Inland shipping - containers
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This guideline deals with the data needed to allocate emissions to containers. A large proportion of these data can be obtained directly from stowage packages. To be able to allocate these emissions, the following must be known about the cargo (for each container): the loading and unloading locations, as well as the weight of the container plus the cargo.

In practice, customers sometimes do not indicate the weight of the (filled) container correctly. This not only leads to incorrect allocations, but can also cause stability problems. In this guideline we assume that the indicated weight is accurate.

The inland shipping of containers involves transporting sea containers between container terminals: sea terminals and container depots at seaports, and hinterland terminals.

These containers may be filled with cargo or empty. Sea containers are counted in TEUs: a 20 ft container is 1 TEU and a 40 ft container 2 TEUs. The actual dimensions may deviate from 20 ft and 40 ft.

At each terminal a skipper has to perform stability calculations and draw up a loading/unloading plan. Taking this plan as a basis, the containers are unloaded and loaded in such a way that the vessel remains stable in the water, the weight is evenly distributed and the containers can be unloaded efficiently at the next stop.
To perform these calculations, the following is known about each container:

- The unique container number;
- The dimensions;
- The total weight;
- Where the container is loaded;
- Where the container has to be unloaded.

These are exactly the data about the cargo and the origin/destination that are needed to allocate emissions to each container.

Stability calculations can be performed efficiently by computer. The most commonly used software packages for stability calculations and loading/unloading plans are able to export all these data digitally, making processing extremely straightforward.

### Origin and destination

All container terminals in Europe have a standardized code, the so-called UN/LOCODE, with a suffix indicating the terminal. As the geocoordinates of all these codes are known, automatic processing is a very simple task. The example data format below includes transport by truck and inland shipping, both of which use terminal codes.

### Input data format - Location: UN/LOCODE

<table>
<thead>
<tr>
<th>Order number</th>
<th>Mode</th>
<th>Date</th>
<th>Quantity (tons)</th>
<th>UN/LOCODE - origin</th>
<th>UN/LOCODE - destination</th>
<th>Customer/recipient (group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trucks</td>
<td>05/11/2019</td>
<td>22</td>
<td>ATENA</td>
<td>ATKRE</td>
<td>OOMER</td>
</tr>
<tr>
<td>2</td>
<td>Inland shipping</td>
<td>05/11/2019</td>
<td>22</td>
<td>ATENA</td>
<td>ATLNZ</td>
<td>OOMER</td>
</tr>
<tr>
<td>3</td>
<td>Trucks</td>
<td>05/11/2019</td>
<td>21</td>
<td>ATENA</td>
<td>ATVIE</td>
<td>OVIEW</td>
</tr>
<tr>
<td>4</td>
<td>Inland shipping</td>
<td>05/11/2019</td>
<td>28</td>
<td>ATENA</td>
<td>BEANR</td>
<td>OVIEW</td>
</tr>
<tr>
<td>5</td>
<td>Trucks</td>
<td>05/11/2019</td>
<td>28</td>
<td>ATENA</td>
<td>BEZEE</td>
<td>OOMER</td>
</tr>
</tbody>
</table>
Fuel consumption

An inland vessel’s fuel consumption is dependent on a large number of factors:

1. The speed (A) at which the vessel sails and the resistance of the hull as it moves through the water (B).

2. The draft of the loaded vessel: the greater the weight being carried, the lower the vessel will sit in the water.

3. How much water lies between the keel and the bed of the inland waterway, and whether the bed is muddy or hard.

4. How fast the rivers are flowing.

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1 hydrodynamic resistance
There are models that try to predict fuel consumption by taking all these factors into account. The alternative is to measure consumption in practice on an ongoing basis and apply so-called regression analysis to the measured data. This statistical analysis shows which influencing factors appear to have a major impact on the result. In this way the data from practice provide a wealth of information about these influences.
Measuring consumption

Some vessels can measure their consumption precisely between two stops at terminals. For allocation purposes the intention is to determine the consumption for a round trip: the sum of the fuel consumption measured at each stop. This allows emissions to be allocated to individual orders as precisely as possible.

Other vessels determine how much fuel has been consumed over a certain period during bunkering/refueling. This results in emissions being allocated to orders more on the basis of averages. While the total is still correct, the differences are less visible in this case.
Allocation

Containers have fairly standard dimensions, so at first glance allocation on the basis of TEUs would be the obvious approach. This would be the most straightforward method, but performing allocation on the basis of total weight per container is better. Taking weight as the basis ensures that the effect of 'more weight means more draft means more fuel consumption' is taken into account. The effect of 'more draft means less water between the keel and the bed means more consumption' is also factored in.
Example calculation

In this example a triangular route is navigated, starting in Nijmegen, traveling to Rotterdam and Antwerp, and then sailing back to Nijmegen. The vessel carries containers for two customers (shippers) and unloading and loading are required at each port. What happens is presented schematically below.

In this example, for clarity, we first break down the order by shipper (when software works this out all calculations are performed simultaneously). The principle of allocating the CO₂e on the basis of the weight per container is the same and can be easily performed using software.

For simplicity, in the example the size of the container in TEU is taken as a measure for allocation purposes rather than the weight of the container. Weight is a better measure, but it makes the calculation more difficult to follow.
In Nijmegen 20 TEUs of containers are loaded for shipper 1: 10 with the destination Rotterdam and 10 with the destination Antwerp.

In Rotterdam 10 TEUs of containers are unloaded and 10 additional TEUs are loaded with the destination Antwerp.

In Antwerp 20 TEUs of containers with the destination Antwerp are unloaded. Then 10 TEUs of containers with the destination Nijmegen are loaded and the vessel sails back to Nijmegen to unload them.

The great-circle distance (distance between ports) has to be determined for each TEU of cargo and therefore its relative share expressed in TEU.km

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**Tea Diagram:***

- **Nijmegen**: Loaded 20, Unloaded 0
- **Rotterdam**: Loaded 10, Unloaded 10
- **Antwerp**: Loaded 10, Unloaded 10

**Great-circle distances (kms):**

- Nijmegen - Rotterdam: 96
- Nijmegen - Antwerp: 123
- Rotterdam - Antwerp: 70
- Antwerp - Nijmegen: 123
- Rotterdam - Nijmegen: 96

**Total TEU.km:** 4,120
In Nijmegen 40 TEUs of containers are loaded for shipper 2: 30 with the destination Rotterdam and 10 with the destination Antwerp.

In Rotterdam 30 TEUs of containers are unloaded. Then 20 TEUs of containers with the destination Antwerp and 10 TEUs of containers with the destination Nijmegen are loaded.

In Antwerp the 30 (20+10) TEUs of containers with the destination Antwerp are unloaded. Then 30 TEUs of containers with the destination Nijmegen are loaded and the vessel sails back to Nijmegen to unload them.

The great-circle distance (distance between ports) has to be determined for each TEU of containers and therefore its relative share expressed in TEU.km

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**Shipper 2**

<table>
<thead>
<tr>
<th>Location</th>
<th>Loaded</th>
<th>Unloaded</th>
<th>Onboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nijmegen</td>
<td>40</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>Rotterdam</td>
<td>30</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Antwerp</td>
<td>30</td>
<td>40</td>
<td>30</td>
</tr>
</tbody>
</table>

- **Nijmegen - Rotterdam**: 30 TEUs from Nijmegen, 10 TEUs from Rotterdam, distance 96 kmgcd, TEU.km = 2,880
- **Nijmegen - Antwerp**: 10 TEUs from Nijmegen, distance 123 kmgcd, TEU.km = 1,230
- **Rotterdam - Antwerp**: 20 TEUs from Rotterdam, distance 70 kmgcd, TEU.km = 1,400
- **Antwerp - Nijmegen**: 30 TEUs from Antwerp, distance 123 kmgcd, TEU.km = 3,690
- **Rotterdam - Nijmegen**: 10 TEUs from Rotterdam, distance 96 kmgcd, TEU.km = 960

**Total TEU.km**: 10,160
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The total number of TEU.kmgcd is 4,120+10,160= 14,280 (100%).
4,120 TEU.kmgcd represents 28.9% of the total and 10,160 TEU.kmgcd 71.1% of the total.
The same percentage allocation can now be applied for each container.

Example: 4,000 liters of diesel are consumed for the trip. At 3.23 kg CO2e (WTW) per liter this amounts to: 12,920 kg CO2e of emissions in total.

The 10 TEUs from Nijmegen to Rotterdam are allocated 6.7% of the emissions.
This corresponds to 6.7% x 12,920 = 868.8 kg CO2e. Per TEU that amounts to 86.86 kg CO2e.

Using the same calculation method, the 30 TEUs of shipper 2 transported from Antwerp to Nijmegen are allocated 25.8% = 3,339 kg CO2e, or 111.3 kg per TEU. The great-circle distance between Antwerp and Nijmegen is greater than that between Rotterdam and Nijmegen, so the allocated emissions per TEU are higher.
Carbon Footprint guidelines

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