Impact of Digitalization in Driving Decarbonization in Multimodal Logistics

November 07th, 2024

Executive summary

Direct emission savings with digitalization

Direct emissions are GHG emissions linked to production, distribution, use, storage and end-of-life of the shipping documentation. Digitalizing these paper documents eliminates the need for physical handovers, most part carried out by couriers using polluting means of transport.

- 99.8%
CO2eq from paper-based to digital-based[1]

61,563 tCO_2eq
for the multimodal HB/L scope[2]

615,626 tCO_2eq
for the total HB/L scope[3]

[1] Calculations based on comparison of paper-based documentation handovers (MB/L and HB/L) to digital-based documentation handovers (MeB/L and HeB/L) for specific scenarios detailed in appendix.
[2] Savings based on a potential of 2.37 million documents, considering multimodal HB/L from the use case, hypotheses described in appendix with calculation details.
[3] Savings based on a potential of 23.7 million documents, considering all HB/L from the use case scaling, hypotheses described in appendix with calculation details.

Executive summary

Indirect emission savings with digitalization

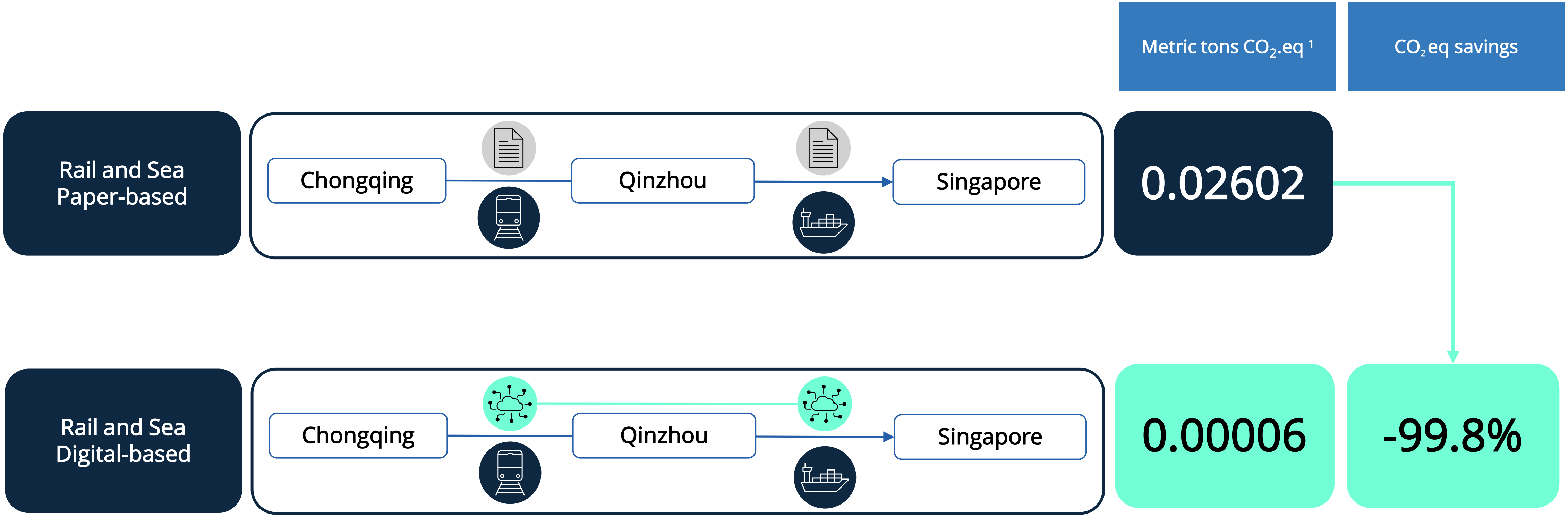
Indirect emission savings result from the modal shift, from road to multimodal transportation, induced by the simplification of documentation handling, thanks to the matching of HeB/L to MeB/L.

- 48.8%
CO_2eq from road to rail transportation [1]

889,655 tCO_2eq[2]

[1] Calculation detailed in appendix, based on two scenarios, from Chongqing to Singapore through Qinzhou port. In one scenario, shipments are transported by road between Chongqing and Qinzhou, in the other one they are transported by rail.
[2] Savings based on a potential of 2.37 million documents, considering multimodal HB/L from the use case, hypotheses described in appendix with calculation details.

Direct emissions' results, linked to paper-based vs digital-based documents



[1] CO_2 eq emissions linked to documentation only

Indirect emissions' results, linked to road vs rail transportation

	GHG emissions linked to transportation in kg CO_2 eq	Metric tons CO_2 eq [1]	CO_2 eq savings
Road and Sea	Chongqing – 2.286 – Qinzhou – 0.787 – Singapore	3.073	
Rail[2] and Sea	Chongqing – 0.785 – Qinzhou – 0.787 – Singapore	1.572	-48.8%

[1] CO_2 eq emissions linked to transportation only
[2] The chosen scenario is based on multimodal transport by train, considering the use case conducted with NLSC

Appendices

- Methodology overview
- Direct savings
    - B/L process & scenario
    - Detailed results
    - Calculation details
- Indirect savings
    - Shipment flow scenario
    - Detailed results
    - Calculation details
- Emission factors
- References

Methodology overview

1. Direct savings: Emissions savings from the use of HeB/L instead of paper-based HB/L

Methodology (similar to previous assignment)

- Definition of the HB/L physical flow
- Identification of significant GHG emission items
- Comparison with the HeB/L emissions (similar calculation as for the MeB/L)

Data

- Shipper's location
- FF's location at origin and destination
- Consignee's location
- Transport means
- Number of HB/L per MB/L

2. Indirect savings: Emissions savings from the modal shift induced by the simplification of documentation handling, thanks to HeB/L

Methodology

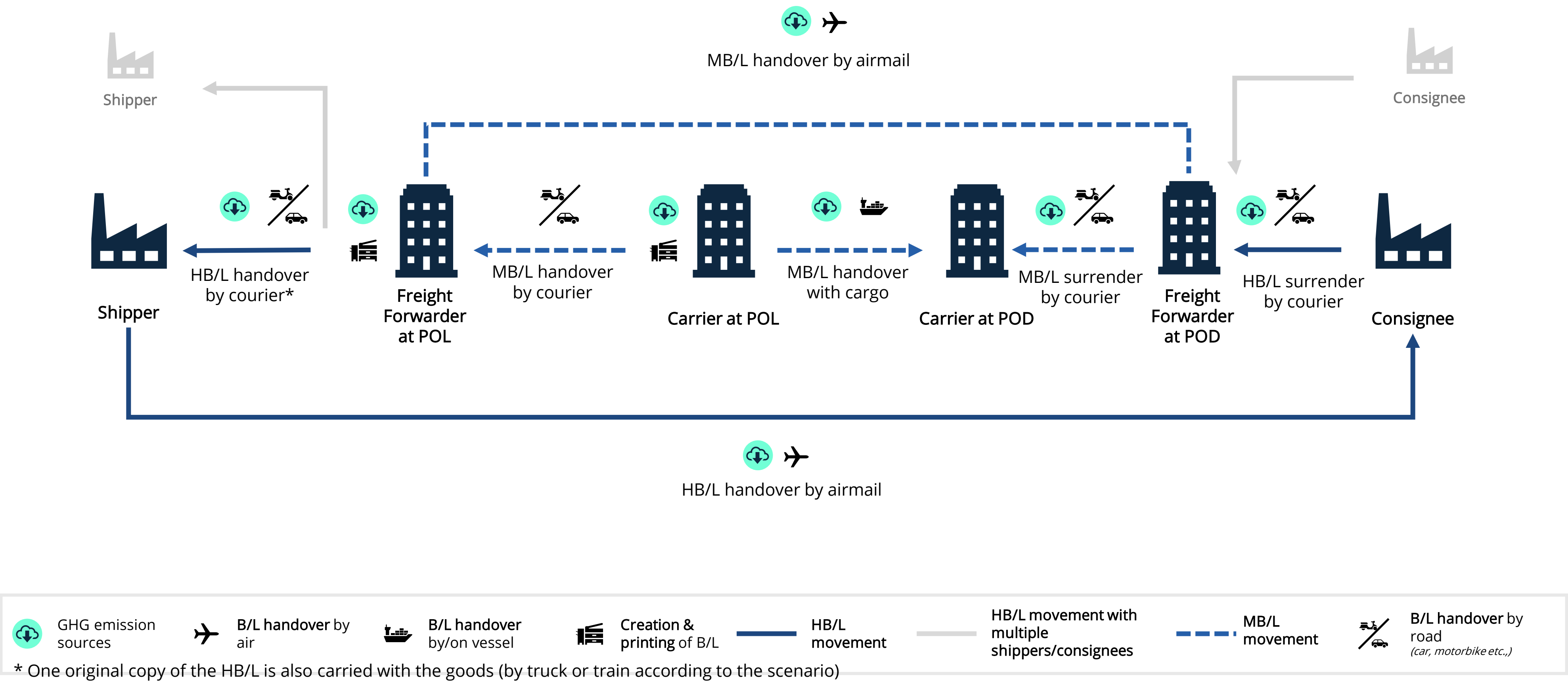
- Definition of the shipment movements
- Calculation of the emissions linked to the truck delivery from the shipper/FF to POL
- Calculation of the emissions linked to the truck delivery from POD to the FF/consignee
- Comparison with the multimodal deliveries' emissions

Data

- Shipper's location
- FF's location at origin and destination
- POL/POD locations
- Transport means
- Definition of the percentage of modal shift induced by HeB/L solution

Paper-based Bill Of Lading process

The following figure describes the traditional paper-based B/L processes (MB/L and HB/L) chosen for the use case.



* One original copy of the HB/L is also carried with the goods (by truck or train according to the scenario)

Paper-based Bill Of Lading process

Paper-based MB/L process

For the MB/L, the process involves the issuance and exchange of three original copies of the MB/L, each following a different path:

- One original copy of the MB/L stays with the carrier and follows the cargo from the POL to the POD.
- Two original copies of the MB/L are collected by the freight forwarder from the carrier's office.
  - One is kept at the freight forwarder's office at the POL.
  - One is handed over by airmail to the freight forwarder's office at the POD. It is then surrendered to the carrier at the POD.

Paper-based HB/L process

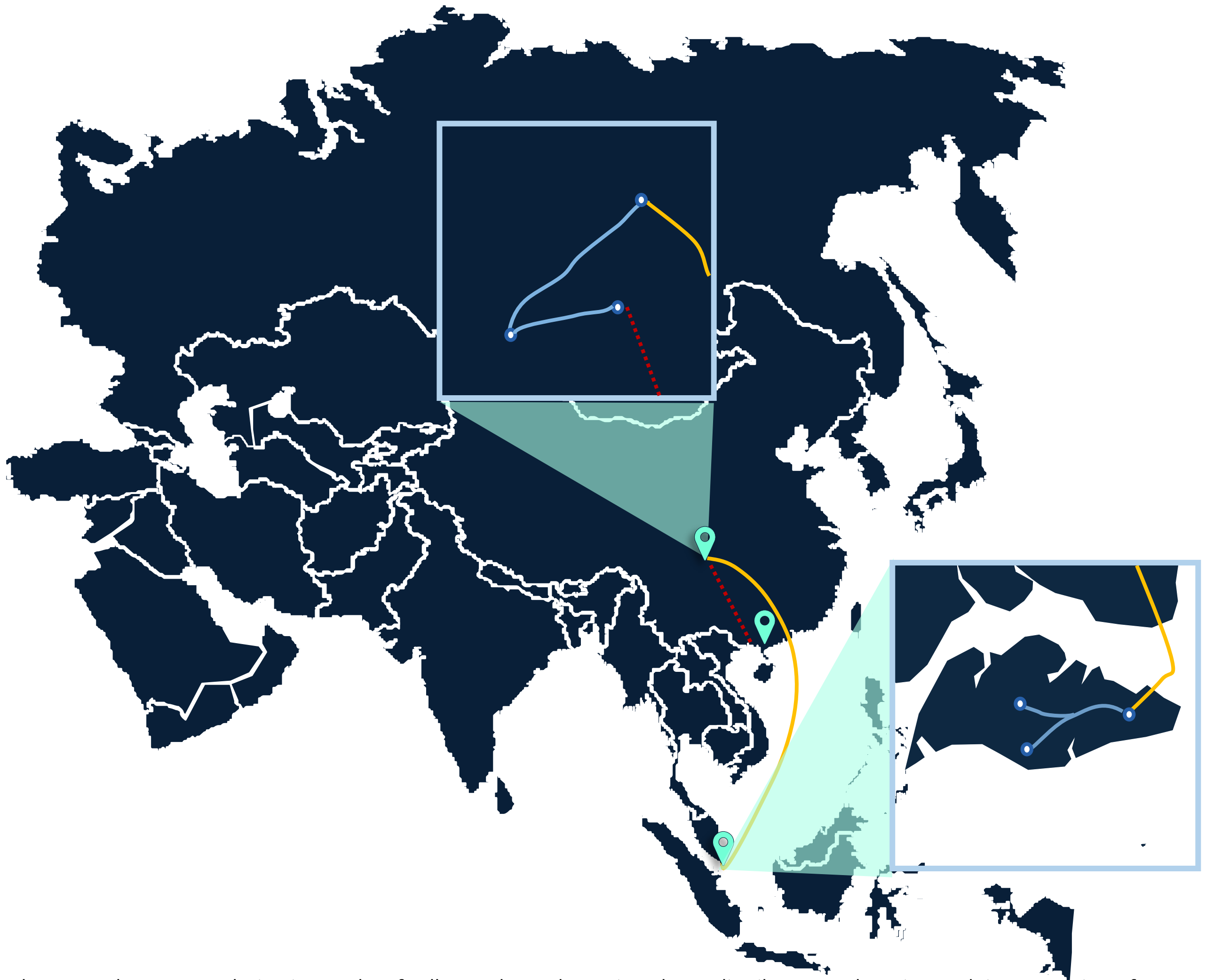
For the HB/L, the process involves the issuance and exchange of three original copies of the HB/L, each following a different path:

- Two original copies of the HB/L are handed over by the freight forwarder with the shipment to the shipper.
  - One is kept at the shipper's office.
  - One is handed over by airmail to the consignee. It is then surrendered to the freight forwarder's office at destination.
- One original copy of the HB/L is carried with the goods (by truck or train according to the scenario).

Usually, multiple HB/Ls can be issued by the freight forwarder matching one MB/L, as freight forwarders consolidate shipments of multiple shippers. Therefore, the HB/L physical flows would be multiplied by the number of shippers. For this study, we will consider a basis scenario of **2 HB/L issued by the freight forwarder for 1 MB/L**[1].

[1] Based on NLSC average

Paper-based HB/L scenario



Comparative Distances & Modes of Transport for HB/L

Document handover by road courier (scooter)

- HB/L handover: freight forwarder ➡ shipper
- HB/L handover consignee ➡ freight forwarder

Total of 88 km by road

Document handover by airmail

- HB/L handover from shipper in Chongqing ➡ consignee in Singapore

Total of 3,167 km by air

Document handover with the goods

- HB/L handover from shipper ➡ POL

Total of 1,767 km by road or 1,200 km by rail

Paper-based MB/L scenario

Comparative Distances & Modes of Transport MB/L

Document handover by road courier (scooter)

- MB/L handover: carrier POL ➡ freight forwarder
- MB/L surrender: freight forwarder at destination ➡ carrier POD

Total of 202 km by road

Document handover by airmail

- MB/L handover from freight forwarder at origin ➡ freight forwarder at destination

Total of 3,167 km by air

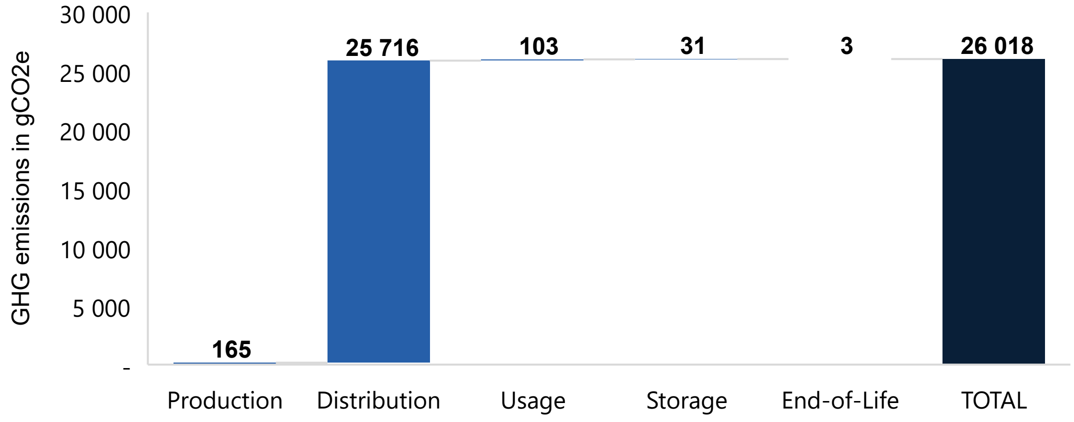
Document handover with cargo

- MB/L handover from carrier POL ➡ carrier POD

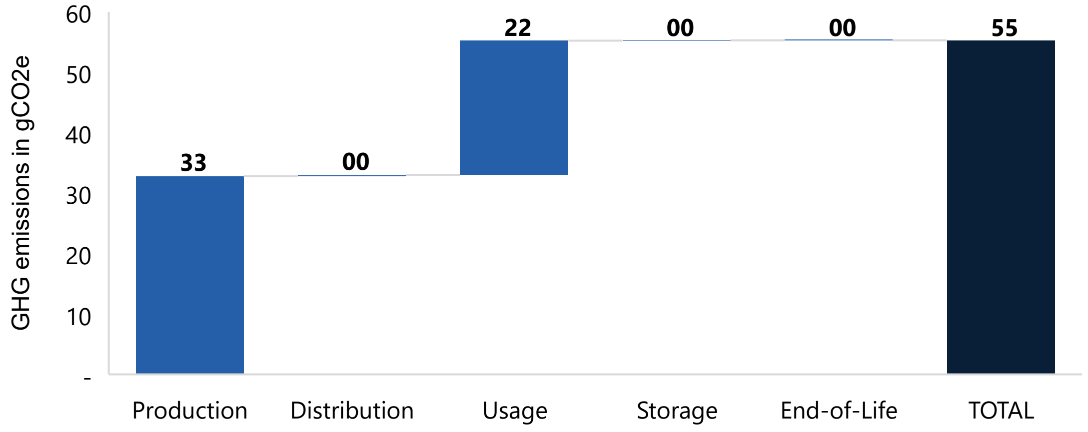
Total of 2,528 km by sea

Detailed results from direct savings

Emissions from paper-based MB/L & HB/L transactions



Emissions from MeB/L & HeB/L transactions



	Paper-based	Digital-based
Document GHG emissions	26,018 gCO_2eq/BL	55.3 gCO_2eq/BL
Difference with the reference scenario		- 99.8%

In 2021, DCSA estimated that 16 million original MB/Ls[1] were issued by ocean carriers, with only about 1.2% digitalized. With the following hypotheses:

- 75% of these MB/Ls were issued to freight forwarders[2]
- 2 HB/Ls issued by freight forwarders on average per MB/L[3]
- 10% of the shipments related to these HB/L were transported by multimodal mode (rail or inland waterway - sea)[4]

The potential direct savings applies to a basis of about 23.7 million documents, or 2.37 million if only multimodal is considered.

615,626 tCO2eq savings considering all HB/L

61,563 tCO2eq savings for multimodal HB/L

[1] DCSA. (2022). Streamlining international trade by digitalising end-to-end documentation
[2] Sia Partners' hypothesis based on market data
[3] Considering the use case conducted with NLSC
[4] Average for top 10 shipping ports based on official ports websites

Calculations details for direct savings

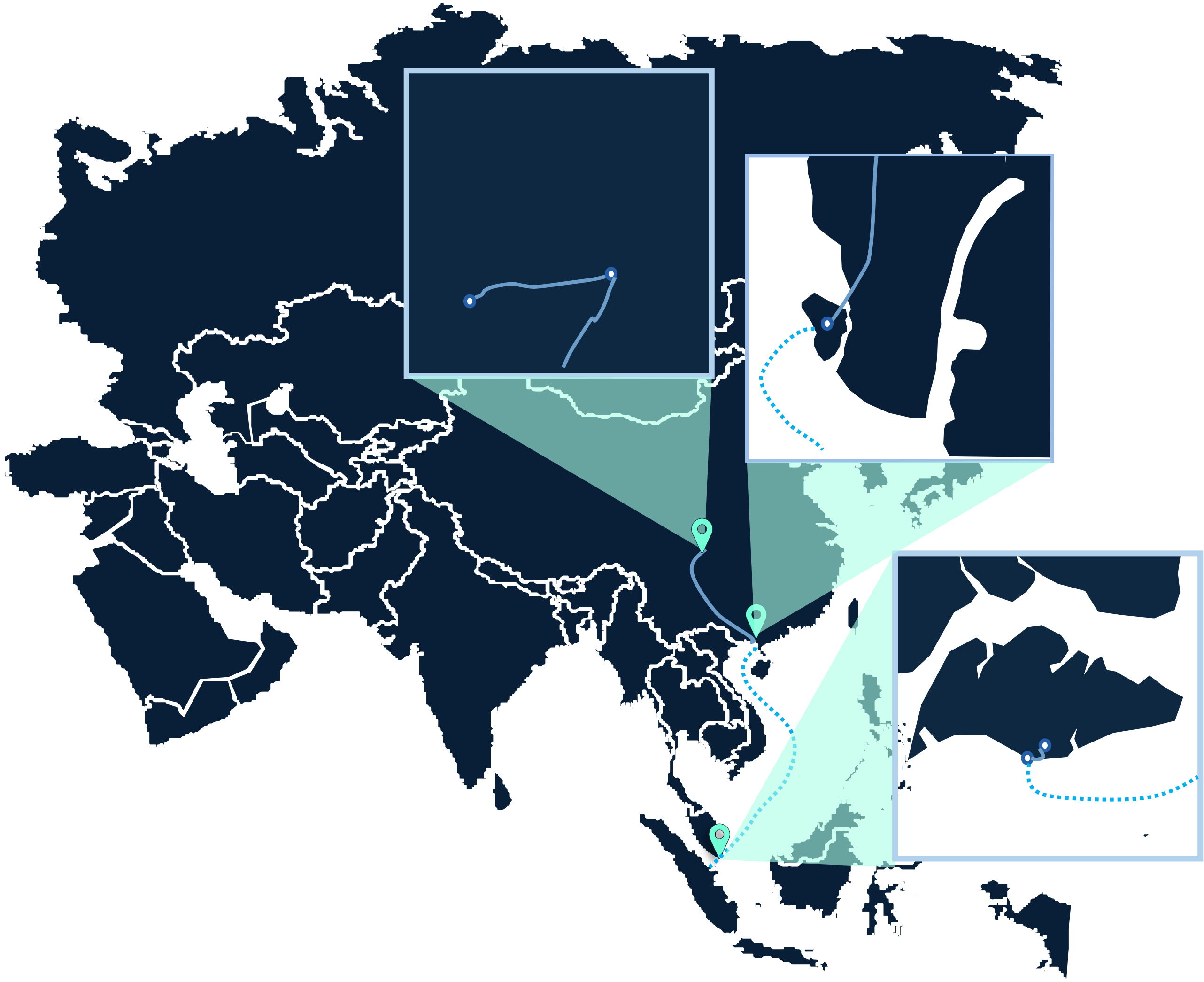
Formulas to measure GHG emissions related to paper-based MB/L & HB/L

Product life cycle	Calculation Formula
Material Acquisition & Production	• [(laptop emission factor ÷ # of working hours per year) × time to create a B/L] • [(paper emission factor + printing emission factor) × # of pages per B/L × # of B/L]
Distribution	• [distance between stakeholders × road vehicle emission factor × weight of transported B/L] * • [distance between airports × cargo plane emission factor × weight of transported B/L] • [distance between ports × sea freight emission factor × weight of transported B/L] for MB/L only • ***The counted distance will be for stakeholders from a same country (e.g., distance from shipper to airport)*** • ***Road vehicles used may differ depending on the distance or country, and may range from passenger car, bike to scooter***
Use	• [(scan emission factor × carbon intensity of electricity generation in issuing country × # of pages per B/L) × # of stakeholders] • [(emission factor of writing, sending and reading 1 email with 1 attachment) • × # of stakeholders]
Storage	• [(1GB data storage emission factor × data size of scanned image × # of pages per B/L)] • [Total emissions for a given storage room × # of B/L stored in that room]
End-of-life	• Emissions from recycling the paper documents included in paper factor emission • [incineration emission factor × # of B/L × # of pages per B/L × weight of transported B/L] • No direct emissions from deleting data stored in the cloud

Formulas to measure GHG emissions related to paper-based MeB/L & HeB/L

Product life cycle	Calculation Formula
Material Acquisition & Production	• [(laptop emission factor ÷ # of working hours per year) × time to create a B/L] • [(server emission factor ÷ # of hours per year) × time to create a B/L]
Distribution	• [(blockchain server power usage ÷ # of B/L generated) × energy mix emission factor] • [network usage per B/L × # of nodes in the blockchain × emission factor of network usage] • ***Distances between participants are not considered***
Use	• [(laptop emission factor ÷ # of working hours per year) × time to endorse a B/L × # of endorsement] • [(emission factor of writing, sending and reading 1 email with 1 attachment) × # of stakeholders]
Storage	• [(data storage emission factor per GB × data size of eB/L) × # of transactions]
End-of-life	• Emissions from deleting data stored in the cloud

Shipment flow – Road / Sea



Comparative Distances & Modes of Transport for shipment

Shipment transported by road (freight forwarder)

Shipper → 15 km → Freight Forwarder's wharehouse

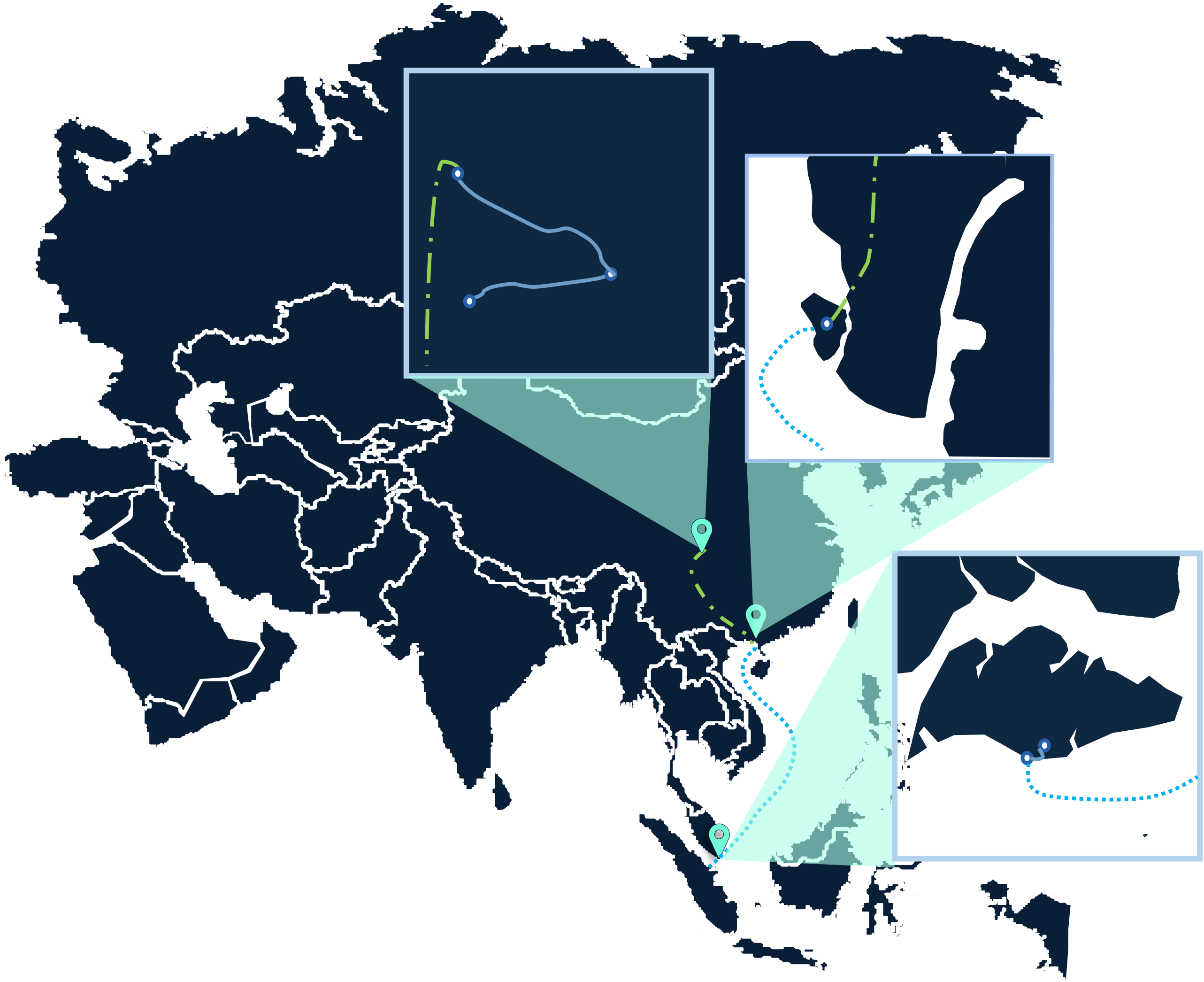
Freight Forwarder's wharehouse → 1,056 km → Qinzhou

Singapore Port → 12 km → Consignee

Shipment transported by sea (carrier)

Qinzhou → 2,528 km → Singapore

Shipment flow – Rail / Sea



Comparative Distances & Modes of Transport for shipment

Shipment transported by railway (freight forwarder)

Chongqing → Qinzhou: 1200 km

Shipment transported by road – last mile (freight forwarder)

Shipper → Freight Forwarder's wharehouse: 15 km

Freight Forwarder's wharehouse → Chonqging Train Station: 25 km

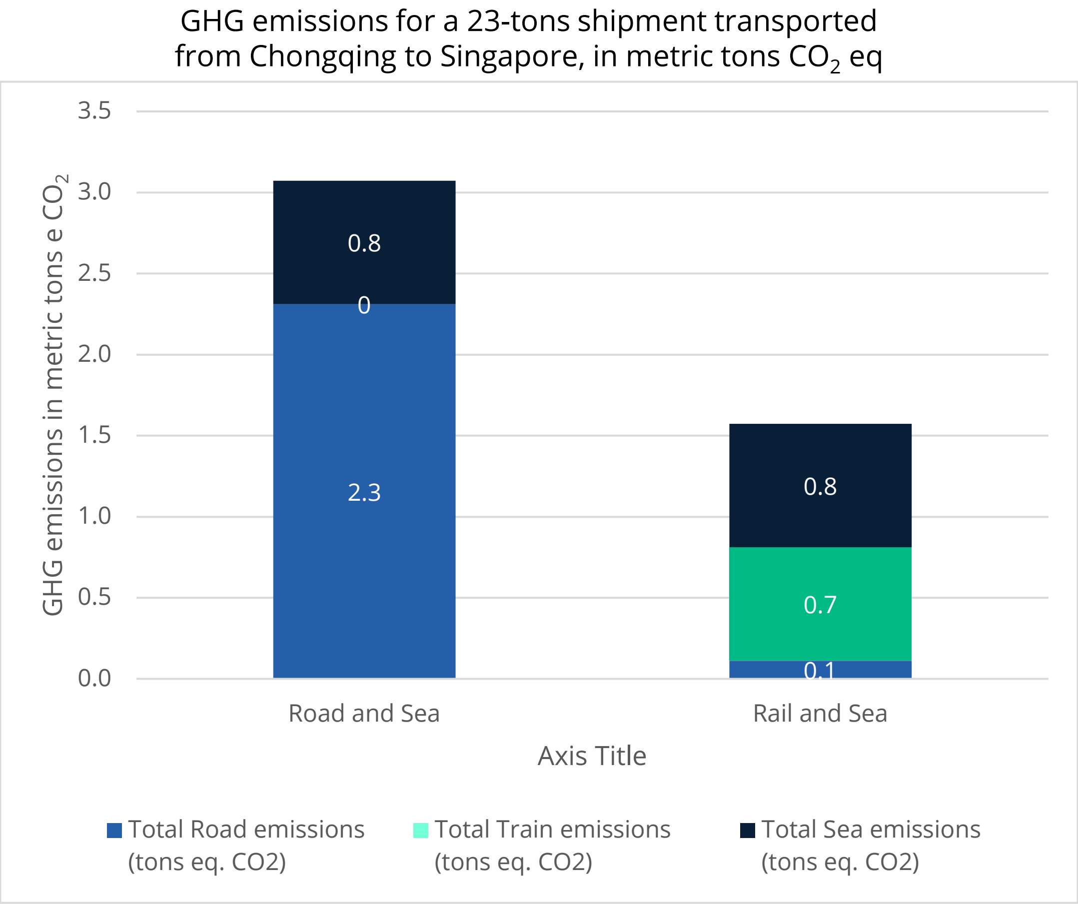
Singapore Port → Consignee: 12 km

Shipment transported by sea (carrier)

Qinzhou → Singapore: 2,528 km

Detailed results for indirect savings

Emissions from shipment transportation, comparing road and rail



	Road and Sea	Rail and Sea
23-tons shipment transported		
Transportation emissions	3.073 metric tons of CO_2 eq.	1.572 metric tons of CO_2 eq.
Difference with the road and sea solution		- 48.8%

Calculation details for indirect savings

Hypotheses

- In 2021, **16,000,000 MB/Ls** were issued worldwide, as per DSCA's report[1].
- It is assumed that **75%** of MB/Ls involve a freight forwarder[2].
- With, on average, **2 HB/L** per MB/L and **23 tons** of goods per HB/L[3].
- In 2023, an average of **10%** of TEU arrived or departed from major ports in train or by inland waterway transportation[4]. This number is taken as modal share for multimodal-sea transportation, and 90% is taken as modal share for road-sea transportation. In this calculation, multimodal transportation takes into account all means of inbound/outbound traffic from ports that are not road (meaning train and waterway).
- The share of multimodal-sea transportation is set to increase by **25%**, rising from 10% to 12.5% share for inbound transport to ports[2].
- The scenarios studied for the indirect calculations are taken as basis for the scaling up calculations. In particular, multimodal-sea emissions are calculated from the train-sea scenario. As fluvial emission factor is lower than the train's, we can expect that the savings calculated hereunder are under evaluated.

As is

90% of the inbound transport of shipping is done by road, representing:

65,584,481 metric tons of CO_2 eq

10% of the inbound transport of shipping is multimodal (rail or inland waterways), representing:

3,728,544 metric tons of CO_2 eq

Total Emissions:
69,313,025 metric tons of CO_2 equivalent

+ 592,800 HB/L issued for multimodal-sea transportation

889,655 metric tons of potential indirect CO_2e savings with digitalization

To be

87.5% of the inbound transport of shipping is done by road, representing:

63,762,690 metric tons of CO_2 eq

12.5% of the inbound transport of shipping is multimodal (rail or inland waterways), representing:

4,660,680 metric tons of CO_2 eq

Total Emissions:
68,423,369 metric tons of CO_2 equivalent

[1] DCSA. (2022). Streamlining international trade by digitalising end-to-end documentation
[2] Based on the average Chinese multimodal growth rate
[3] Considering the use case conducted with NLSC
[4] Average for top 10 shipping ports based on official ports websites

Calculation details for indirect savings

To estimate the emissions due to shipment transportation from Chongqing to Singapore the following actors and locations were used, with the associated distances.

Actor	Location
Shipper	Shapingba District
Freight Forwarder	Expeditors,68 Zourong Road, Central District Chongqing
Train Station Chongqing	Tuanjiecun Railway Station Huochang Yihuo Qu
Train Station Qinzhou	Guangxi Qinzhou Port Est Railway Station
POL Qinzhou Port	Guangxi Qinzhou Port
POD Singapore Port	Pasir Pajang Terminal
Consignee	Singapore City Center

Road and Sea	Distance in km
Road from Shipper to Freight Forwarder's warehouse	15
Road from Freight Forwarder's warehouse to POL	1,056
Carrier from POL (Qinzhou Port) to POD (Singapore)	2,528
Road from POD (Singapore Port) to Consignee	12

Train and Sea	Distance in km
Road from Shipper to Freight Forwarder's warehouse	15
Road from Freight Forwarder's warehouse to Chongqing train station	25
Train from Chongqing to POL as per New Land-Sea Corridor route	1,200
Carrier from POL (Qinzhou Port) to POD (Singapore Port)	2,528
Road from POD (Singapore Port) to Consignee	12

Emission factors

Indirect Savings : the calculations were done considering an average of 23 metric tons* of shipment per client for the freight forwarder.
The emission factors are from ADEME. Similar results were obtained using the webtool Ecotransit.
The formula used for calculation is : 23,000 kg x Distance (km) x Emission factor (kg eq. CO2/t.km)

Emission factor	Unit	Source	Details
Truck	0,0928 kg eq. CO_2/t.km	ADEME	Emission factor for a 34-40t (25t), considering a load factor of 60%
Train	0,0253 kg eq. CO_2/t.km	ECOTRANSIT	Emission calculations for rail are carried out with *Ecotransit*, which adapts its calculations to the train line in question, in particular for electric vs. diesel sections.
Carrier	0,0131 kg eq. CO_2/t.km	ADEME	Container carrier/Dry/other detailed connections
Paper	0.919 kg eq. CO_2/kg	ADEME	Paper/Medium/Out-of-use and end-of-life → Considering 1 sheet = 5g CO2 equivalent per kg × weight of one sheet in kg
Laptop	45.3 $kgCO_2$/year	ADEME	Average impact of a laptop, including manufacture, transport, and end-of-life for professional use, based on one year's use. Laptop; use mix, professional use; average configuration: 15.4 inch-es screen, 1 CPU, 15 GB RAM, 660 GB SSD, 4 years lifespan; RAS
Print	0.003 $kgCO_2$/year	Assumption	Based on 1500W BP-50C26 printer assumptions: 15 seconds to print 1 sheet, Carbon intensity of electricity generation in China: 531.15 gCO2/kWh
Road - Scooter	0.0736 $kgCO_2$/ passenger.km	ADEME	Motorcycle =< 250cm3. Urban use for passenger transport. Assumed to be similar for transporting paper documents.

*Source: NLSC

Emission factors

Emission factor	Unit	Source	Details
Road - Passenger Car	0.0736 $kgCO_2$/ passenger.km	ADEME	Passenger car/Core range - Com-pact vehicle/Hybrid, full, Prius
Air - Cargo Plane	1.2 $kgCO_2$/t*km	ADEME	Medium-haul air transport (includ-ing fleet, utilization and infrastruc-ture) [tkm], GLO
Sea - Cargo	0.00875 $kgCO_2$/t*km	ADEME	Bulk shipping 100-200,000 t (in-cluding fleet, utilization and infra-structure) [tkm], GLO
Scan	0.000066 $kgCO_2$/BL	Assumption	based on 45W EPSON GT-S85 scanner assumption: 5 seconds per scan (1 page), Carbon intensity of electricity generation in China: 531.15 gCO2/kWh
Email with attachment	0.0171 $kgCO_2$/mail	ADEME	Write, send and read 1 e-mail of 1MB (attachment) to 5 recipients via a fixed connection, storage for 10 years and 3 redundancies for sender and recipient. Configuration : Write, send and read an email; 1MB size, to five recipient, with a fixed-line connection, 50% desktop computer, 50% laptop computer, 10year storage with 3 redundancies on the send-er and receiver sides; FR. Impacts take into account end-user devices, networks and data centers. They are an average configuration. Usage profile in active mode: desktop 3.45 hours/day, laptop 3.45 hours/day. Power in active mode: desktop 79.41 W, laptop 23.11 W, monitor 55.59 W Data center block + transmitter storage: server power per user 0.22 W/user, PUE = 1.16 Service life: fixed computer 6 years, laptop 5 years, Firewall 5 years, Switch 5 years, Router 5 years, Server 5 years, Storage 5 years, Support equipment and architecture 25 years Number of e-mails sent and re-ceived per day: 117.7 e-mails Time to receive and read: 0.1667 min Datacenter based on market average Number of users per server: 1668 users considering 367W per server Average storage fill rate: 50%. Network impact: see NegaByte data

Emission factors

Emission factor	Unit	Source	Details
Cloud Storage	0.0253 $kgCO_2/GB$	ADEME	Store 1GB of data in the cloud via a fixed connection for 10 years. Storage in the cloud; 1GB of da-ta, for 10 years, via a fixed connection, end-user equipment not included; EN. Impacts take into account end-user networks and data centers. They are an average configuration. Block data center + transmitter storage: Netflix technical performance; PUE = 1.3 Lifespan: Firewall 5 years, Switch 5 years, Router 5 years, Server 5 years, Storage 5 years, Support equipment and architecture 25 years Network impact: see NegaByte data
Physical Storage	2700 $kgCO_2/year$	Assumption	For a 60sqm storage room Assumptions: based on French DPE - D class building with emissions of 45 kgCO2e/sqm/year. 70% of the room can be used (= 42sqm), 1 sheet of paper is 0.063 sqm (hence 667 sheets or 333 B/L)
Incineration	0.0528 $kgCO_2/kg$	ADEME	Waste incineration - Paper waste, RER
Network	0.00443 $kgCO_2/GB/year$	ADEME	Impact transferring 1GoB of data with a Fixed-line network. Data come from the installation of hardware and the energy consumption in a 2020 ADEME study.
Server	732 $kgCO_2/year$	ADEME	Configuration: Server; use mix; mix of rack and blade, 1U, average configuration: 2,5 CPU, 36 cores, 22,5 RAM 43,3 GB each, 7,2 HDD 6,7 TB each, 11,8 SSD 0,71 TB each, 5 years lifespan; cradle to tomb. The configuration is based on an average of more than 40 server configurations (industry sources). Average weight: 24.1 kg

References

This study relies on hypotheses and sources from the previous study:

GSBN. (2024). Impact of Digitalization in Driving Decarbonization in the Shipping Industry, from https://www.gsbn.trade/_files/ugd/ac729f_421e587f04354a2b9ad5d00f1bcc5053.pdf

Complementary references:

- DCSA. (2022). Streamlining international trade by digitalising end-to-end documentation
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- Port Office of Ningbo. (2024). Ningbo container sea-rail intermodal transport is eye-catching http://kab.ningbo.gov.cn/art/2024/1/4/art_1229104354_58895376.html
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- Gxzf.gov.cn. (2024). Container traffic of the new western land-sea corridor trains will increase by 13.8% in 2023 http://zmqzcyyq.gxzf.gov.cn/xwzx/mtbd/t17790915.shtml

Comparative calculations done with Ecotransit tool:

https://www.ecotransit.org/fr/