

READER – GREEN TRANSPORT

Collection of the passages from the viadonau "Manual on Danube Navigation" (2019) as well as from other relevant sources relevant for the set of slides "Green Transport".



1. Transport and environment

Logistics plays an essential role in the economy as it ensures that goods are transported from the raw material supplier via the producer to the end consumer. Although logistics encompasses many processes and activities, transport and thus freight traffic can be identified as the most environmentally damaging area. Above all, congestion and greenhouse gas emissions caused by freight transport can be identified as the most serious environmental problems in the logistics sector in the EU.¹

As shown in the figure below, the transport sector in the EU was responsible for 25% of greenhouse gases in 2018.²

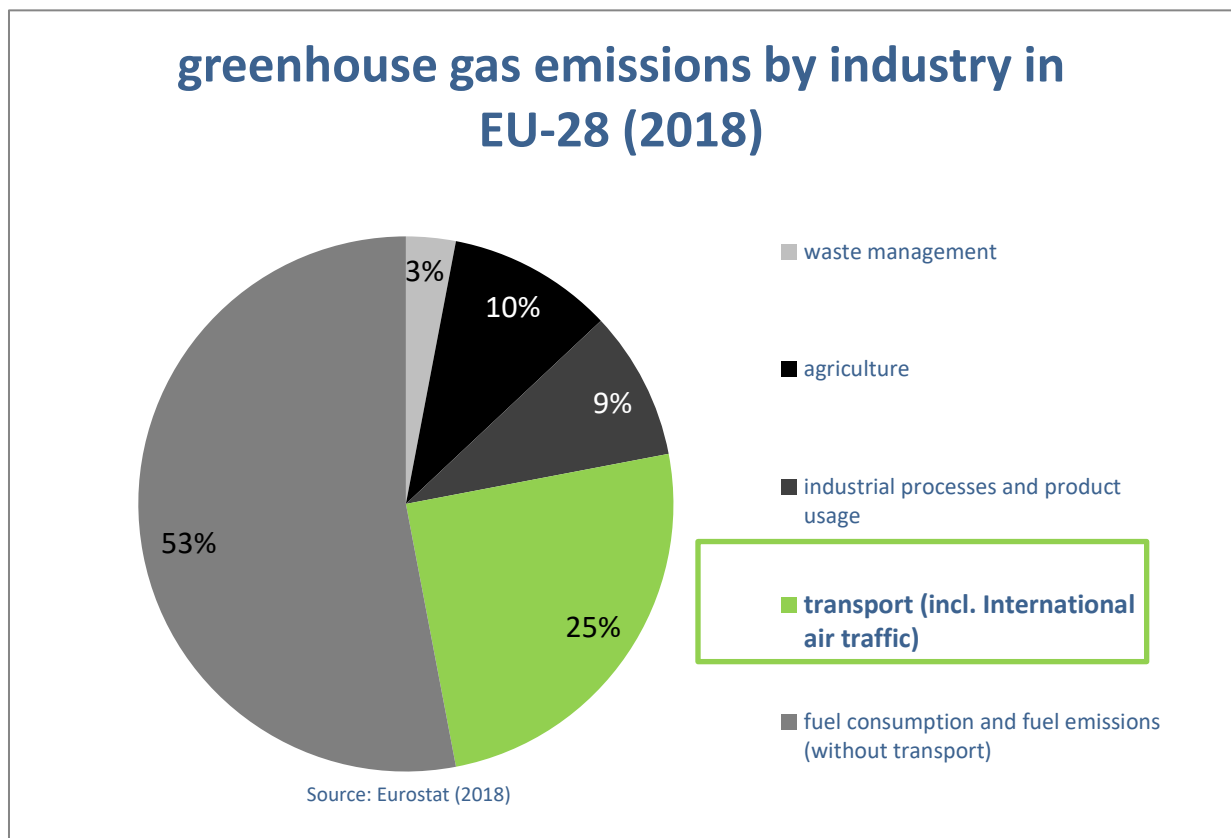


Figure 1 – greenhouse gas emissions by industry in EU-28 (2018)
(Source: own illustration based on Eurostat, 2018)

¹ Cf. Whiteing, 2010, p 7

² Cf. Eurostat, 2018

For society, the negative effects of freight transport are particularly present: private individuals in particular associate negative characteristics with trucks, whereas entrepreneurs associate predominantly positive characteristics with trucks. For example, environmental pollution, particulate matter, noise and traffic pollution or obstruction are associated primarily with the truck.

A comparison of transport modes also shows that trucks are responsible for a large proportion of greenhouse gases (see Figure 2).³

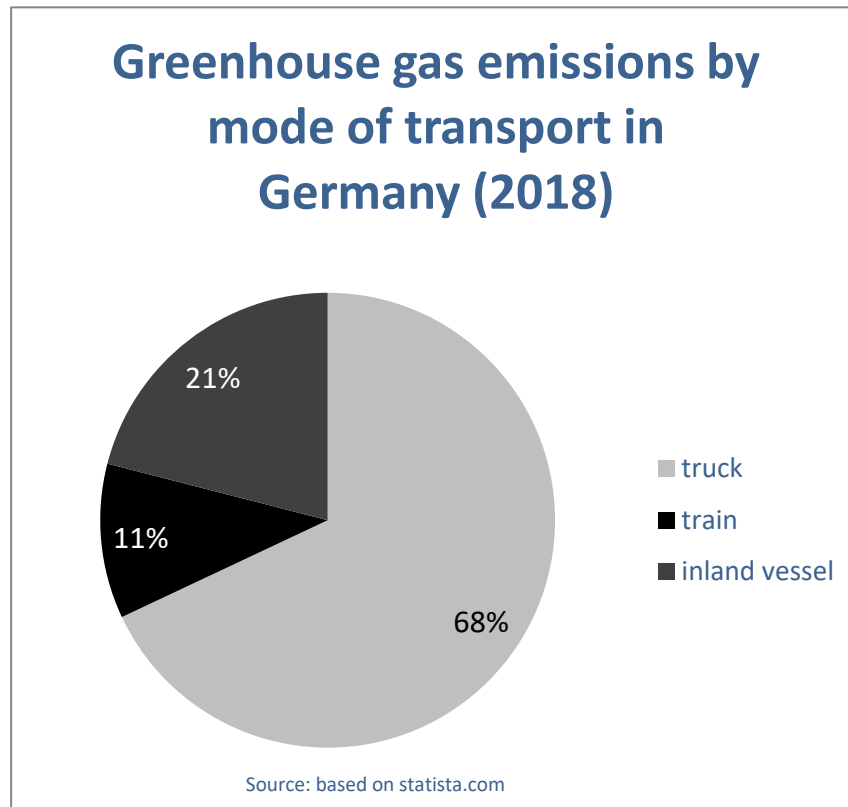


Figure 2 – Greenhouse gas emissions by mode of transport in Germany (2018)
(Source: own illustration based on statista.com)

International freight traffic in particular will increase, and with it the transport distances. As a result, the transport infrastructure will increasingly reach its limits, resulting in traffic jams.⁴

1.1. Sustainable development in freight transport

As already mentioned, freight transport is increasingly reaching its limits. It is therefore important that freight traffic develops sustainably in the future. Various drivers have already been identified that are accelerating such a development. These are also recognized by the European Commission and appropriate measures have been defined to counteract them.

³ Cf. statista.com, online: <https://de.statista.com/statistik/daten/studie/881600/umfrage/co2-emissionen-im-deutschen-gueterverkehr-nach-verkehrsmitteln/> [17.08.2020].

Drivers for a sustainable development

According to Bretzke & Barkawi, four drivers can be identified that contribute to sustainable development:⁵

- Rise in energy costs: Due to the dependence on oil in the transport sector and the increasing transport volume described above, the transport sector is facing an increase in energy costs. This in turn has a negative impact on transport costs.
- Bottleneck in the transport infrastructure: The rising volume of transport leads to increasing traffic congestion, which manifests itself in rising levels of congestion. Figure 3 shows the European cities with the highest congestion volumes in 2019.

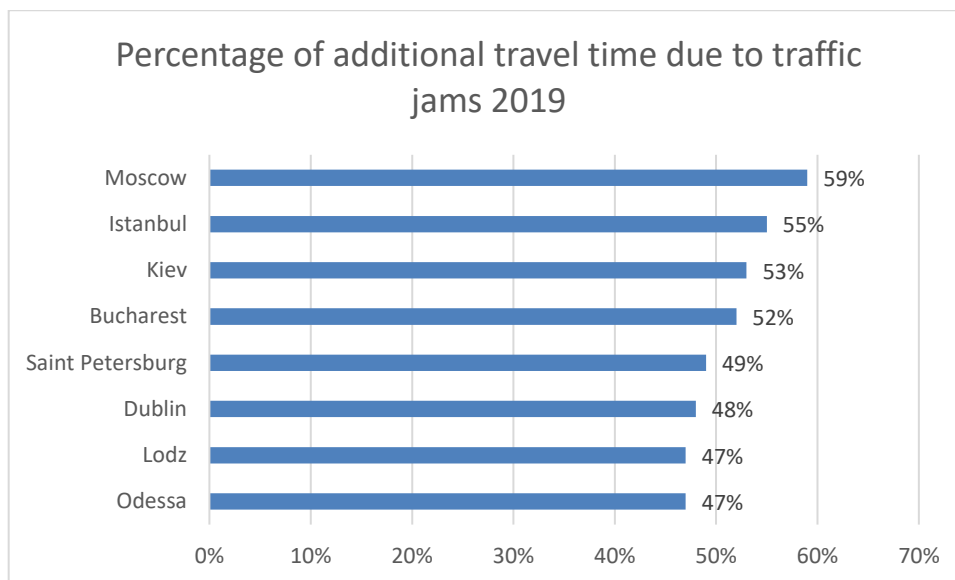


Figure 3 - Percentage of additional travel time due to traffic jams 2019 (Source: own illustration based on <https://www.statista.com/chart/20668/percentage-of-extra-travel-time-due-to-congestion-in-europe/> [07.09.2020])

- Political pressure: There is increasing pressure from policymakers for sustainable modes of transportation. This is expressed through taxes, an increasing consideration of the external costs and the setting of emission limits for means of transport. These measures in turn influence transport costs, which should motivate transport service providers to use more sustainable modes of transport.
- Social pressure: In addition, society has an increased interest in environmentally friendly transport solutions without having to restrict its own mobility. In addition, there is increasing demand for sustainable products, especially in the food sector, which suggests that society is

⁵ Cf. Bretzke & Barkawi, 2010, S.33ff und Kudla, 2010, p.232.

becoming more environmentally aware. The transport industry is mainly influenced by social trends, due to its proximity to the economy and private shippers.

Political measures

As already mentioned, policymakers are trying to promote the use of sustainable modes of transport through various measures. The European Commission's 2011 White Paper "Roadmap to a Single European Transport Area - Towards a competitive and resource-efficient transport system" presented the EU's vision for transport in the future. This White Paper contains proposals for action by the EU to make transport more sustainable in the future. Since an increased volume of transport is expected in the future, traffic avoidance is not an option. For this reason, the use of different modes of transport (multimodality) is seen as the most appropriate measure to make efficient use of existing resources and avoid further bottlenecks in the infrastructure. Rail and inland waterways are recognized as sustainable transport modes. Therefore, a modal shift towards these modes of transport should also take place. The goal is to shift 30% of road traffic exceeding 300 km to rail or inland waterways by 2030. By 2050 the value should be 50 %.⁶

Green Logistics

Currently, a large number of companies are mainly designing their production to be sustainable, and are increasingly trying to use sustainable raw materials for their products. Since transport plays an essential role in this context in order to connect the different actors such as raw material supplier and producer, transport services must also be increasingly sustainable in order for a product to be truly sustainable.⁷

An important concept in connection with sustainable transport is "Green Logistics". "Green logistics is a logistics concept that demands that logistics must be environmentally friendly, socially responsible and financially viable. Rituray Saroha (2014)⁸

This means that a balance should be achieved between the following three dimensions of sustainability: economy, ecology and social issues. This leads to areas of tension between these three areas, as not all the goals of each of them can be pursued at the same time. The following goals can be assigned to the respective areas:

⁶ Cf. European Commission, 2011, p 3ff

⁷ URL: <https://www.youtube.com/watch?v=50fhMxRRyec> [07.09.2020].

⁸ Cf. Saroha, 2014

- Social goals: To raise awareness for sustainable transport in order to motivate consumers to use it in addition. Furthermore, a good quality of life should be guaranteed for society in general.

- Ecological goals: From an ecological point of view, the reduction of emissions as well as the general reduction of resource consumption can be named as goals.

- Economic goals: From a financial point of view, no additional costs should be incurred or a cost reduction realized in the use or provision of sustainable transport services, and unproductivity should be minimized.

Of course, different goals can be assigned to the different areas, which makes it even more difficult to achieve a balanced pursuit of goals across all areas. ⁹

1.2. Challenges for a sustainable freight transport

The realization of sustainable freight transport is connected with different challenges. On the one hand, there are different fields of influence and actors in freight transport that influence each other and therefore measures have to be planned accordingly to achieve the desired effect. Nevertheless, there are also various other measures to promote sustainable freight transport in addition to the political measures already mentioned. The fields of influence of freight transport, the challenges and possible measures are discussed below. In addition, best practice examples will be given at the end of the paper which companies already use or offer sustainable transport. ¹⁰

Fields of influence in freight transport

The share of the respective modes of transport in the volume of goods traffic (modal split) depends primarily on the supply of goods traffic and the demand. On the supply side, the following fields of influence can be identified: existing infrastructure, new technologies, free capacities and competition on the market. ¹¹

In addition, society, the economy and politics determine the environment of freight transport. The demand for goods is primarily determined by the procurement and distribution strategy of the companies. The choice of transport mode by companies also has a significant impact on the volume of freight traffic. This can lead to tensions between freight companies and customers, as both parties

⁹ Cf. Pazirandeh, Jafari, 2013; Green Logistics, online unter: <https://www.youtube.com/watch?v=xPohCtbL4SQ> [07.09.2020].

¹⁰ Cf.. Holderied, 2005, p 17ff

¹¹ Cf.. Holderied, 2005, p 17ff

may have different transport requirements. For example, freight companies aim to utilize transport capacities as much as possible, whereas customers want fast delivery times and low transport costs.¹²

In summary, it can be said that quality traffic depends on many different factors, which in turn influence each other. Therefore, different approaches and challenges arise for the sustainable orientation of freight transport.¹³

- For example, the use of new technologies in the transport sector is not yet possible in a commercial sense.
- The choice of transport depends primarily on the value of the goods transported and the transport time. Due to the cost advantage of truck transport, it is still frequently used as a mean of transport.
- The trend away from mass production towards individualization means that shipments are increasing and the volume of transport is growing.
- Rail has the disadvantage that passenger transport is often given preferential treatment and fewer innovations are available in the technical field. This makes this mode of transport less attractive as an alternative to the truck.
- As local waste disposal declines, the need for reverse logistics for recycling processes or waste management results in higher transport volumes.¹⁴

1.3. Promotion of sustainable freight transport

Different possibilities can be identified to promote sustainable freight transport:

Since the choice of transport mode is strongly dependent on transport prices, a new pricing system in the transport sector could help to increase the use of sustainable transport modes. The development and use of alternative fuels could also lead to more sustainable freight transport.

As already mentioned at the beginning of the reader, modal shift is also seen as a suitable measure to promote sustainable freight transport. By shifting from road to rail or waterway, the environmental impact should thus be reduced.

¹² Cf.. Holderied, 2005, p 17ff

¹³ Cf. Institute for Transport Studies, 2010, p 15

¹⁴ Cf. Institute for Transport Studies, 2010, p 15

With regard to means of transport, improvements to existing means of transport in terms of size, weight or capacity and fuel consumption can be useful in order to achieve sustainable freight transport in the long term. Also the development of new means of transport according to the requirements of the transported goods would be a possible solution (e.g. self-propelled means of transport).

The environmental impact can also be reduced by an efficient combination of existing modes of transport. By using information and communication technologies (ICT), transports can be planned more efficiently and better, which could, for example, reduce empty runs or ensure efficient capacity utilization.

Finally, the development of new business models can also lead to freight transport becoming more sustainable. By focusing on local production and local distribution, for example, long transport distances could be reduced.¹⁵

1.4. Best Practice examples

Some logistics service providers already offer the possibility to ship goods in an environmentally friendly way. As part of the DHL GoGreen initiative, DHL offers the option of sending shipments in a climate-neutral manner by paying a surcharge. The proceeds are then invested in climate protection projects to compensate for the CO₂ emissions caused by the transport.¹⁶

The start-up company "ImagineCargo" offers customers (private or corporate) the possibility to send items such as letters or parcels in an environmentally friendly way. The railroad is used and bike couriers are used to transport the shipments from the sender to the recipient.¹⁷

2. Characteristics of sustainable transport modes

Currently, ecological (especially CO₂ emissions) and economic factors (transport costs) are in the focus of the evaluation of the transport modes. From a business point of view, environmental protection is often seen as an opportunity to reduce costs or increase revenue.¹⁸ Environmental protection is still a secondary condition for many companies and is mainly used for marketing purposes.¹⁹ However, for a comprehensive comparison of transport modes from the perspective of

¹⁵ Cf. Institute for Transport Studies, 2010, p. 21ff

¹⁶ URL: <http://www.dhl.de/de/paket/information/privatkunden/gogreen-klimafreundlicher-versand.html> [07.09.2020]

¹⁷ URL: <http://www.imaginecargo.com/> [07.09.2020]

¹⁸ Cf. Pazirandeh & Jafari, 2013, p. 890

¹⁹ Cf. Bretzke & Barkawi, 2010, p. 47

sustainability, other factors from the 3 dimensions of sustainability must be considered in addition to emissions and transport costs. These are discussed in the following chapter.

2.1. Ecological fields of influence

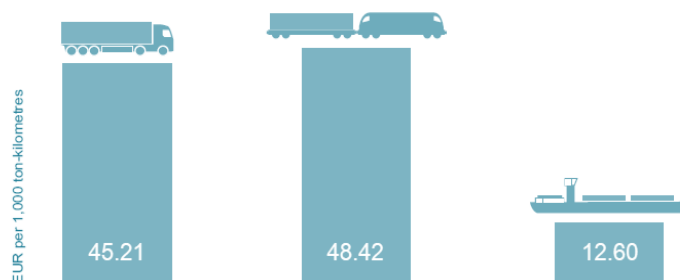
From an ecological point of view, emissions, land consumption and thus infrastructure costs, noise and specific energy consumption can be mentioned as important assessment criteria.

Land consumption/infrastructure costs

Infrastructure costs consist of the costs for the construction and maintenance of traffic routes. In the case of inland waterways, it is usually possible to fall back on natural infrastructure, so the costs for infrastructure and land consumption are correspondingly low. Detailed relevant comparisons to land transport modes are available from Germany: Here, the infrastructure costs per ton-kilometer for rail or road are about four times as high as for waterways.

According to current cost estimates for infrastructure projects in the riparian states, the improvement of the entire infrastructure of the Danube waterway, which is just under 2,415 km long, would amount to a total of EUR 1.2 billion. This corresponds roughly to the costs incurred for the construction of about 50 km of road or rail infrastructure. Current European rail tunnel projects cost around EUR 10 to 20 billion each.²⁰

Land consumption / infrastructure costs



Source: PLANCO Consulting & Bundesanstalt für Gewässerkunde 2007

Figure 4 - Comparison of infrastructure costs using the example of German land transport modes (Source: PLANCO Consulting & Bundesanstalt für Gewässerkunde 2007 in Manual on Danube Navigation, p. 19)

²⁰ Cf. viadonau, 2019, p 20.

2.1.1. Specific energy consumption

Looking at the specific energy consumption, inland navigation can be considered the most effective and therefore most environmentally friendly mode of transport. The inland vessel can transport a ton of cargo almost four times as far as a truck for the same energy consumption.²¹

Specific energy consumption

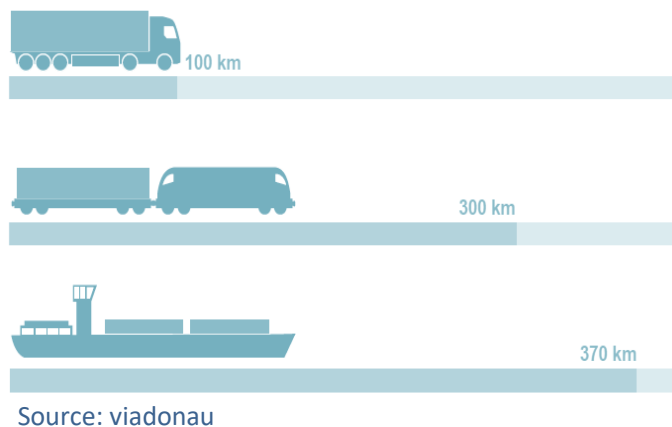


Figure 5 - Transport distances for a ton of goods with the same energy consumption (Source: viadonau in Manual on Danube Navigation, p 18)

2.1.2. Noise

Due to the network density and the proximity to settlements and conurbations, noise pollution is mainly caused by the road. Railroad noise affects the environment especially in certain areas whereas freight traffic on waterways hardly causes any noise at all. Noise also depends on subjective perception - for example, road noise is perceived as more disturbing than railroad noise for the same noise level.²²

As the "Noise Viewer" of the Noise Observation and Information Service for Europe shows, the UK and Germany are affected by road noise at night and during the day. In Austria, noise pollution during the day is mainly due to rail traffic. In Italy and France, a large part of the population is affected by both road and rail noise during the day and at night.²³

²¹ Cf. viadonau, 2019, p 18.

²² Cf. VDC, Online: <https://www.vdc.org/themen/verkehrslaerm/strassenlaerm/> [07.09.2020].

²³ URL: <http://noise.eionet.europa.eu/viewer.html> [07.09.2020]

2.2. Social fields of influence

Social fields of influence can be understood as traffic safety as well as the working conditions associated with the different modes of transport. These are described below.

2.2.1. Traffic safety

Compared to rail and truck, inland waterways can be considered the safest means of transport.²⁴ This is made possible by high security standards. This in turn has an impact on accident costs, which are comparatively low (see also external costs in comparison). In 2018, for example, there were only 12 accidents on the Danube and no personal injury.²⁵

2.2.2. Work conditions

In inland navigation, long stays on the ship are not uncommon, which also means that a large part of the leisure time is spent on the ship.

The railroads often have a 3-shift model which leads to regulated working hours. As passenger traffic is given priority during the day, the majority of freight traffic takes place at night, which in turn leads to night work.

Truck drivers are often faced with long and irregular working hours. In addition, the deadline and time pressure in the competition-driven industry means that driving and rest periods are neglected. For long-distance truck drivers, the long absence from home is an additional factor.²⁶

2.3. Economic fields of influence

From an economic point of view, external costs are increasingly important in a comparison of modes of transport, in addition to transport costs per se. Both types of costs are briefly presented in the following comparison of modes of transport.

2.3.1. Transport costs

Transport costs are one of the most important factors in an economic comparison. They are mainly influenced by the transport volume and thus the capacity utilization of the carriers, the transport distance and the type of goods transported. In principle, transport costs decrease with increasing transport distance for all modes of transport. In terms of transport per ton-kilometer,

²⁵ Cf. Jahresbericht der Donauschifffahrt 2018, Wien, 2019, p. 36

²⁶ Cf. Bundesamt für Güterverkehr (BAG), 2014, p. 9, 33, 47.

inland waterways are the cheapest mode of transport compared to rail and truck.²⁷ However, the actual costs of a transport route may vary depending on the transported goods and the distance.²⁸

2.3.2. External costs

The external costs, i.e. those costs resulting from climate gases, air pollutants, accidents and noise, are also lowest for inland waterway vessels. In particular, CO₂ emissions are comparatively low, which means that inland navigation can make a contribution to achieving the climate goals of the European Union.²⁹

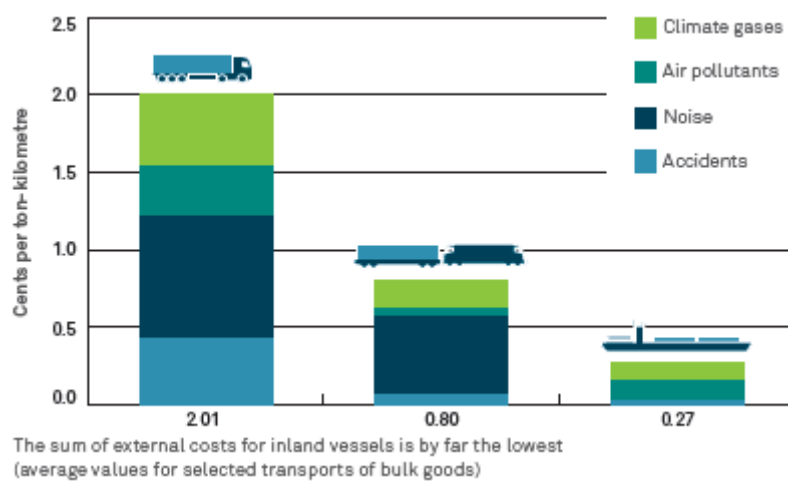


Figure 6 External cost comparison (Source: PLANCO Consulting & Bundesanstalt für Gewässerkunde 2007 in viadonau in Manual on Danube Navigation ,p. 19)

3. Comparison of transport modes

In the following, the strengths and weaknesses of the transport modes road, rail and waterway are shown.

3.1. Road transport

Strengths

The high transport speed in comparison to rail and waterways can be cited as an advantage of road transport. Also the area coverage of the infrastructure and thus the possibility of network formation (door-to-door) are among the strengths of the road. Due to the wide range of different means of transport, this mode of transport offers great flexibility. Also many IT solutions (e.g. tracing

²⁸ Cf. Kille & Schmidt, 2008, p 22

²⁹ Cf. viadonau, 2019, p. 18.

and tracking) are already widely used. In addition, the use of the infrastructure is associated with low costs (costs for road damage are only partially covered).³⁰

Weaknesses

As the costs of congestion or noise pollution (so-called external costs) are gaining more and more attention, roads are facing increasing cost pressure. Time restrictions in the form of driving bans also have an impact on the road transport mode. With regard to environmental aspects such as noise pollution or accidents, road scores relatively poorly in a comparison of transport modes.³¹

3.2. Railway transport

Strengths

Especially for block or direct trains, the rail can score points with a fast transport speed. In addition, the mode of transport is capable of mass transport and the transports are predictable. Due to several standards the security level is very high. Unlike road transport, transport prices are not influenced by toll charges and can therefore be relatively favourable depending on the quantity transported. Also the lower CO₂ consumption compared to road transport can be mentioned as an advantage.³²

Weaknesses

Due to infrastructural differences, cross-border transport by rail is still difficult. The dependence on timetables impairs the flexibility of the transports. In addition, tracking and tracing is very difficult compared to road transport. Furthermore, unlike air transport, rail transport does not have any tax advantages.³³

3.3. Inland waterway transport (IWT)

Strengths

The strengths of inland navigation lie above all in its ability to transport large volumes per ship unit (see Figure 7) in its low transport costs and in its environmental friendliness. In addition, it can be used around the clock (e.g. no weekend or night driving bans) and can boast high safety and low infrastructure costs.³⁴

³⁰ Cf. Kille & Schmidt, 2008, p 53

³¹ Cf. Kille & Schmidt, 2008, p 53; viadonau, 2019, p 17ff.

³² Cf. Kille & Schmidt, 2008, p 54

³³ Cf. Kille & Schmidt, 2008, p 54

³⁴ Cf. viadonau, 2019, p 18

1 pushed convoy with four pushed lighters: 7,000 Nt (net tons)



175 railcars à 40 Nt



280 trucks à 25 Nt



Source: viadonau

Inland vessels beat rail and trucks for transport capacity

Figure 7: bulk freight capacity of inland vessels (Source: viadonau, Manual on Danube Navigation, p 19)

Weaknesses

The dependence on fluctuating fairway conditions and the associated varying degree of utilization of the ships, the low transport speed and the low network density, which often require pre-carriage and onward carriage by road or rail, can be seen as weaknesses.³⁵

3.4. Combination of transport modes

By combining the modes of transport, the specific advantages of the individual modes of transport mentioned above can be exploited and the specific disadvantages minimized. Some strengths and weaknesses of the individual modes of transport are listed in the table below.

Due to the high network density and the speed of short transport distances, road is particularly suitable for the pre- and post-carriage of multimodal transports.

Due to the low environmental impact and the relatively low transport costs of rail and waterways for medium and long transport distances and high volumes, these two modes of transport are suitable for the main leg of multimodal transport. Through the bundling of transports corresponding transport

³⁵Cf., viadonau, 2019, p 17.

volumes can be achieved, which can justify transport with these modes of transport from an economic point of view.³⁶

Transport modes	Strengths	Weaknesses
Road	<ul style="list-style-type: none"> • High network density • Speed for short transport distances 	<ul style="list-style-type: none"> • Low transportation volumes • High external costs
Railway	<ul style="list-style-type: none"> • Low environmental impact (CO₂, pollutants, noise) • Denser network (comparison waterway) • Inexpensive & fast on medium transport distance 	<ul style="list-style-type: none"> • Lower network density as road
Inland waterways	<ul style="list-style-type: none"> • Low transport costs and low negative effects with high volumes 	<ul style="list-style-type: none"> • Duration of transport • Network density

Tabelle Table 1 - Comparison of strengths and weaknesses of transport modes (Source: own illustration based on Kille & Schmidt, 2008).

The share of inland waterways in the modal split in 2018 in the 28 countries of the European Union was 6.0% - thus 6.0% of the total freight ton kilometers were covered by waterways. This share differs greatly in the individual EU countries. The Netherlands, for example, has important seaports and an extensive and fragmented network of waterways, and therefore has the highest share of inland waterway transport in the 28 countries of the EU (44.7% in 2018).³⁷

4. Liquefied gas - LNG

Another important step towards sustainability is the use of LNG as an alternative propulsion system. LNG or liquefied natural gas is natural gas that is cooled down to at least -162° C and thus takes up 600 times less space than unprocessed natural gas. In addition to being used as a fuel for inland waterway vessels and trucks, LNG can also be used for industrial processes in gas form.³⁸

Within the network of inland waterway transport, there are already two bunker stations on the Rhine - in the port of Rotterdam and the port of Amsterdam. These are truck-to-ship bunker stations, which means that the truck is connected to the ship that refuels it. Norway and other Scandinavian countries can be seen as pioneers for LNG.³⁹ In 2019, 75 LNG-operated ships were active worldwide, another 155 ships under construction.⁴⁰

³⁶ Cf. viadonau, 2019, p. 184ff.

³⁷ Cf. Handbuch der Donauschifffahrt, 2019, p 21

³⁸ Cf. Aymelek, 2014, p.768

⁴⁰ Cf. Statista.com; online: <https://www.statista.com/statistics/1102212/lng-fueled-vessels-worldwide-by-type/> [19.08.2020].

The LNG value chain begins with the extraction and production of natural gas. In the next step, the gas is liquefied and is thus ready to be transported to the ship. After transport, LNG is vaporized again and stored until the end consumer needs it. Since the end of 2019, the largest supplier of LNG to Europe has been the USA with 107,000 tons per day. Japan, on the other hand, is the largest importer until at least 2022.⁴¹

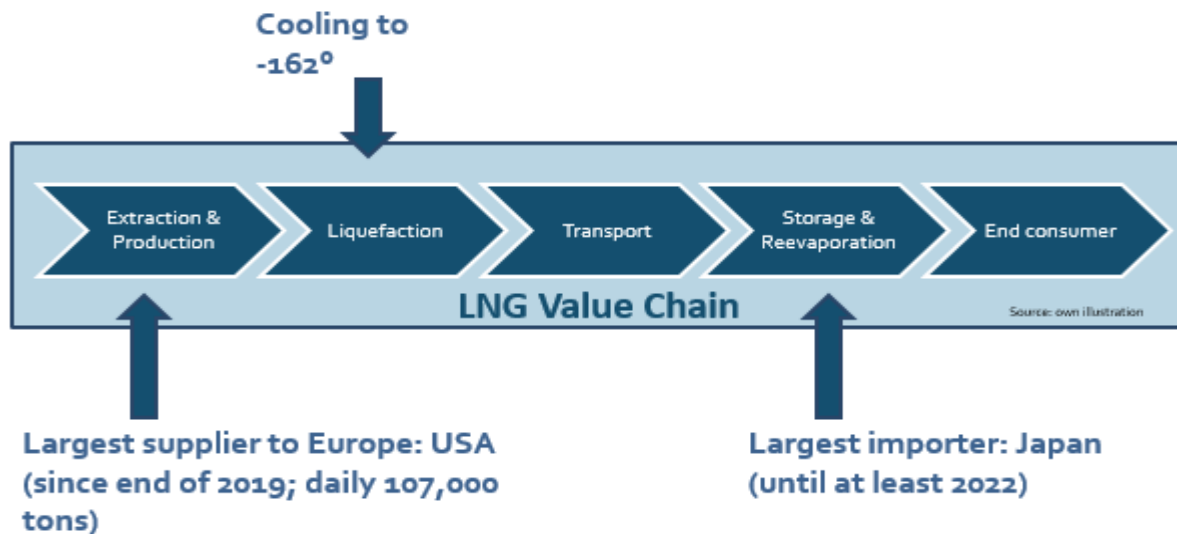


Figure 8: LNG value chain (Source: own illustration based on <https://www.youtube.com/watch?v=WyZTuzUzR68>)

However, even in this area there are not only advantages and opportunities, but challenges must also be taken into account, for example.⁴²

- Political instability at the national level or economic instability related to prices and demand.
- LNG bunker facilities are associated with high investments. It is therefore important to invest in the right places, but this is not always predictable.
- Existing ships have to be converted and new ships have to be planned appropriately, which involves investment costs and development/reconstruction times.
- As handling LNG involves very low temperatures, training of personnel is necessary to ensure proper handling. Furthermore, further investigations are necessary to ensure safety.
- As already mentioned, numerous investments are required. It is therefore necessary to define who will bear the costs.

⁴¹ URL: Liquefied Natural Gas LNG 101; Online: <https://www.youtube.com/watch?v=WyZTuzUzR68> [07.09.2020]; Der größte Lieferant von Naturflüssigerdgas (LNG) nach Europa ..., online: <https://www.umwelt-energie-report.de/2020/04/der-groesste-lieferant-von-naturfluessigerdgas-lng-nach-europa.html> [07.09.2020]; LNG-Investitionen 2019 auf Rekord-Niveau, online: <https://www.en-former.com/lng-investitionen-2019-auf-rekord-niveau/> [07.09.2020]

⁴² Cf. De Loon, Marjan, S. 91,93; Liquefied Natural Gas LNG 101; online: <https://www.youtube.com/watch?v=WyZTuzUzR68> [07.09.2020]

5. Sources

- Aymelek, Murat: Challenges and opportunities for LNG as a ship fuel source and an application to bunkering network optimisation, 2014.
- Bretzke, W.-R., & Barkawi, K. (2010). *Nachhaltige Logistik. Antworten auf eine globale Herausforderung*. Berlin Heidelberg: Springer-Verlag Berlin Heidelberg.
- Bundesamt für Güterverkehr (BAG). (August 2014): Auswertung der Arbeitsbedingungen in Güterverkehr und Logistik 2014-I: http://www.verkehrsrundschau.de/sixcms/media.php/4513/BAG-Bericht_5D_2014_Fahrzeugführer_2014.pdf [07.09.2020]
- en-former:]; LNG-Investitionen 2019 auf Rekord-Niveau, online: <https://www.en-former.com/lng-investitionen-2019-auf-rekord-niveau/> [07.09.2020]
- European Comission. (2011). *White Paper - Roadmap to a single european transport area — towards a competitive and Resource-efficient transport system* , online unter https://ec.europa.eu/transport/sites/transport/files/themes/strategies/doc/2011_white_paper/white-paper-illustrated-brochure_en.pdf [07.09.2020]
- DHL: Klimafreundlicher Versand, online unter: <http://www.dhl.de/de/paket/information/privatkunden/gogreen-klimafreundlicher-versand.html> [07-09.2020].
- Energiereport: Der größte Lieferant von Naturflüssigerdgas (LNG) nach Europa, online: <https://www.umwelt-energie-report.de/2020/04/der-groesste-lieferant-von-naturfluessigerdgas-lng-nach-europa.html> [07.09.2020];
- Holderied, C. (2005). *Güterverkehr, Spedition und Logistik. Managementkonzepte für Güterverkehrsbetriebe, Speditionsunternehmen und logistische Dienstleister*. München: Oldenbourg Wissenschaftsverlag GmbH.
- Imaginecargo, online unter: <http://www.imaginecargo.com/> [07.09.2020.]
- Institute for Transport Studies. (2010). *Die Zukunft der Nachhaltigkeit in Güterverkehr und Logistik.*, online unter [http://www.europarl.europa.eu/RegData/etudes/note/join/2010/431578/IPOL-TRAN_NT\(2010\)431578_DE.pdf](http://www.europarl.europa.eu/RegData/etudes/note/join/2010/431578/IPOL-TRAN_NT(2010)431578_DE.pdf) [07.09.2020]
- Kille, C., & Schmidt , N. (2008). *Wirtschaftliche Rahmenbedingungen des Güterverkehrs. Studie zum Vergleich der Verkehrsträger im Rahmen des Logistikprozesses in Deutschland*. Nürnberg: Fraunhofer IRB Verlag.
- Kudla, N. (2010). Nachhaltigkeitsmanagement. In W. Stölzle, & H. P. Fagagnini, *Güterverkehr kompakt* (S. 230-242). München: Oldenbourg Wissenschaftsverlag GmbH.

Lehrmacher, W. (2015). *Wirtschaft, Gesellschaft und Logistik 2050 in Logistik – eine Industrie, die (sich) bewegt. Strategien und Lösungen entlang der Supply Chain 4.0*. Bonn: Springer Fachmedien Wiesbaden.

OECD, International Transport Forum. (2015). http://www.oecd-ilibrary.org/transport/itf-transport-outlook-2015_9789282107782-en;jsessionid=8gr2ul2hqogso.x-oecd-live-02 [07.09.2020]

Pazirandeh, A., & Jafari, H. (2013). Making sense of green logistics. *International Journal of Productivity and Performance Management*, Vol.62 Iss 8, S. 889-904.

statista.com, online: <https://de.statista.com/statistik/daten/studie/881600/umfrage/co2-emissionen-im-deutschen-gueterverkehr-nach-verkehrsmitteln/> [17.08.2020].

Umweltbundesamt (UBA). (2012). *Daten zum Verkehr – Ausgabe 2012.*, online unter <https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/4364.pdf> [07.09.2020].

VDC, Online: <https://www.vcd.org/themen/verkehrslaerm/strassenlaerm/> [07.09.2020].

viadonau: Manual on Danube Navigation, Viena, 2019

viadonau: Annual Report on Danube Navigation, Viena, 2019.

Whiteing, A. (2010). *Die Zukunft der Nachhaltigkeit*, online unter [http://www.europarl.europa.eu/RegData/etudes/note/join/2010/431578/IPOL-TRAN_NT\(2010\)431578_DE.pdf](http://www.europarl.europa.eu/RegData/etudes/note/join/2010/431578/IPOL-TRAN_NT(2010)431578_DE.pdf) [07.09.2020].

Youtube: Liquefied Natural Gas LNG 101; Online: <https://www.youtube.com/watch?v=WyZTuzUzR68> [07.09.2020];

Youtube: Synchromodality, online unter: <https://www.youtube.com/watch?v=5ofhMxRRyec> [07.09.2020].