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# Development of a standardized tool to calculate carbon footprint in ports

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*ABSTRACT*

Ports are essential contributors of a country's economy. One of the significant environmental threats in ports is Climate Change due to carbon dioxide emissions generated by different activities in these areas. 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. There is no single or unified method to calculate Carbon Footprint in ports.
Therefore, the aim of this paper is to present the development of a practicable, user-friendly and free available tool with a standardized method for the calculation of Carbon Footprint in ports. This has been demanded by the port sector in different occasions (e.g. Greenport, 2018).
The tool provides options to select the scopes 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.
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:
*- Step1: General data such as the port's 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 $CO_2$ equivalent emissions and also with emissions by capacity (Carbon Footprint) and by scope. This document can be saved as a pdf file.*



## 1. Introduction.

Growing emissions of Greenhouse Gases (GHG) have been proved to be the cause of global Climate Change in port operations [IAPH, 2010] and it is one of the main environmental concerns in recent years. In a survey conducted by the European Sea Port Organization (ESPO) in 2019, Climate Change occupied the 3rd position in the ranking of top 10 environmental priorities in ports [ESPO, 2019]. This shows the fact that the topic of Climate Change in the maritime industry is getting more importance every day.

For ports it is increasingly acknowledged that the consequences of Climate Change, such as changes in sea level rise, changes in weather or in the storm frequency, will affect both existing and new seaport, and inland waterway infrastructures [Becker et al., 2012]. Therefore, ports require special treatment because of their economic importance as essential links in supply chains, their location in the heart of sensitive estuarine environments, their reliance on waterfront locations, and the significant existing infrastructure that links them to inland transportation networks [Becker et al., 2012].

In order to calculate, control and reduce $CO_2$ emissions in ports, an indicator has been developed: Carbon Footprint. The Carbon Footprint is the total amount of Greenhouse Gases emissions that are emitted directly and indirectly by an activity.

As mentioned before, in recent years some ports have calculated their carbon footprint and reported it. The problem is

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that 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 [GreenPort, 2019]. In this regard, the main aim of this research is to develop this standardized tool. In the next section the concepts of Climate Change and Carbon Footprint are explained in more detail.

## 2. Climate change and carbon footprint.

Climate Change is an inherent global issue which has become a major focus of attention because of its potential hazards and impacts on the environment [Sánchez-Arcilla et al., 2011]. Due to the increase of the industrialization of human society, the already variable climate of the Earth has been influenced significantly by such human actions [Chao & Feng, 2018].

Generally, Climate Change refers to the gradual change in the Earth's climate and physical geography that accompanies an increase in the Earth's temperature [Karl et al., 2009]. The human contribution to this effect can be measured by the carbon footprint.

Wiedmann & Minx [Wiedmann & Minx, 2007] propose the following definition of the term Carbon Footprint: "The Carbon Footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product."

Concerns about Climate Change were expressed for the first time in 1979, when the first World Climate Conference was held in Geneva and sponsored by World Meteorological Organization (WMO) [Sprinz & Luterbacher, 1996].

In 1988 the Intergovernmental Panel on Climate Change (IPCC) was set up by both the United Nations Environmental Program (UNEP) and WMO, to provide policymakers with regular scientific assessments on the current state of knowledge about Climate Change [IPCC, 2015]. This was followed in 1992 by the development of the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro to stabilize GHG concentrations in the atmosphere [UN, 1992]. The IPCC Guidelines for National Greenhouse Gas Inventories were accepted in 1994 and published in 1995. The revised version of the IPCC Guidelines for National Greenhouse Gas Inventories were issued in 2006 and updated in 2019 [IPCC, 2006] and [IPCC, 2019]. These guidelines have been used as a reference to developed the new tool.

In addition, in 1998 the World Resources Institute (WRI) and World Business Council for Sustainable Development [14] together with companies, governments and environmental groups from around the world developed the GHG protocol. The GHG Protocol developed standards, tools and online training that helped countries and cities to track progress towards their climate goals [WRI, 2004]. These GHG protocol related documents have been also used to developed the new tool.

Since then several attempts by different organizations have been done to control the effects of Climate Change. The most recent and important one in 2015, the Paris Agreement, recognized Climate Change as an urgent threat and set the mitigation goal of limiting the global temperature increase up to 2 °C and ideally up to 1.5°Cwithin the framework of the United Nations Framework Convention on Climate Change [UN, 2016].

As mentioned before, one of the human activities which have an effect on Climate Change is activities in ports and maritime sector. International attempts to control Climate Change in ports are introduced below.

In April 2008, the World Ports Climate Initiative (WPCI) was established by the International Association of Ports and Harbours [IAPH, 2010]. As a part of the WPCI's mission to provide a platform for the exchange of information, a guideline was developed to serve as an introduction to "carbon footprinting" and as a resource guide for ports wanting to develop or improve their GHG emissions inventories [16]. This guideline is another reference that has been used to develop the new tool.

Beside these initiatives, in recent years several attempts have also been done in this regard. For example, IMO's recent decisions, such as the adoption of a strategy to reduce GHG emissions from shipping by 50% until 2050 (compared to 2008), created a need for finding ways to comply with this goal [BPO, 2019].

As it can be seen, some initiatives have been carried out to foster the reduction of GHG's in the maritime sector. In addition, diverse methods have been developed to calculate the carbon footprint in ports. In a study by Azarkamand et al. [Azarkamad et al., 2020], more than 21 different methodologies to calculate Carbon Footprint in ports, port terminals and ships were studied and analysed. Ships studies were also included since their emissions are contributing to the total port area carbon footprint. This study presented the Strengths and Opportunities for further development of these methods. The main weaknesses were:

- Each procedure was different and there was not any standard method to calculate CO2 emissions in this sector.
- In most of the cases, all the emission sources mentioned in the standard guidelines (direct or indirect) were not calculated. In order to have a comprehensive and realistic figure of GHG emissions and Carbon footprint in ports, all emission sources should be taken into account.
- In the majority of the methods emissions from waste operations, which can take place in a port such as incinerators or waste water treatment plants, were not included in the calculation.
- In most of the studies, scopes were not defined based on the standard methods.
- In around 70% of the cases, emissions from employees' commuting were not included. These are a significant source of emissions in scope 3 (i.e. emissions from tenants, vessels and employees' commuting).
- In around 65% of the cases, some of the recognized scopes or parts of them were excluded. For example, the calculation of the scope 3 emissions was not taken into account in some ports.

- In around 60% of the studies, the whole set of scope 3 emissions were not calculated.

Therefore, the total amount of CO2 emissions would not present a real figure of the Carbon footprint in that particular port.

- In about 60%of the studies where a tool was developed (five cases), the access to this tool was not possible.

As a consequence of this analysis, the need of a tool that overcome all these weaknesses and includes most of the strengths was required. This development of this new tool is introduced in the next sections.

## 3. Methodology.

Taking all the strengths and weaknesses into account a new standardized tool has been developed. The creation of this tool has been done by the use of Excel software and Visual Basic. In addition, the tool has been based on the IPCC [IPCC, 2006] and [IPCC, 2019], GHG protocol [WRI, 2004] and WPCI guideline [WPCI, 2010].

In the new tool, all scopes and all the direct and indirect emission sources are taken into account. The new tool also includes emissions from waste treatment plants present in the port area such as incinerators, waste water treatment plants and others. They should be taken into account, where there exist, since they are sources of $CO_2$ emissions as well that should be counted in the total carbon footprint of a port. In addition, emissions from ships are added to this tool.

Moreover, the three main GHG (carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$)) are included in the new tool and the total amount is presented as a $CO_2$eq, as it includes all three GHGs emissions.

Finally, the calculation of carbon footprint is presented as a total value as well as a ratio between the total amount of $CO_2$eq and the total cargo of the port, following the example of a successful experience of Climeport project [CLIMEPORT, 2011]. This would allow more realistic comparisons between ports if they want to share their figures. In addition, this is basically done to allow a comparison of the results of different ports on the same ground.

The tool provides options to select the scopes and boundaries that are more suitable and applicable to each port.

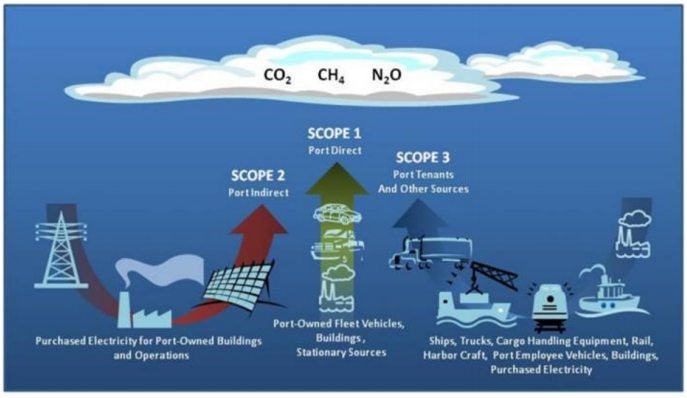
In order to choose the sources and scopes, WPCI guidelines are used. Based on this guideline scopes in ports are divided in three main groups (Figure 1) [WPCI, 2010]:

**Scope 1:** Port Direct Sources. These sources are directly under the control and operation of the port administration entity and include port-owned fleet vehicles, port administration owned or leased vehicles, buildings (e.g., boilers, furnaces, etc.), port-owned and operated cargo handling equipment, and any other emissions sources that are owned and operated by the port administrative authority.

**Scope 2**: Port Indirect Sources. These sources include port purchased electricity for port administration owned buildings and operations. Tenant power and energy purchases are not included in this Scope.

**Scope 3**: Other Indirect Sources. These sources are typically associated with tenant operations and include ships, trucks, cargo handling equipment, rail locomotives, harbour craft, tenant buildings, tenant purchased electricity, and port and tenant employee commuting (train, personal car, public transportation, etc.).

Figure 1: Emission sources in ports [WPCI, 2010].




Source: WPCI, 2010.

In addition, in the new tool emission sources are categorized based on WPCI [WPCI, 2010] guidelines and GHG protocol [WRI, 2004]. In WPCI, emission sources in ports are divided into two main groups, mobile sources and stationary sources [WPCI, 2010]:

**- Mobile sources**

Greenhouse gas emissions are produced by mobile sources as fuels are burned. The mobile sources in a port are divided in three main groups: on-road vehicles, waterborne vehicles and construction equipment.

**- Stationary sources**

Stationary sources are the second group of sources emitting GHG found at ports. They typically account for significantly less Greenhouse gas emissions than the mobile sources. Stationary source emissions come from fixed, particular, identifiable, localized sources or facilities that use combustion processes. The main stationary sources in ports are power plants, boilers, emergency generators and purchased electricity.

As employee commuting is one of the main sources of GHG emissions in scope 3, this source has also been included in the new tool, based on the GHG protocol [WRI, 2004].

In order to choose the calculation method, IPCC (2006, 2019) and GHG protocol guidelines have been used. UNFCCC COP3 which was held in 1997 in Kyoto reaffirmed that the IPCC Guidelines for National Greenhouse Gas Inventories should be used as ”methodologies for estimating anthropogenic emissions by sources and removals by sinks of greenhouse gases” [IPCC, 2003].

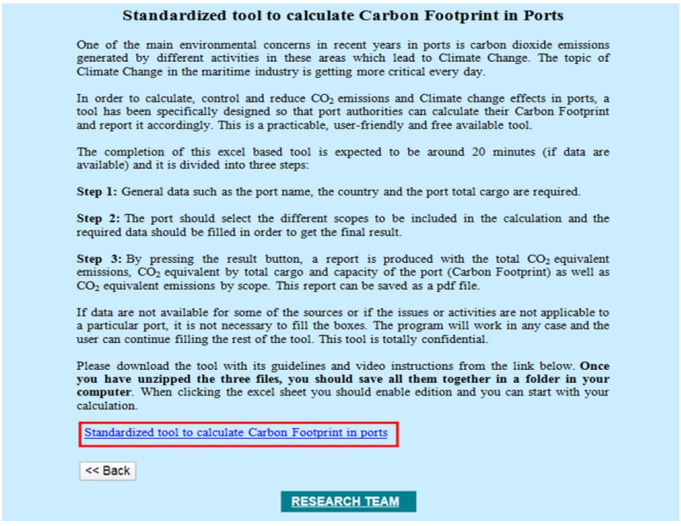
## 4. Development of the tool.

The new tool is specifically designed for port authorities to calculate their Carbon Footprint and report it accordingly. This tool is user-friendly, voluntary and free-available.

Options are provided in the tool so that each port authority can calculate the scope and boundaries that are more suitable and applicable to its circumstances.

The tool, the guidelines and the video can be downloaded from http://eports.cat/carboonfootprint. Once the user downloads the three files, he/she should save them all together in a folder. Then, the user could run the tool by enabling it. Figure 2 shows the screenshot of the website and the link of the tool.

Figure 2: The screenshot of the website of the tool.

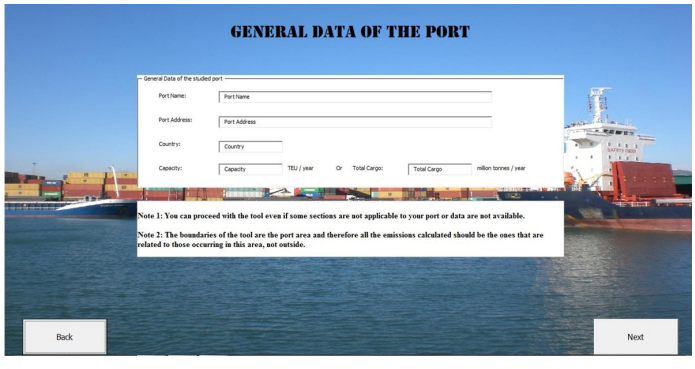



Source: Authors.

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:

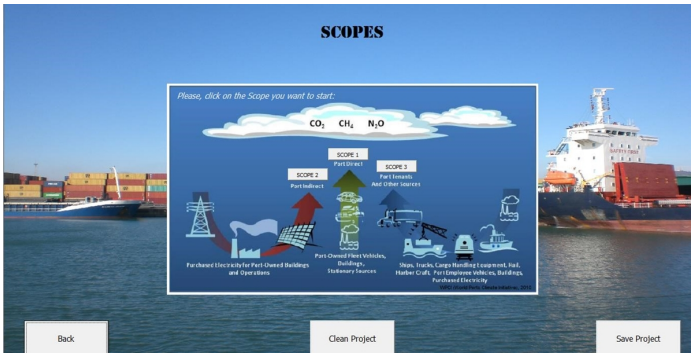
- Step1: General data such as the port name, the country and the port total cargo are required (Figure 3).

Figure 3: General data of the port.



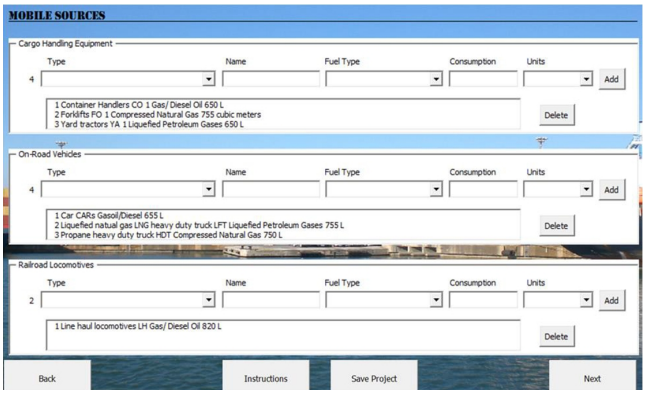

Source: Authors.

Figure 4: Scopes' selection.




Source: Authors.

Figure 5: Sample calculation page of scope 1.




Source: Authors.

- 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 (Figure 4). Figure 5 shows a sample page of scope 1 to calculate emissions.

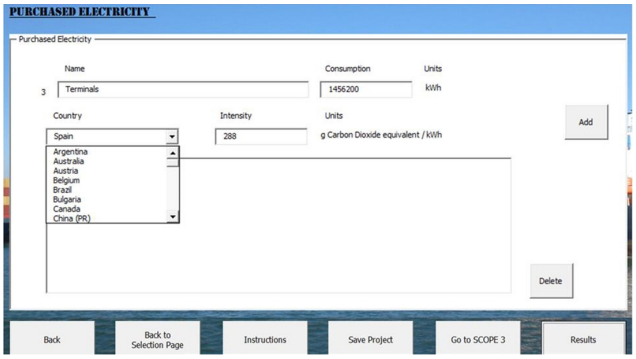
As mentioned before emission sources are divided into two main groups; mobile sources and stationary sources. For the calculation of all sources of scope 1, the related cells should be filled with appropriate data. Two pages of scope 1 belong to mobile sources and two pages belong to stationary sources.

In scope 2, emissions from purchased electricity for port administration owned buildings and operations are calculated. The needed data are consumption amount and intensity. This latter value is different in each country and you can select from a list your country and the value appears directly (Figure 6).

In scope 3, emissions from tenant are calculated. The emission sources of the tenants are divided into four main groups which are mobile sources, stationary sources, purchased electricity and employee commuting. The required data of these three sources should be filled in eight sheets of the tool. Figure 7 shows the sample calculation page of the scope 3.

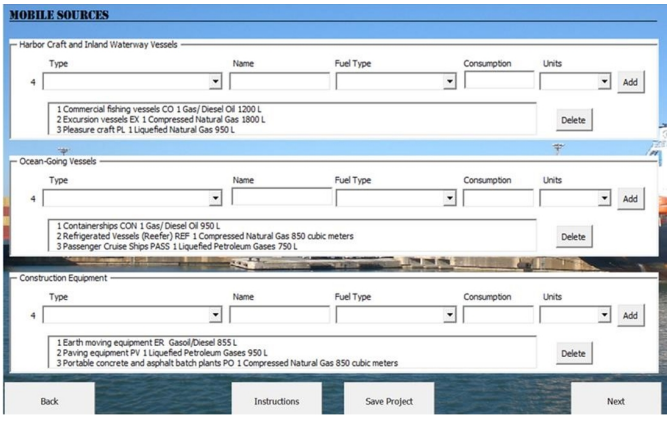
Step 3: By pressing the result bottom (Figure 8), a report is produced with the $CO_2$ equivalent emissions by scope, the total ones and the carbon footprint which can be saved as a pdf file. Figure 9 shows the sample of pdf result of the tool.

Figure 6: The calculation page of scope 2.



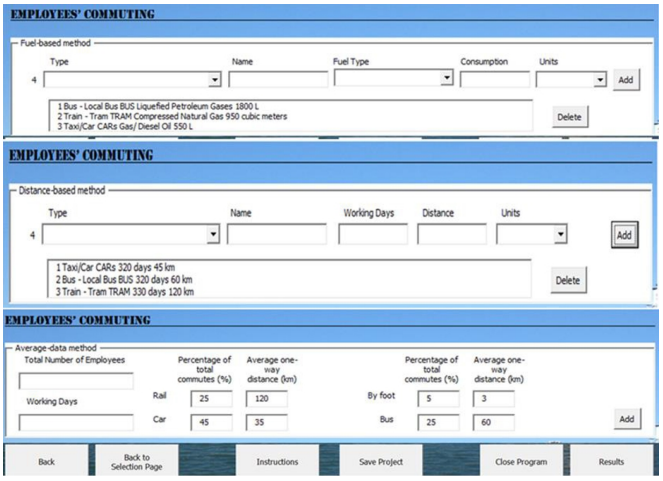

Source: Authors.

Figure 7: The sample calculation page of scope 3.



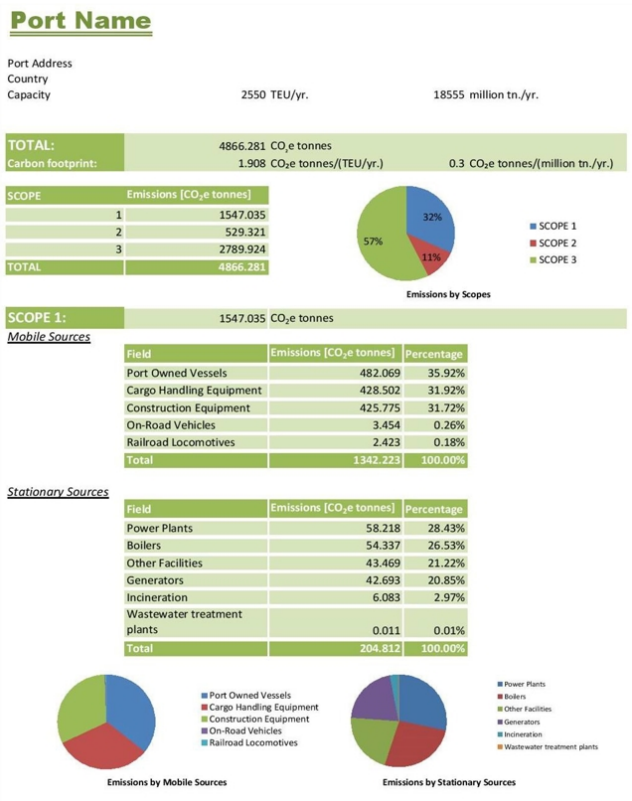

Source: Authors.

Figure 8: The last page of the tool.




Source: Authors.

Figure 9: The sample of the results of the tool as a pdf file .




Source: Authors.

## Conclusions.

In recent years, international organizations and ports are implementing measures to fight against Climate Change effects and to reduce $CO_2$ emissions. The review of different studies shows that in recent years many ports calculate their Carbon Footprint and report it. However, each port uses each own method and the emissions from some sources such as wastes, commuting employees and vessels are excluded from calculation in many cases. Therefore, there is not any unified and complete method to calculate Carbon Footprint that allows comparing results among different ports. This proves the need for such a methodology for ports. This is supported by most of the participants in the Greenport Congress in Valencia that consider that a common port-sector Carbon Footprint scheme would benefit individual port authorities and the portsector as a whole. Therefore, the development of a practical tool with a standardized method for the calculation of Carbon Footprint in ports could be very helpful.

The creation of the tool has been done by the use of Excel software and Visual Basic, based on the WPCI, IPCC and GHG protocol guidelines. This tool is specifically designed for port authorities to calculate their Carbon Footprint and report it accordingly.

It should be mentioned that the development of the tool is just the first step. This tool has been improved and modified based on the feedback obtained from diverse world-wide re-

viewers. In order to complete and improve this tool, it will be tested with data gathered from different case studies. The results obtained from the tool will be compared with the results of the ports which calculate their Carbon Footprint with their different calculation methods. This will help to have a better understanding of the benefits of this method and it will show the areas which may need to be improved. Then, the required modifications and improvements will be implemented to finalize the tool. In the next step, the tool will be to distribute to all interested ports in Europe and outside Europe for free. .

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