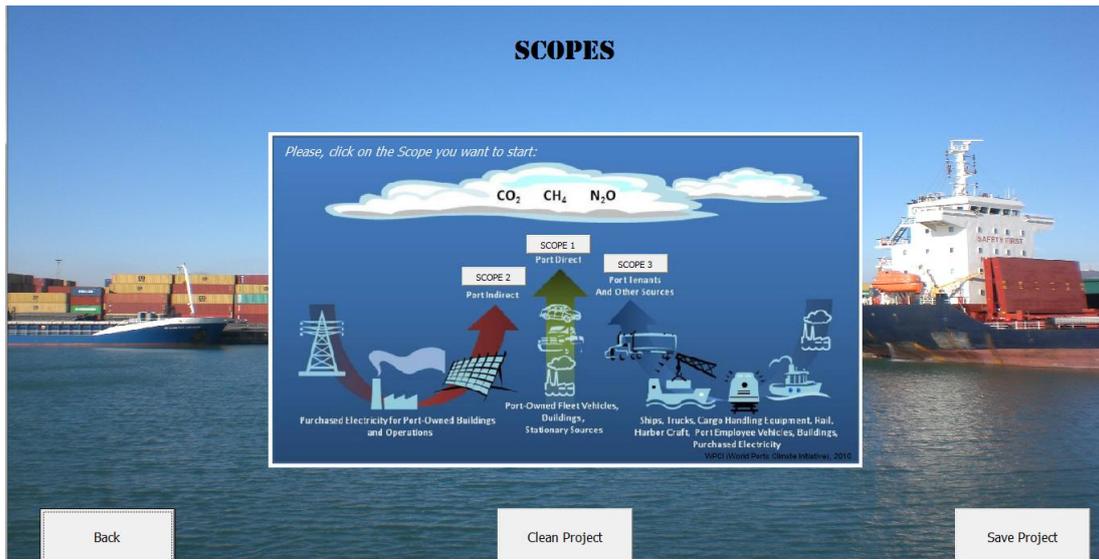


Figure 4: Scopes' selection

3. Scope 1

If you select to start your calculation with emissions from scope 1, you will be taken to the next page. In this step, a brief explanation of scope 1 is presented (Figure 5). By pressing the 'Next' button, you will go to the calculation page for scope 1. In this slide you can also download these guidelines in case you need it.

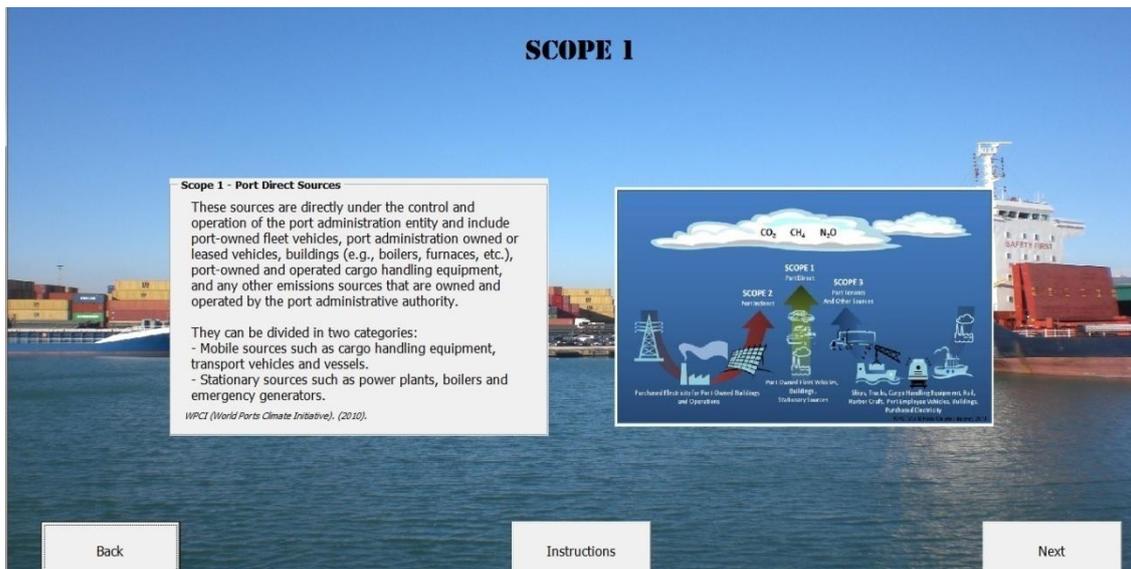


Figure 5: Definition of scope 1

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Now in the next slides you will have to provide the data required to calculate the emissions sources related to scope 1. Emission sources in this scope are divided into two main groups: mobile sources and stationary sources. For the calculation of all sources of scope 1, you should fill in the related cells if appropriate with the required data. There will be two screens pages for scope 1 (Figures 6 and 7) that belong to mobile sources and two screen pages that belong to stationary sources (Figures 8 and 9).

In Figure 6, you can see the first screen page for scope 1 where you should fill in the data related to three categories of the mobile sources (if they exist in the port):

- Cargo Handling Equipment
- Heavy-Duty On-Road Vehicles
- Railroad Locomotives

For each cell, you should choose the source type, fuel type, consumption amount and consumption unit. Then by pressing the 'Add' button, you could add the source to the list. You can add all those sources that you have. At the same time, if you are mistaken you can press the "delete" button to erase those that you consider.

The screenshot shows a web application interface titled "MOBILE SOURCES". It is divided into three main sections, each with a table for data entry and a "Delete" button. The sections are:

- Cargo Handling Equipment:** The table has 5 columns: Type, Name, Fuel Type, Consumption, and Units. There are 4 rows in the table. Below the table, a "Delete" button is present, followed by a list of source types: "1 Container Handlers CO 1 Gas/ Diesel Oil 650 L", "2 Forklifts FO 1 Compressed Natural Gas 755 cubic meters", and "3 Yard tractors YA 1 Liquefied Petroleum Gases 650 L".
- On-Road Vehicles:** The table has 5 columns: Type, Name, Fuel Type, Consumption, and Units. There are 4 rows in the table. Below the table, a "Delete" button is present, followed by a list of source types: "1 Car CARs Gasoil/Diesel 655 L", "2 Liquefied natural gas LNG heavy duty truck LFT Liquefied Petroleum Gases 755 L", and "3 Propane heavy duty truck HDT Compressed Natural Gas 750 L".
- Railroad Locomotives:** The table has 5 columns: Type, Name, Fuel Type, Consumption, and Units. There are 2 rows in the table. Below the table, a "Delete" button is present, followed by a list of source types: "1 Line haul locomotives LH Gas/ Diesel Oil 820 L".

At the bottom of the screen, there are four navigation buttons: "Back", "Instructions", "Save Project", and "Next".

Figure 6: First calculation screen of the mobile sources (scope 1)

By clicking the 'Next' button, you will go to the next screen. In this slide of scope 1 (Figure 7), you should also fill in the data related to two other categories of mobile sources (if they exist in the port):

- Port owned vessels
- Construction Equipment

Again for each cell, you should choose the source type, fuel type, consumption amount and consumption unit. Then by pressing the 'Add' button, you could add the source to the list (see Figure 7).

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MOBILE SOURCES

Port Owned Vessels

Type	Name	Fuel Type	Consumption	Units	
4					Add

1 Local ferries LO 1 Gas/ Diesel Oil 650 L
2 Excursion vessels EX 1 Compressed Natural Gas 850 cubic meters
3 Pleasure craft PL 1 Liquefied Petroleum Gases 655 L

Delete

Construction Equipment

Type	Name	Fuel Type	Consumption	Units	
4					Add

1 Earth moving equipment ER 1 Gasol/Diesel 750 L
2 Paving equipment PV 1 Liquefied Petroleum Gases 542 L
3 Portable concrete and asphalt batch plants PO Compressed Natural Gas 750 cubic meters

Delete

Back Instructions Save Project Next

Figure 7: Second calculation screen of the mobile sources (scope 1)

Now if you click the “Next” button, you will proceed to fill in the first page of required data for stationary sources related with scope 1 (Figure 8). You should fill in the data (fuel type, consumption amount and consumption unit) related to 3 groups of stationary sources (if they exist in the port). These sources are:

- Power plants
- Boilers
- Incineration plants

By pressing the ‘Add’ button, you could add them to the calculation list. Please, remember to save the project from time to time to avoid losing all the information already introduced.

STATIONARY SOURCES

Power plants

Name	Fuel Type	Consumption	Units	
2 Power Plant				Add

1 Power Plant PO1 Gas/Diesel Oil 750 L

Delete

Boilers

Name	Fuel Type	Consumption	Units	
2 Boiler				Add

1 Boiler BO Gas/Diesel Oil 700 L

Delete

Incineration plants

Type	Name	Fuel Type	Consumption	Units	
2					Add

1 Continuous stoker CO 1 Municipal Solid Waste - Continuous and Semi-continuous 450 kg

Delete

Back Instructions Save Project Next

Figure 8: First calculation screen of the stationary sources (scope 1)

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By pressing the 'Next' button, you will go to the last page of scope1. In this screen (Figure 9), you should fill in the required data (fuel type, consumption amount and consumption unit) related to three other groups of stationary sources (if they exist in the port):

- Generators
- Facilities that use combustion processes
- Wastewater treatment plants

In the case of wastewater treatment plants, you should choose the type of wastewater treatment plant and the type of industry where this water comes from. In addition, in order to obtain a final value, you should complete the data related to the "Organic component removed as sludge in inventory (kg COD)" and "Amount of CH₄ recovered in inventory (kg CH₄)".

Then you could get the total emissions of scope 1 by clicking the 'Results' button and save it as a pdf file. Alternatively, if you prefer to continue with the rest of the scopes and get the total amount of emissions at the end, you should click the 'Go to Scope 2' button. If want to go to "scope 3" you should click the button "Back to selection page".

The screenshot shows the 'STATIONARY SOURCES' interface. It features three main sections for data entry:

- Portable or emergency generators:** A table with columns for Name, Fuel Type, Consumption, and Units. An 'Add' button is present. A sample entry shows '1 Generator GN 1 Gas/Diesel Oil 550 L' with a 'Delete' button.
- Facilities that use combustion processes:** A table with columns for Name, Fuel Type, Consumption, and Units. An 'Add' button is present. A sample entry shows '1 Other Facilities OT 1 Gas/Diesel Oil 560 L' with a 'Delete' button.
- Wastewater treatment plants:** A table with columns for Type, Name, Industry Type, Production, and Units. An 'Add' button is present. Below the table are two additional input fields: 'Organic component removed as sludge in inventory, kg COD' and 'Amount of CH₄ recovered in inventory, kg CH₄'. A sample entry shows '1 Untreated wastewater treatment plant UT 1 Fish Processing 855 kg 0.1 0.25' with a 'Delete' button.

At the bottom of the screen, there are six buttons: 'Back', 'Back to Selection Page', 'Instructions', 'Save Project', 'Go to SCOPE 2', and 'Results'.

Figure 9: Second calculation screen of the stationary sources (scope 1)

4. Scope 2

Figure 10 presents the screen introduction to scope 2, where a brief definition of this scope is presented. By clicking the 'Next' button, you go to the calculation page for scope 2.

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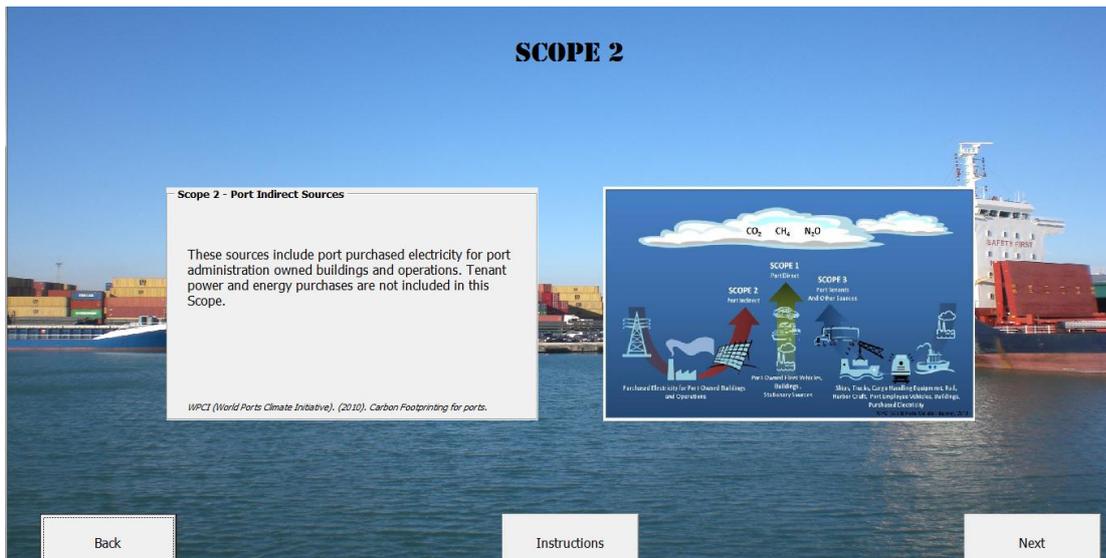


Figure 10: Definition of scope 2

In Figure 11, information on electricity data consumed by the port authority is required. The consumption amount has to be introduced and the intensity can be selected from a list according to the country. The mix of energy and therefore the emissions will vary in function of the country. If your country is not in the list or if you are not satisfied with the intensity value, you can choose the “other option” and add your own value to the intensity box. By pressing the ‘Add’ button, different sources can be added to the emission list.

Then, the result of this scope can be obtained by clicking on the ‘Results’ button. Alternatively, you can press the button ‘Go to Scope 3’ and continue with the calculation.

Figure 11: Calculation screen of the scope 2

5. Scope 3

If you have proceeded to scope 3, you will get a new screen (Figure 12) in which a definition of this scope is given. In this scope, you should provide data related to tenants ‘emissions and only from

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those emissions produced by their activities inside the port area, not outside as mentioned in the note present in this screen.

These emissions are divided into four main groups: mobile sources, stationary sources, purchased electricity and employees' commuting. You should complete the needed data of these four sources in the next consecutive eight screens of the tool (Figures 13-21).

As it will be seen, most of the mobile and stationary sources are the same as scope 1, apart from 'Ocean-going vessels' in mobile sources that is included in this scope since they do not belong to the port authority.

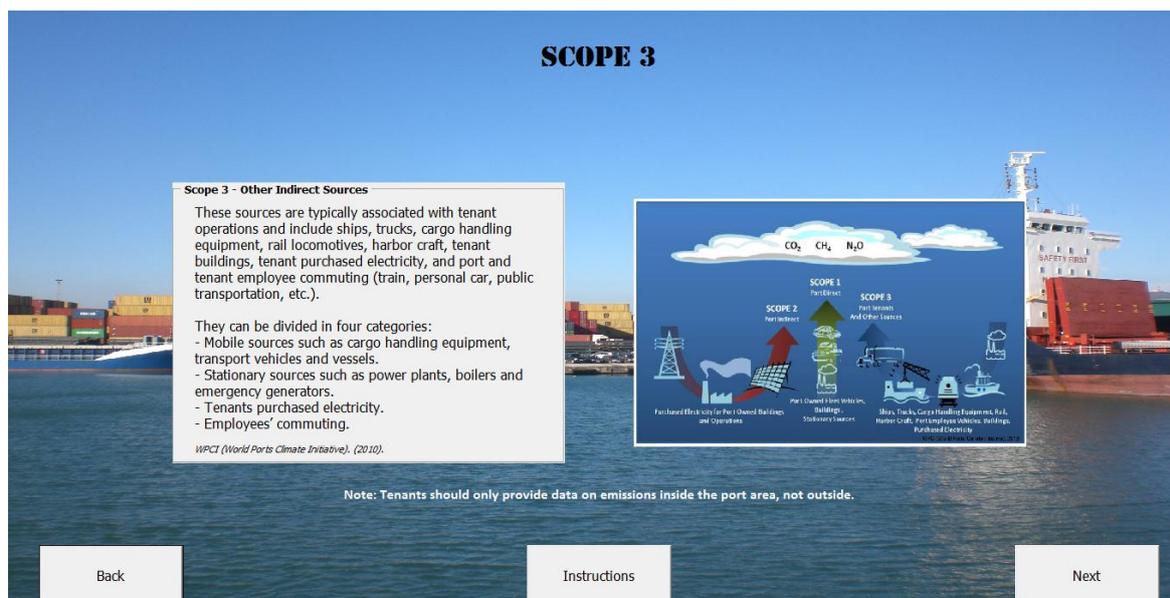


Figure 12: Definition of scope 3

By clicking on the 'Next' button in Figure 12, you could start to calculate the emissions of mobile sources of scope 3. As it can be seen in Figure 13, you should fill in the data related to the three categories of the mobile sources (if they exist in the port):

- Cargo Handling Equipment
- Heavy-Duty On-Road Vehicles
- Railroad Locomotives

In this step, the required data are fuel type, consumption amount and unit selection. Then, by pressing the 'Add' button, you could add all the sources you want to the list. By clicking on the 'Next' button, you will be taken to the next calculation page of scope 3.

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MOBILE SOURCES

Cargo Handling Equipment

Type	Name	Fuel Type	Consumption	Units
4				

1 Cranes CR 1 Gas/ Diesel Oil 950 L
2 Forklifts FO 1 Compressed Natural Gas 1560 cubic meters
3 Yard tractors YA 1 Liquefied Natural Gas 1985 L

On-Road Vehicles

Type	Name	Fuel Type	Consumption	Units
4				

1 Car CARs Gasoil/Diesel 1200 L
2 Liquefied natural gas LNG heavy duty truck LFT Liquefied Petroleum Gases 1250 L
3 Propane heavy duty truck PTH Compressed Natural Gas 1350 L

Railroad Locomotives

Type	Name	Fuel Type	Consumption	Units
2				

1 Line haul locomotives LH Gas/ Diesel Oil 1200 L

Back Instructions Save Project Next

Figure 13: First calculation screen of the mobile sources (scope 3)

In the next page of the scope 3 (Figure 14), you should fill in the data related to three categories of mobile sources (if they exist in the port):

- Harbour craft and inland waterway vessels
- Ocean-going vessels
- Construction Equipment

Again for each cell, you should choose the source type, fuel type, consumption amount and consumption unit. Then by pressing the 'Add' button, you could add as many sources as you need to the list.

MOBILE SOURCES

Harbor Craft and Inland Waterway Vessels

Type	Name	Fuel Type	Consumption	Units
4				

1 Commercial fishing vessels CO 1 Gas/ Diesel Oil 1200 L
2 Excursion vessels EX 1 Compressed Natural Gas 1800 L
3 Pleasure craft PL 1 Liquefied Natural Gas 950 L

Ocean-Going Vessels

Type	Name	Fuel Type	Consumption	Units
4				

1 Containerships CON 1 Gas/ Diesel Oil 950 L
2 Refrigerated Vessels (Reefer) REF 1 Compressed Natural Gas 850 cubic meters
3 Passenger Cruise Ships PASS 1 Liquefied Petroleum Gases 750 L

Construction Equipment

Type	Name	Fuel Type	Consumption	Units
4				

1 Earth moving equipment ER Gasoil/Diesel 855 L
2 Paving equipment PV 1 Liquefied Petroleum Gases 950 L
3 Portable concrete and asphalt batch plants PO 1 Compressed Natural Gas 850 cubic meters

Back Instructions Save Project Next

Figure 14: Second calculation screen of the mobile sources (scope 3)

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In the next screen (Figure 15) you should fill in the required data (fuel type, consumption amount and consumption unit) related to 3 groups of stationary sources (if they exist in the port) which are:

- Power plants
- Boilers
- Incineration plants

By pressing the ‘Add’ button, you could add different sources to the calculation list. Please, remember to save the project from time to time to avoid losing the information provided.

STATIONARY SOURCES

Power plants

	Name	Fuel Type	Consumption	Units	
2	Power Plant				Add

1 Power Plant PO 1 Gas/Diesel Oil 850 L

Delete

Boilers

	Name	Fuel Type	Consumption	Units	
2	Boiler				Add

1 Boiler BO 1 Gas/Diesel Oil 750 L

Delete

Incineration plants

	Type	Name	Fuel Type	Consumption	Units	
2						Add

1 Continuous stoker CO1 Municipal Solid Waste - Continuous and Semi-continuous 750 kg

Delete

Back Instructions Save Project Next

Figure 15: First calculation screen of the stationary sources (scope 3)

By pressing the ‘Next’ button, you will go to the next page of scope3. In this screen (Figure 16), you should fill in the required data (i.e. fuel type, consumption amount and consumption unit) related to three other groups of stationary sources (if they exist in the port) which are:

- Generators
- Facilities that use combustion processes
- Wastewater treatment plants

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Figure 16: Second calculation screen of the stationary sources (scope 3)

By clicking on the ‘Next’ button you will calculate the emissions from tenant purchased electricity in scope 3. As in can be seen in Figure 17, the needed data of this stage are consumption amount and the intensity which should be chosen based on the country as explained before or it can be filled in manually in the “Intensity” box.

Figure 17: Tenant purchased electricity emissions calculation screen (Scope 3)

Finally, to calculate the emissions from employees ‘commuting, you should decide which method is more convenient for you according to the available type of the data. Figure 18 offers a decision tree to select the most suitable calculation method for scope 3 emissions from employees’ commuting. Ports may use one of the following methods (WRI and WBCSD, 2013):

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- Fuel-based method: This method involves determining the amount of fuel consumed during commuting and applying the appropriate emission factor for that fuel.
- Distance-based method: This method involves collecting data from employees on commuting patterns (e.g. distance travelled and mode used for commuting) and applying appropriate emission factors for the modes used.
- Average-data method: This method involves estimating emissions from employees' commuting based on average (e.g., national) data on commuting patterns.

By clicking on the method, you will be taken to the related calculation page.

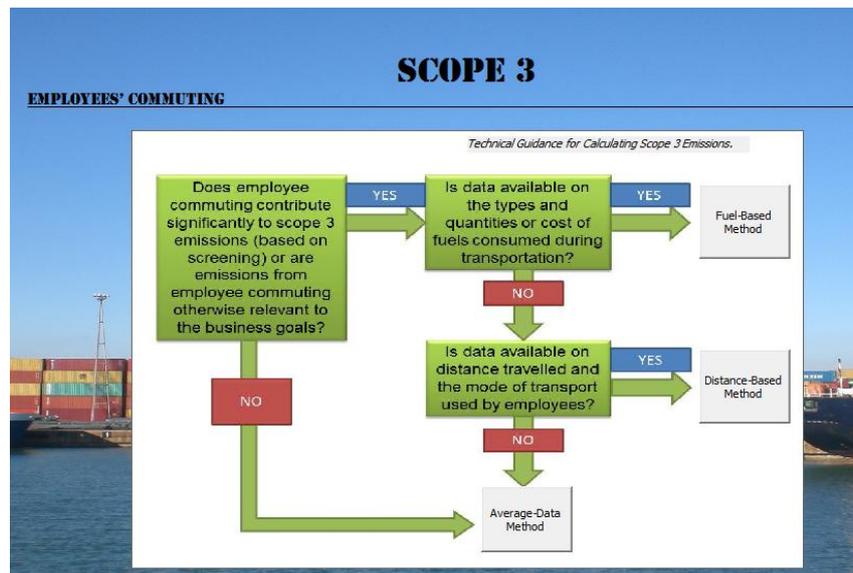


Figure 18: Decision tree to select a calculation method for emissions from employees' commuting

In Figure 19 you can see the calculation page of the Fuel-based method. As it can be seen, the required data are type of vehicle, fuel type, consumption amount and unit. By clicking on the 'Add' button, the data will be added to the list.

The screenshot shows the "EMPLOYEES' COMMUTING" interface for the "Fuel-based method". It features a table with columns: Type, Name, Fuel Type, Consumption, and Units. The "Type" column has a dropdown menu with the number "4" selected. Below the table is a "Delete" button. At the bottom of the screen, there are navigation buttons: "Back", "Back to Selection Page", "Instructions", "Save Project", "Close Program", and "Results".

Type	Name	Fuel Type	Consumption	Units
4				

1 Bus - Local Bus BUS Liquefied Petroleum Gases 1800 L
2 Train - Tram TRAM Compressed Natural Gas 950 cubic meters
3 Taxi/Car CARS Gas/ Diesel Oil 550 L

Figure 19: Calculation screen of employees' commuting (Fuel-based method)

Figure 20 shows the calculation page of the Distance-based method. As it can be seen, the required data are type of vehicle, working days, distance and unit. By clicking on the 'Add' button, the data will be added to the list.

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EMPLOYEES' COMMUTING

Distance-based method

Type	Name	Working Days	Distance	Units
4				

1 Taxi/Car CARs 320 days 45 km
2 Bus - Local Bus BUS 320 days 60 km
3 Train - Tram TRAM 330 days 120 km

Buttons: Back, Back to Selection Page, Instructions, Save Project, Close Program, Results

Figure 20: Calculation screen of employees' commuting (Distance-based method)

Figure 21 shows the calculation page of the Average-data method. As it can be seen, the required data are total number of employees, working days, percentage of total commute based on the vehicle type and average one-way distance. By clicking on the 'Add' button, the data will be added to the list.

EMPLOYEES' COMMUTING

Average-data method

Total Number of Employees:

Working Days:

	Percentage of total commutes (%)	Average one-way distance (km)
Rail	25	120
Car	45	35
By foot	5	3
Bus	25	60

Buttons: Back, Back to Selection Page, Instructions, Save Project, Close Program, Results

Figure 21: Calculation screen of employees' commuting (Average-data method)

6. Results

Finally, by clicking the 'Results' button, you can obtain a pdf file with the results. It includes the results for the total GHG emissions and also the emissions by each of the scopes and by capacity (TEUs or total cargo). A sample of the results is presented in Figures 22 and 23. The results of the tool are divided into four sections:

- **Total amount**

As it can be seen in figure 22, the first information that is presented is the name of the port, followed by the port address, the country and the capacity (TEU or tonnes). Then the total CO₂e emissions are presented as well as the emissions by capacity (TEU/year or million tn/year). In addition, total values per scopes are displayed, including also a pie chart.

- **Scope 1**

In scope 1, the total amount of emissions and emissions of each of the mobile sources and stationary sources from this scope are presented including also two pie charts that summarize the information (Figure 22).

- **Scope 2**

As it is presented in figure 23, the total amount of emissions from purchased electricity is presented.

- **Scope 3**

In this part, the total amount of emissions and the emissions of each of the mobile sources, stationary sources, purchased electricity and employees' commuting from scope 3 are presented and their representation in two pie charts is included (Figure 23).

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Port Name

Port Address

Country

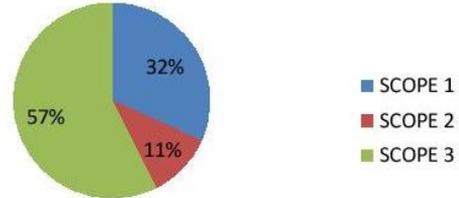
Capacity

2550 TEU/yr.

18555 million tn./yr.

TOTAL:	4866.281 CO ₂ e tonnes
Carbon footprint:	1.908 CO ₂ e tonnes/(TEU/yr.) 0.3 CO ₂ e tonnes/(million tn./yr.)

SCOPE	Emissions [CO ₂ e tonnes]
1	1547.035
2	529.321
3	2789.924
TOTAL	4866.281



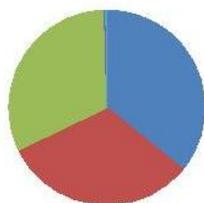
SCOPE 1:	1547.035 CO ₂ e tonnes
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Mobile Sources

Field	Emissions [CO ₂ e tonnes]	Percentage
Port Owned Vessels	482.069	35.92%
Cargo Handling Equipment	428.502	31.92%
Construction Equipment	425.775	31.72%
On-Road Vehicles	3.454	0.26%
Railroad Locomotives	2.423	0.18%
Total	1342.223	100.00%

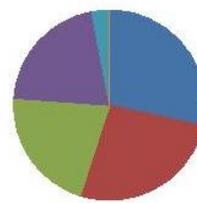
Stationary Sources

Field	Emissions [CO ₂ e tonnes]	Percentage
Power Plants	58.218	28.43%
Boilers	54.337	26.53%
Other Facilities	43.469	21.22%
Generators	42.693	20.85%
Incineration	6.083	2.97%
Wastewater treatment plants	0.011	0.01%
Total	204.812	100.00%



Emissions by Mobile Sources

- Port Owned Vessels
- Cargo Handling Equipment
- Construction Equipment
- On-Road Vehicles
- Railroad Locomotives



Emissions by Stationary Sources

- Power Plants
- Boilers
- Other Facilities
- Generators
- Incineration
- Wastewater treatment plants

Figure 22: Sample of the results (Page 1)

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SCOPE 2: 529.321 CO₂e tonnes

Purchased Electricity

Field	Emissions [CO ₂ e tonnes]
Electricity	529.321

SCOPE 3: 2789.924 CO₂e tonnes

Mobile Sources

Field	Emissions [CO ₂ e tonnes]	Percentage
Cargo Handling Equipment	884.636	47.96%
Construction Equipment	483.116	26.19%
OGV	461.694	25.03%
On-Road Vehicles	6.094	0.33%
Harbor Craft	5.496	0.30%
Railroad Locomotives	3.545	0.19%
Total	1844.582	100.00%

Stationary Sources

Field	Emissions [CO ₂ e tonnes]	Percentage
Generators	151.367	38.76%
Other Facilities	104.792	26.83%
Power Plants	65.980	16.90%
Boilers	58.218	14.91%
Incineration	10.138	2.60%
Wastewater treatment plants	0.015	0.00%
Total	390.511	100.00%

Purchased Electricity

Field	Emissions [CO ₂ e tonnes]
Electricity	14.757

Employees' commuting

Field	Emissions [CO ₂ e tonnes]
Employees' commuting	540.074

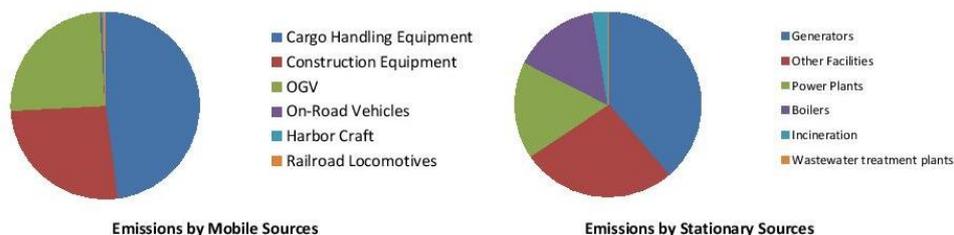


Figure 23: Sample of the results (Page 2)

7. References:

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