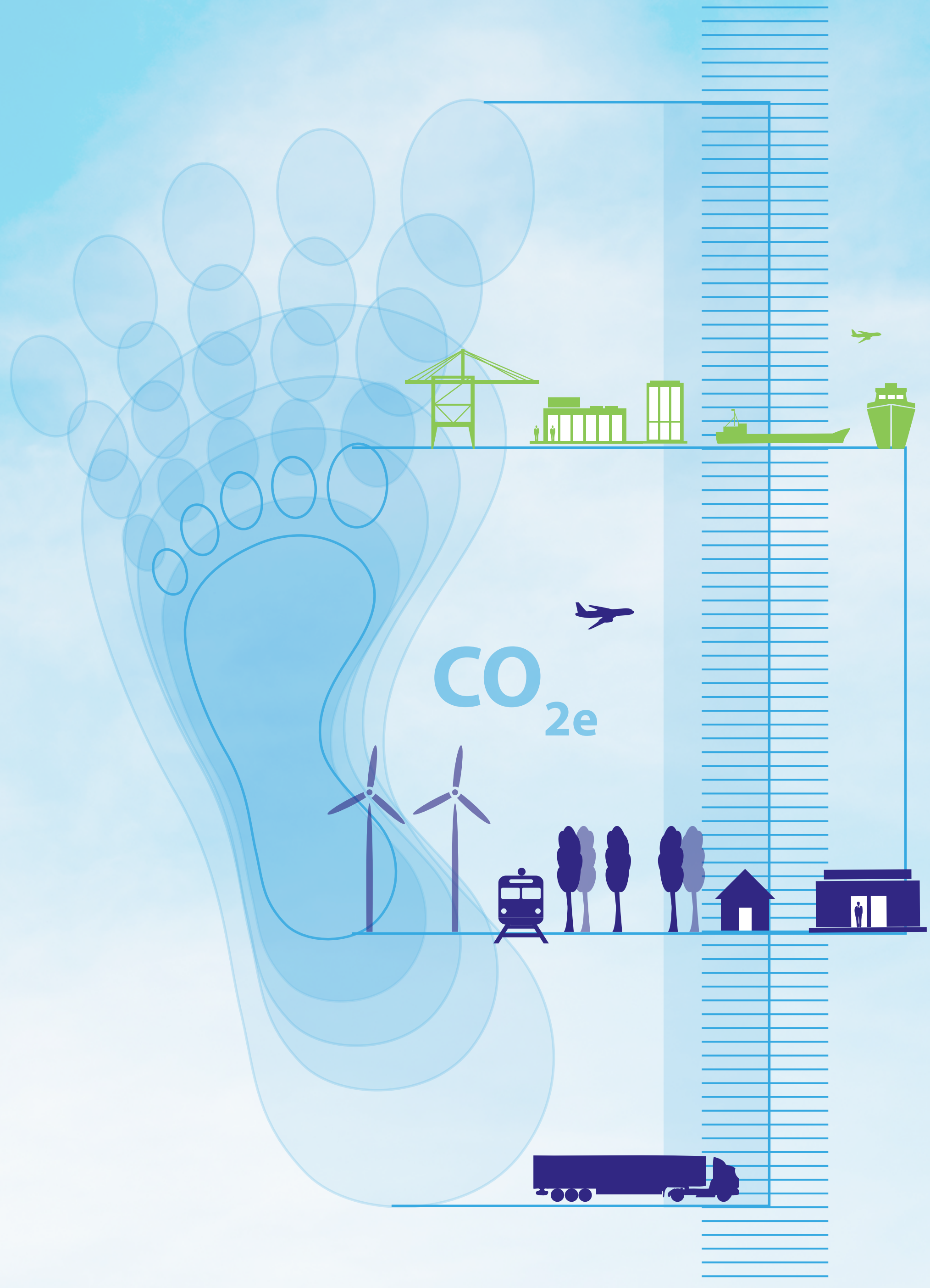
GUIDELINE 5 - CARBON FOOTPRINT IN LOGISTICS



Inland shipping - containers

Colophon

Guideline 5 - Inland shipping - containers

Carbon Footprint in Logistics

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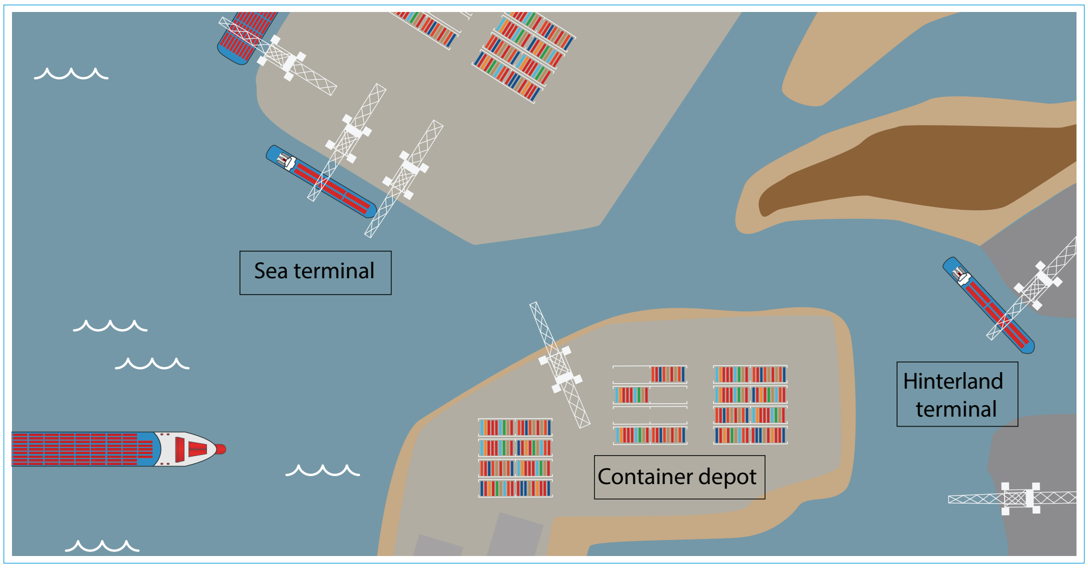
Connekt/Topsector Logistiek
Ezelsveldlaan 59
2611 RV Delft
+31 15 251 65 65
info@connekt.nl
www.connekt.nl

Inland shipping - containers

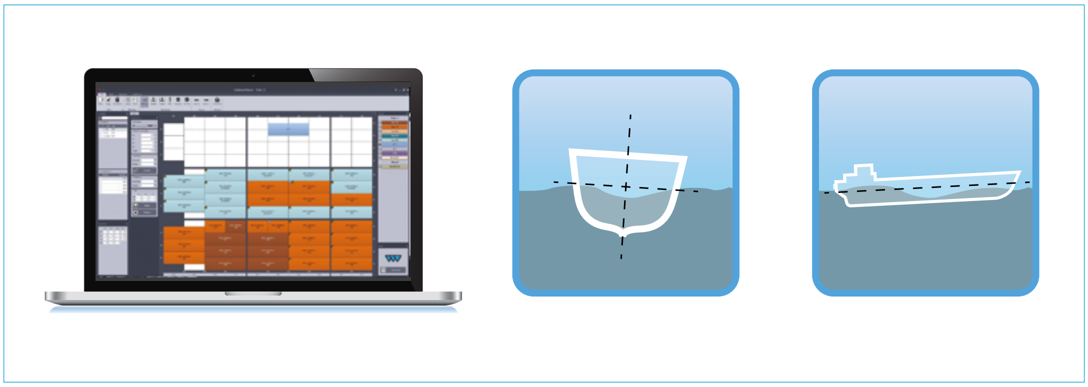
This guideline deals with the data needed to allocate emissions to containers. A large proportion of these data can be obtained directly from stowage packages. To be able to allocate these emissions, the following must be known about the cargo (for each container): the loading and unloading locations,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

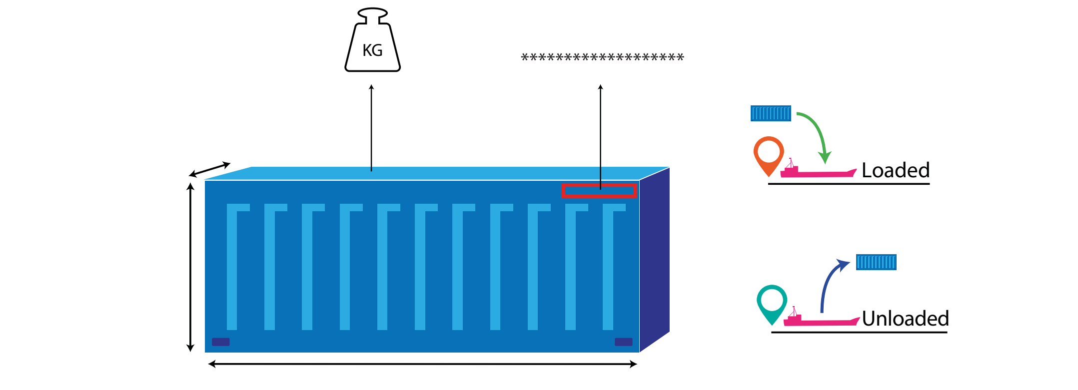


These containers may be filled with cargo or empty.
Sea containers are counted in TEUs: a 20 ft container is 1 TEU and a 40 ft container 2 TEUs.
The actual dimensions may deviate from 20 ft and 40 ft.
At each terminal a skipper has to perform stability calculations and draw up a loading/unloading plan. 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.

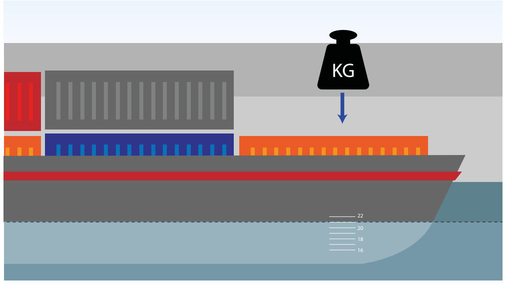
Input data format - Location: UN/LOCODE

Order number	Mode	Date	Quantity (tons)	UN/LOCODE - origin	Terminal code - origin	UN/LOCODE - destination	Terminal code - destination	Customer/ recipient (group)
1	Trucks	05/11/2019	22	ATENA	OENNS	ATKRE	OOMER	Customer A
2	Inland shipping	05/11/2019	22	ATENA	OENNS	ATLNZ	OOMER	Customer B
3	Trucks	05/11/2019	21	ATENA	OENNS	ATVIE	OWIEW	Customer C
4	Inland shipping	05/11/2019	28	ATENA	OENNS	BEANR	OWIEK	Customer D
5	Trucks	05/11/2019	28	ATENA	OENNS	BEZEE	OOMER	Customer E

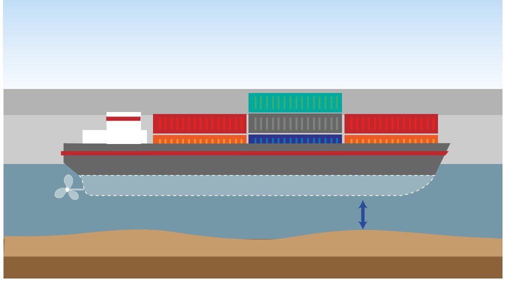
Fuel consumption

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

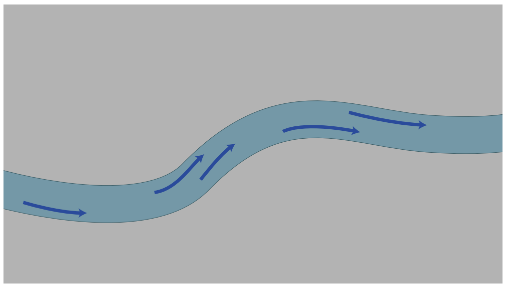
The speed (A) at which the vessel sails and the resistance of the hull as it moves through the water (B[1]).



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

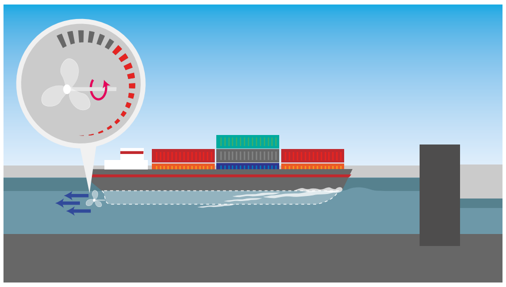


How much water lies between the keel and the bed of the inland waterway, and whether the bed is muddy or hard.

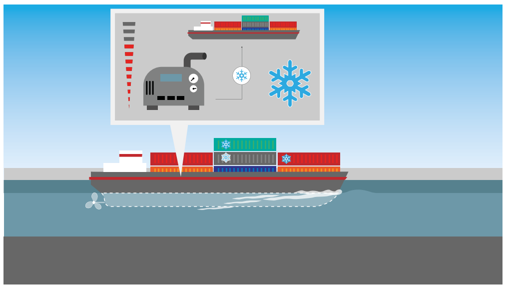


How fast the rivers are flowing.

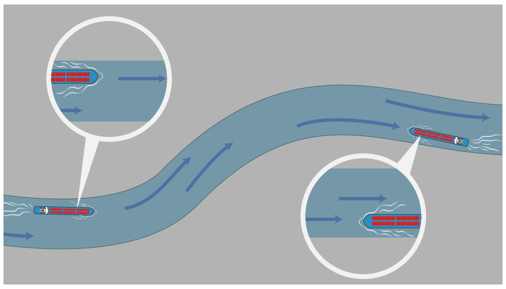
1 *hydrodynamic resistance*



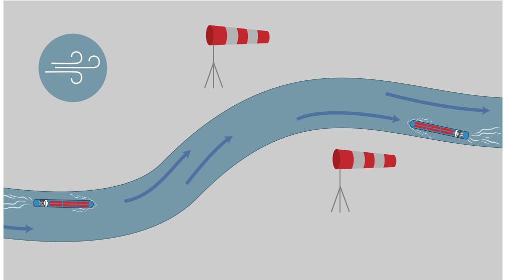
Whether the bow thrusters have to be used a lot, e.g. at locks.



Whether the generator has to deliver a lot of power, e.g. to power refrigerated containers during the trip.



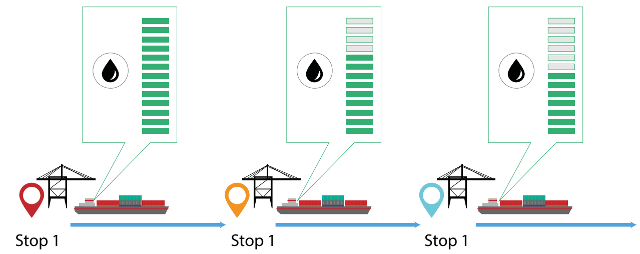
Whether the vessel is sailing against or with the current.



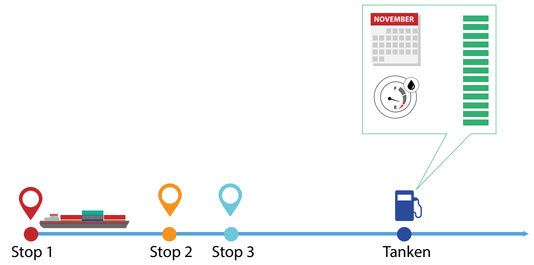
Whether there is a strong tailwind or headwind.

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

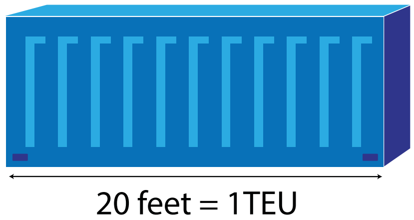


Some vessels can measure their consumption precisely between two stops at terminals. For allocation purposes the intention is to determine the consumption for a round trip: the sum of the fuel consumption measured at each stop. This allows emissions to be allocated to individual orders as precisely as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

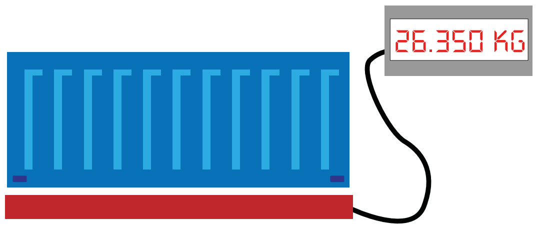


Other vessels determine how much fuel has been consumed over a certain period during bunkering/refueling. This results in emissions being allocated to orders more on the basis of averages. While the total is still correct, the differences are less visible in this case.

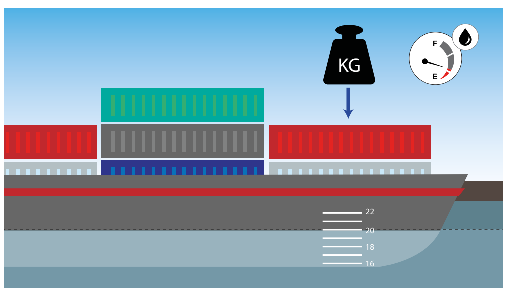
Allocation



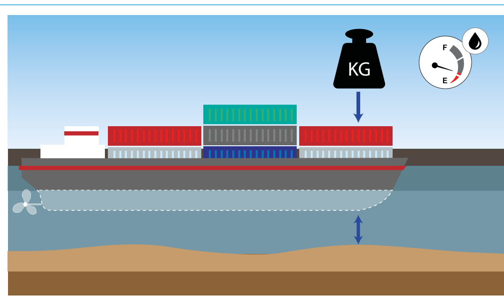
Containers have fairly standard dimensions, so at first glance allocation on the basis of TEUs would be the obvious approach.



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.



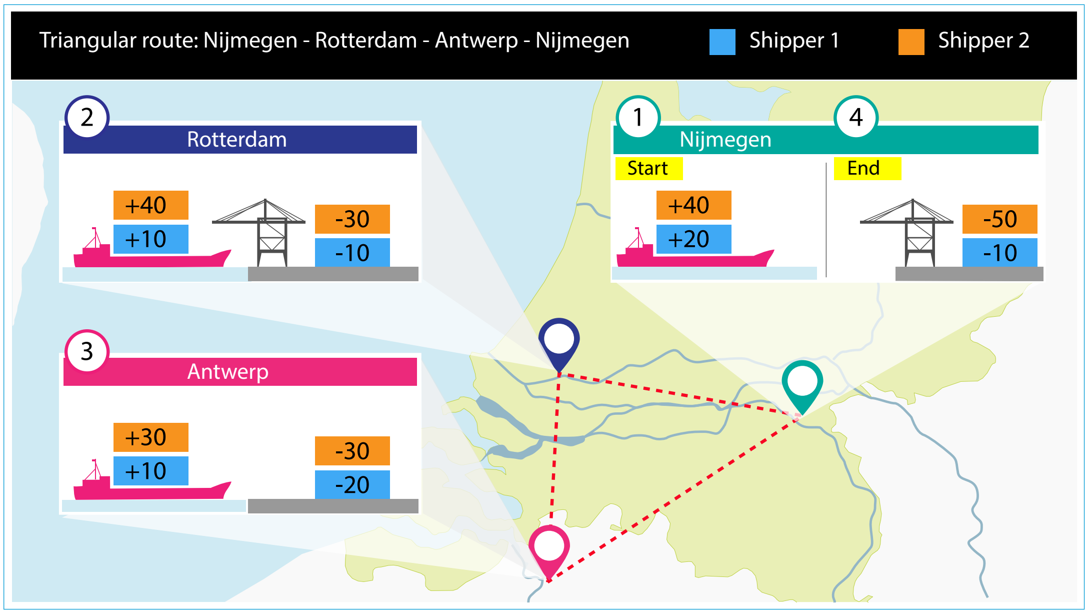
The effect of 'more draft means less water between the keel and the bed means more consumption' is also factored in.

Example calculation

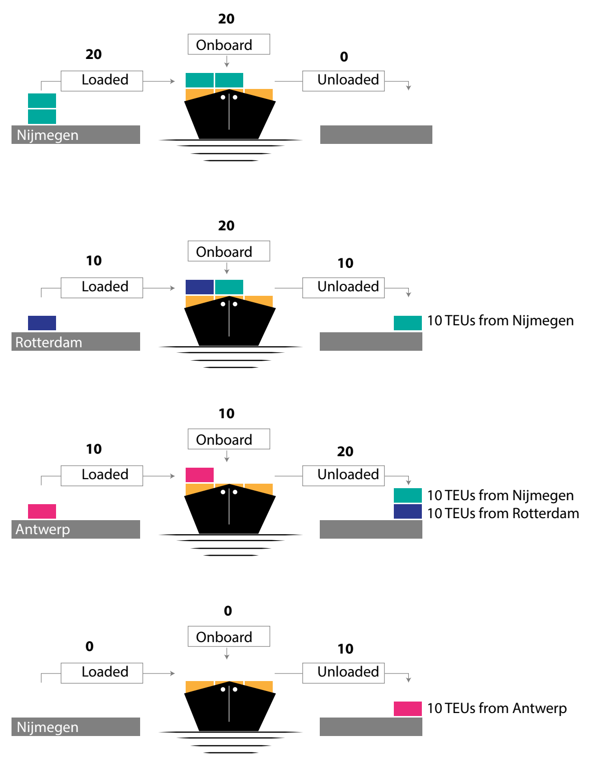
In this example a triangular route is navigated, starting in Nijmegen, traveling to Rotterdam and Antwerp, and then sailing back to Nijmegen. The vessel carries containers for two customers (shippers) and unloading and loading are required at each port. What happens is presented schematically below.

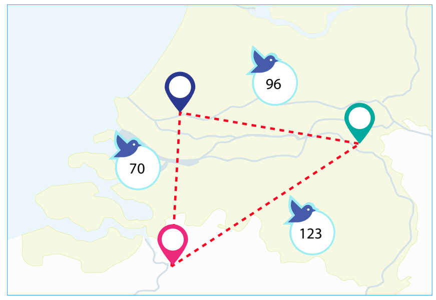
In this example, for clarity, we first break down the order by shipper (when software works this out all calculations are performed simultaneously). The principle of allocating the CO_{2e} on the basis of the weight per container is the same and can be easily performed using software.

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.



Shipper 1





	TEU	km_{gcd}	$TEU.km_{gcd}$
Nijmegen - Rotterdam	10	96	960
Nijmegen - Antwerp	10	123	1,230
Rotterdam - Antwerp	10	70	700
Antwerp - Nijmegen	10	123	1,230
Rotterdam - Nijmegen	0	96	0
			4,120

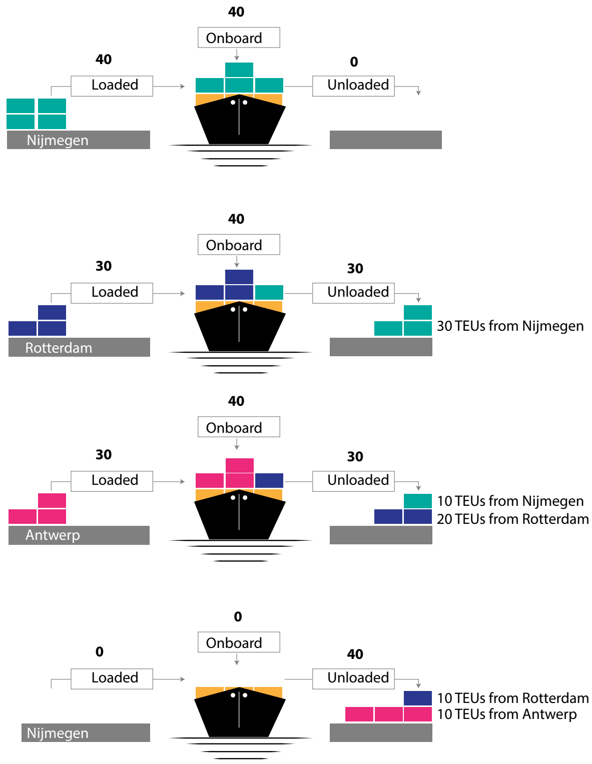
In Nijmegen 20 TEUs of containers are loaded for shipper 1: 10 with the destination Rotterdam and 10 with the destination Antwerp.

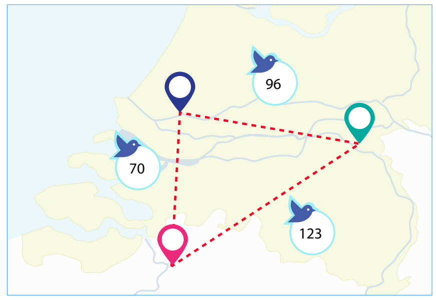
In Rotterdam 10 TEUs of containers are unloaded and 10 additional TEUs are loaded with the destination Antwerp.

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 $TEU.km_{gcd}$

Shipper 2





	TEU	km_{gcd}	$TEU.km_{gcd}$
Nijmegen - Rotterdam	30	96	2,880
Nijmegen - Antwerp	10	123	1,230
Rotterdam - Antwerp	20	70	1,400
Antwerp - Nijmegen	30	123	3,690
Rotterdam - Nijmegen	10	96	960
			10,160

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$_{gcd}$

	TEU	km_{gcd}	$TEU.km_{gcd}$	%	TEU	km_{gcd}	$TEU.km_{gcd}$	%
Nijmegen - Rotterdam	10	96	960	6.7 %	30	96	2,880	20.1 %
Nijmegen - Antwerp	10	123	1,230	8.6 %	10	123	1,230	8.6 %
Rotterdam - Antwerp	10	70	700	4.9 %	20	70	1,400	9.8 %
Antwerp - Nijmegen	10	123	1,230	8.6 %	30	123	3,690	25.8 %
Rotterdam - Nijmegen	0	96	0	0	10	96	960	6.7
			4,120	**28.9 %**			**10,160**	**71.1 %**

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

In this way the total emissions of the inland vessel are allocated to containers.
Example: 4,000 liters of diesel are consumed for the trip. At 3.23 kg CO_{2e} (WTW) per liter this amounts to: 12,920 kg CO_{2e} 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 CO_{2e}. Per TEU that amounts to 86.86 kg CO_{2e}.

Using the same calculation method, the 30 TEUs of shipper 2 transported from Antwerp to Nijmegen are allocated 25.8% = 3,339 kg CO_{2e}, 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

0. Measuring, calculating, allocating and reducing
1. Allocating
2. Cargo
3. Origin and destination
4. Fuel
5. Inland shipping - containers
6. Inland shipping - bulk
7. Freight transport by rail
8. Air freight
9. Maritime and short sea shipping
10. Transshipment
11. Storage
12. Parcel transport and post
13. General road transport
14. Perishable and temperature controlled
15. Outsourced transport
16. Repositioning and empty kilometers
17. (Inter)national supply chains
18. Benchmarking
19. Intermediaries and platforms
20. Auditors and accountants
21. Data quality
22. The relationship between social goals and corporate goals

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