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AN INLAND WATERWAY FREIGHT SERVICE IN COMPARISON TO LAND-BASED ALTERNATIVES IN SOUTH-EASTERN EUROPE: ENERGY EFFICIENCY AND AIR QUALITY PERFORMANCE

Ernestos Tzannatos[1], Basil Tselentis[2], Alkis Corres[3]

[1,2]*Dept of Maritime Studies, University of Piraeus, Greece*
[3]*Dept of Shipping, Trade and Transport, University of the Aegean, Greece*

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Abstract. Towards the strive of developing sustainable freight transport networks in Europe, the EU and the developing South-Eastern Europe in particular, this paper initially examines the feasibility of establishing a navigable link along the Axios–Morava waterway, for freight transport between the Eastern Mediterranean Sea (via the Aegean) and the Danube River, and then proceeds with its energy and air quality comparison with the competing modes of rail and road. It was found that this waterway service is technically feasible and offers an energy and carbon efficient alternative to road-borne and rail-borne freight. However, the land-based services were found to be superior with regard to their impact upon the air quality of the region, mainly attributed to the stricter emission standards applicable to these transport modes. Finally, it is proposed to build on the ongoing international policy and funding interest in this project in order to implement all the necessary infrastructural and operational changes which will make the proposed waterway service a commercially and environmentally sustainable freight transport alternative in South-Eastern Europe.

Keywords: freight transport; modal shift; inland navigation; river transportation; inland waterway; sustainable transport; energy; emissions.

Introduction

During the course of the last three decades, international trade has increased at a rate much faster than the growth in global Gross Domestic Product (GDP) and in relation to 1975 the increase of the former has been nearly double to that of the latter (UNCTAD 2013). During the last decade this trend was intensified through the rapid economic growth of east Asia and the establishment of significant seaborne freight flows between the Far-East (mainly China) and the West (USA and Europe) through the transpacific and east-west (via the Mediterranean) routes (Fig. 1).

For Europe and particularly for the EU, this eastward shift in trade continues to be predominately served through the northern range ports and their logistical chains utilizing and building on the investments made in support of the previously dominant Europe–USA trade. Although there are signs of correction in this North–South imbalance of extra-European trade flows, mainly evident through the increased port throughput in the western Mediterranean basin, northern gateways have in general retained their ability to counter the proximity advantage of Mediterranean ports for the Asia trade (Gouvernal *et al.* 2012).

However, the need to strengthen the role of the European ports of the Mediterranean region in international trade is now becoming urgent for ensuring sustainable growth within the European continent as a whole and that of EU in particular (Costa 2013). This urgency is intensified with regard to the eastern Mediterranean basin, as the increased trade demand associated with the EU-enlargement into eastern and South-Eastern Europe and the recent economic growth observed in all the countries of this region has to be met.

As the seaborne trade between the Far East and Europe via the East-Med is rapidly expanding, the new manufacturing and consuming centers established throughout the eastern region of Central Europe seek the support of nearby and easily accessible trade gateways. The compounded influence of the eastward shift of both the global and European economic centres of gravity highlights the importance of the East-Med European ports in EUs strive to develop a competitive and resource efficient freight transport system.

Corresponding author: Ernestos Tzannatos
E-mail: *et@unipi.gr*

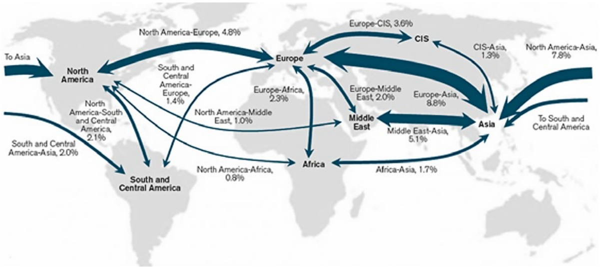


Fig. 1. Percentage share of international trade flows in 2011 (Costa 2013)

In this respect, the latest White Paper (EC 2011), sets a range of specific targets including modal shifts towards sustainable and energy efficient modes of transport, as well as reduction goals in GHG, pollutants and oil consumption. Despite all efforts, the growth of the non-road modes of freight transport remains a strong challenge for Europe, as during 2001–2011 road-borne freight strengthened its share from 75 to 76% of the total inland intra-EU transport work (ton-km), whilst railways were reduced to 18% (from 19%) and waterways maintained their portion of 6% (Eurostat 2013).

The White Paper (EC 2011) acknowledges the fact that so far rising volumes of freight transport have outweighed efficiency gains in transport and new vehicle and fuel technologies alone will not be sufficient to meet the challenge of the sustainable EU transport by 2030 and 2050. Therefore, '*specially developed freight corridors optimised in terms of energy use and emissions, minimising environmental impacts, but also attractive for their reliability, limited congestion and low operating and administrative costs will be also necessary*'. Amongst the ten key benchmarks of the White Paper (EC 2011) for the achievement of a competitive and resource-efficient transport system are included:

- '*a 30% shift of road freight over 300 km to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors*';
- '*a fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high-quality and capacity network by 2050 and a corresponding set of information services*'.

Both benchmarks are relevant to '*the optimisation of the performance of multimodal logistic chains, including the greater use of more energy-efficient modes*', which constitutes one of the three pillars of the White Paper (EC 2011) strategy on transport. Furthermore, it is also stated that '*on the coasts, more and efficient entry points into European markets are needed, avoiding unnecessary traffic crossing Europe. Seaports have a major role as logistics centres and require efficient hinterland connections. Their development is vital to handle increased volumes of freight both by short sea shipping within the EU and with the rest of the world*', and with specific significance for this paper, the previous statement closes by the sentence: '*inland waterways, where unused potential exists, have to play an increasing role in particular in moving goods to the hinterland and in linking the European seas*'. Towards meeting this objective, the knowledge and experience gained through the NAIADES I (2006–2013) and NAIADES II (2014–2020) programmes for the 'Navigation and Inland Waterway Action and Development in Europe', as well as the implementation of their supporting programmes PLATINA I and II, will play a major role (*http://www.naiades.info*).

The role of inland navigation in a sustainable transport system has been recently presented by Caris *et al.* (2014) within the context of intermodal transportation and studied by Rohács and Simongáti (2010), whilst the significance of the Danube River as a vital transport artery for the EU and the European continent has been presented in the work of Radmilović and Dragović (2007), and more recently by Mihic *et al.* (2011), and Radmilović and Maraš (2011). Furthermore, the environmental impact of inland navigation in the context of the air pollution produced by the riverboats has been addressed by Den Boer (2011), whilst the work by Radojcic (2009) was conducted with reference to Danube and that by Ljevaja (2011) and Radonjić (2011) for Serbia.

Amongst the people of the Balkans, the concept of the Axios–Morava navigation route connecting the eastern Mediterranean (via the Aegean Sea) with thr Danube River dates back to at least five generations, but the first comprehensive approach into its feasibility was presented by Jovanovski (2011) and has lately resurfaced as a project proposition mainly due to the expressed international interest in the project amidst a mounting pressure to develop sustainable transport corridors in Europe (Corres 2014; Dunčić, Lukić 2013; Radaković 2012). The ongoing political and economic reform within the Balkans makes the region the ideal playing field for each of the great powers i.e. USA (via NATO and EU), Russia (via Serbia) and China (via Serbia), in their effort to establish their presence and exercise their influence in the future affairs of the wider region.

This paper makes a unique contribution to existing literature, because it examines the Axios–Morava waterway within the context of the current White Paper (EC 2011) strategy on the EU transport. More specifically, the comparative analysis with the competing modes of road and rail transport of freight in terms of fuel use and atmospheric impacts highlights the challenges associated with the proposed modal shift with regard to energy efficiency and environmental (atmospheric) quality.

From this point onwards, the paper is organised as follows: The description of the Axios–Morava waterway link is presented in Section 1, whilst Section 2 highlights the international interest on the development of this link into a navigable route over the years. Section 3 describes the operational characteristics of the three competing transport modes (i.e. the waterway, rail and road service). The methodology for estimating the energy efficiency and air quality performance for each service is given in section 4. The results of the comparison analysis are illustrated and discussed in Section 5. Conclusions and suggestions are presented in last Section.

1. Description of the Waterway Link

The Danube River with a length of around 3000 km is the longest river in the EU and through its connection with the Rhine–Main (500 km) forms a fully navigable link between the North Sea (Rotterdam) and the Black Sea (Constanta), thus being an integral part of the Trans European Transport Network (TEN-T). The Danube passes through ten riparian countries (seven EU member states) and its basin extends to nine more, contributing to the socio-economic growth of the Central, Eastern and South-Eastern region of the European continent.

The proposed waterway link essentially utilizes the route offered by the Axios (or Vardar) River at the south and that of the Morava River over the north section (Fig. 2). Axios is the longest river that runs through Greece and FYROM, having a length of 275 km, with a width presently ranging from 50 to 600 m and a depth, which can reach up to 4 m. It extends northbound into FYROM territory under the name Vardar and joins the Morava River further in north. The Morava runs over 345 km through Serbian land and joins the Danube at 50 km east of Belgrade. The overall length of the waterway link between the Aegean Sea and the Danube River is equal to 650 km, thus offering a 1200 km shorter route between the eastern Mediterranean and Central Europe (via the Black Sea).

However, making the Axios–Morava waterway navigable and ready for service will require extensive construction work, which will involve the building of canals (a short main canal and 4–5 lateral), wharfs, numerous locks and dams, as well as the opening of new roads and other supporting facilities. To this effect, the accumulated knowledge and experience in the building and operation (incl. maintenance) of navigable waterways is adequate for such undertaking. In terms of added value, the construction and operation of the waterway link will bring socio-economic growth in the region, whilst the river-borne trade will boost the productivity of the agricultural sector which is dominant in this peripheral area of Europe.

2. International Interest

Although the discussion for the navigability of Morava dates back to the 1840s, the development of the entire Axios–Morava link into a navigable waterway was of a scale and character, which was bound to require international intervention. In 1907, the American government established in New Jersey the American engineering commission for the observation of the Morava–Vardar waterway. The Balkan wars of 1912–1913 and the regional instabilities of the interwar period put the project aside. After the end of World War II and up to the beginning of the 80s, the political orientation of former Yugoslavia was not favouring the co-operation with the west and most importantly Greece as a riparian country, whilst the emergence of ethnic tensions between Serbia and the ex-Yugoslavian republics during the 80s and their eventual engagement in war during the 90s (terminated with the NATO bombing of Serbia in 1999) inevitably placed the region under other priorities.

The big change came recently through the attraction of the Chinese interest in investments throughout the Balkans. After visiting more than thirty locations along the route, during a period of three months, the Chinese have concluded that the project is technically feasible and funding will follow the example of COSCO's concession in the Port of Piraeus. Combining China's interest in this project, it is important to note that with major Chinese investments in the Ports of Piraeus and Thessaloniki, and with similar projects in the infrastructure sector in the countries of southern and South-Eastern Europe, "*China creates an alternative route for the entry of products in Europe, which is the largest market and which, unlike the ports of northern Europe, it would be for 99 years under its influence and management*", significantly boosting its geopolitical position (Corres *et al.* 2014).

Apart from Greece, FYROM and Serbia, which are directly involved, the project is also attracting directly or indirectly the attention of Russia, the EU and the USA. In this context, there is already Russian interest in the privatization plan of the Hellenic Railways and the Port

Fig. 2. Axios–Morava inland waterway (Zepp-LaRouche 2012)

of Thessaloniki, whilst the EU is bound to exercise its influence through:

- Serbia's accession negotiations with the EU which started on 1 January 1 2014;
- the policy for river transportation (NAIADES II) which integrates it into the European Transport Networks (TEN-T) with a substantial budget for infrastructure projects;
- the socio-economic interest in the developmental character of the project.

Last, but not least, although the project does not clearly relate to the USA interests in the transport sector, it is otherwise significant within the framework of geopolitical influence. A possible long-term presence of Chinese and/or Russian interests in the region could clash with other USA priorities especially after the recent developments in Ukraine.

3. Operational Profile of Freight Transport Services

The performance of a waterway link is mainly related to the riverboats, which use it and specifically to their design parameters which are dictated by the navigational constraints imposed upon them. Riverboat water and air draft, length and beam are tailored to the waterway natural and man-made characteristics. For example, navigability through the entire stretch of the Danube River allows a maximum loaded draft of around 2.0 m to account for adequate clearance at swallow waters. In general, beam and length are restricted by the size of locks with length being also limited by waterway bends and air draft by the height of bridges.

A concise presentation of the basic designs (self-propelled, barges etc.) of freight riverboats engaged in Europe is given in the work by Radmilović and Maraš (2011), whilst detailed descriptions of the various designs involved in the European waterway network in general and for the Danube River in particular can be obtained through the reporting of the SPIN-T programme (*http://spin-tn.factline.com*). The types of riverboats, which are currently active in Danube range from dry bulk carriers and tankers to general cargo (incl. containers) carriers and Ro-Ro. Self-propelled riverboats vary from 38–40 m long having a payload capacity of about 300 tons at 2.5 m draft to 110 m long with on average 1900 tons payload at the same draft. In recent times, even considerably larger vessels have become usual on the Rhine River having a length of up to 135 m, a beam of up to 17 m and a payload of about 3500 tons at only 2.5 m draft. Barges range between 70.0–76.5 m in length, a beam between 9.5–11.4 m and a cargo carrying capacity, which is mainly determined by the available depth of the waterway. Indicative draft for a given payload of a typical Danube barge (77×11×2.8 m) is: 1.0 m for 300–400 tons, 1.5 m for 700–800 tons, 2.0 m for 1100–1200 tons, 2.5 m for 1500-1600 tons, 2.8 m for 1800 tons and 4.0 m for 4000 tons. Barge convoys usually consist of 2 to 6 barges, which carried in various combinations in tandem and/or in parallel by a push boat (or very rarely by a pull/tug boat) of appropriate power. Finally, a self-propelled riverboat may also carry 1 or 2 barges abreast.

Indicative data with regard to the riverboat characteristics which would be suitable for the Axios–Morava waterway link can be obtained through reference to the fleet of the largest river shipping company in Serbia, 'Yugoslav River Shipping'/'*Jugoslovensko Recno Brodarstvo* (JRB)'(*http://www.jrb.rs*). The main particulars of the JRB fleet are synoptically shown in Table 1 and their dry cargo self-propelled riverboat (Fig. 3) was selected for the Axios–Morava waterway service to be operated at the fully loaded condition of 2000 tons (at 2.7 m water draft).

For the purposes of providing a level-playing field for the comparison of the energy, carbon and air quality performance of the three competing freight transport services, the land-based vehicles were assumed to operate over the route between Thessaloniki and Belgrade and the equivalence of their utilisation with the riverboat's payload was achieved as shown in Fig. 4. With regard to the road service the 'fastest' (as opposed to the shortest) distance between Thessaloniki and Belgrade based on the route which offers minimum 'flow resistance' and was found to be equal to 677 km, whilst the

Fig. 3. JRB's self-propelled dry cargo riverboat (*http://www.jrb.rs*)

Table 1. JRB's riverboat fleet

Riverboat type		Number	Average payload capacity [tons]	Average propulsion power [kW]
Barges	Dry cargo	62	1732	–
	Liquid cargo	58	1386	–
Self-propelled	Dry cargo	1	1892	1276
	Liquid cargo	1	1246	551
Push-boats		14	–	1199
Tugboats		2	–	885

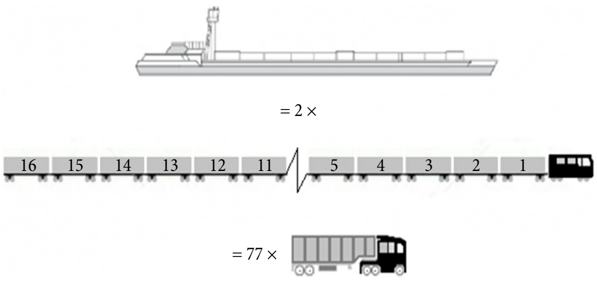


Fig. 4. Number of vehicles for payload capacity equivalence of 2000 tons

corresponding railway link stretches over the distance of 664 km.

For the payload equivalence, the road service was assumed to employ 77 diesel-trucks each of 40 tons gross weight (26 tons payload capacity), whilst the railway service employed two freight train formations each of nearly 1500 tons gross weight consisting of a diesel locomotive and 16 wagons each of 84 tons gross weight (61 tons payload capacity). The vehicles of both land-based services are typical of the heaviest types operating in this region.

A critical performance parameter in waterway freight services is that of transit time, as it is widely acknowledged that it is the slowest mode of motorized transport. This stems basically from the fact that cargo riverboats have a full-body hull which inevitably restricts their speed in favour of increased cargo carrying capacity under the waterline, whilst sailing resistance increases at low clearances between the river-bed and the keel. Furthermore, waterway authorities usually impose speed limits to avoid damage to riverbanks and wharfs produced by the hull wake, which can be profound in swallow waters especially near the critical (hull) speed regime. During sailing in swallow waters, squat effects must also be controlled through the reduction of speed. Away from these constraints, low draft vessels can reach service speeds of 20 km/h, but transit times are also prolonged due to delays at the locks (waiting at entry and lock transit) and in many cases because only daytime navigation is allowed. On this basis, the selected riverboat will require on average 50% of its MCR of 1300 kW to develop an average speed of 10 km/h through the relatively swallow (<4.0 m), occasionally narrow (down to 50 m) and 'meandering' Axios–Morava waterway, before it enters the less restrictive the Danube River. At this sailing speed, the passage through the entire 650 km route will take 65 hours, whilst the total transit time including 11 canal approaches and transits, as well as five 12-hour overnight stops is expected to last 180 hours (or 7.5 days) – Corres *et al.* (2014).

Based on the data presented by popular truck manufacturers (MAN Trucks 2014; Volvo Trucks 2014), the rated power of the truck's engine was assumed to be equal 315 kW (420 hp) being typical of modern tractors suitable to international haulage within the South-Eastern European region for the carriage of a maximum payload of 26 tons (40 tons gross weight). At the fully loaded condition, the truck is capable of developing an average speed of 80 km/h, which will cover the Thessaloniki–Belgrade distance in 8.5 hours (excl. stoppage time). Similarly, drawing on information relevant to modern diesel locomotives specifically adapted for cross-border operation in Europe (GE Transportation 2014), the traction of the 1500 gross tons train will require an engine of 2760 kW (3700 hp) rated power which can accommodate the railway gradients within the Balkan Peninsula and will offer an average train speed of 70 km/h for covering the Thessaloniki–Belgrade distance in 9.5 hours (excl. stoppage time).

4. Energy Efficiency and Environmental Performance

At a time of increased commercial competition and fuel prices, the energy efficiency offered by transport services is very important as fuel expenditure constitutes a major part of their overall cost function. However, apart from the internal (private) costs, transport companies are faced with the challenge of reducing their negative externalities mainly in order to alleviate the social costs amidst the emerging wave of cost internalization, but also in an effort to improve their commercial image. Transport-related exhaust emissions have atmospheric impacts at global, regional and local level causing significant damage to the natural and built environment, and most importantly to human health. Amongst them, CO_2, SO_2, PM and NO_x are widely acknowledged for their most important impacts (Table 2). However, the fact that energy savings reduce emissions either directly (for CO_2) or indirectly (for the other pollutants) presents transport companies with a powerful incentive to improve their energy efficiency record in order to cut down on fuel costs and improve their environmental performance too.

Table 2. Impact of exhaust emissions

Emission	Impact
CO_2	Global warming – climate change
SO_2	Acidification, eco-toxicity, human toxicity
PM	Human toxicity, summer smog
NO_x	Acidification, eutrophication, eco and human toxicity, summer smog

The energy and emission performance of the three modes of freight transport was modelled according to an activity-based methodology, which utilised the operational parameters of the vehicles involved and the fuel consumption and exhaust emission coefficients of their engines. In each transport mode, the latest (strictest) engine emission standards were considered.

More specifically, with regard to the NO_x and PM emission coefficients of the riverboat, the strictest standards of Directive 2004/26/EC – Stage IIIA currently applicable to inland navigation were assumed, as they cover all new engines from 01/07/2007. Furthermore, the SO_2 emission coefficient was estimated using the

LR (1995) expression according to the work by Cooper and Gustafsson (2004) for Medium Speed Diesel (MSD) engine operation on fuel with 10 ppm sulphur, being the upper limit for inland waterway transport from 01/01/2011 according to Directive 2009/30/EC. For the NO_x and PM emissions of the railway service, the Stage IIIB standards of Directive 2004/26/EC were assumed as they currently apply to all new diesel-locomotive engines from 01/01/2012, whilst their SO_2 emissions were based on the 10 ppm sulphur limit of fuel imposed also on rail by the aforementioned Directive 2009/30/EC from 01/01/2011. Finally for the NO_x and PM emissions of the truck engines, their compliance with the recently (01/01/2013) enforced EURO VI standards was assumed (Directive 2003/17/EC), whilst their SO_2 emissions were also based on the 10 ppm sulphur limit for road diesel (EN 590:2009). The NO_x, PM and SO_2 emission limits applicable to the engines associated with the three modes of transport service are shown in Table 3.

Table 3. Engine emission limits per transport mode

Emission coefficient	Riverboat	Truck	Rail
NO_x [g/kWh]	6.0	0.4	2.0
PM [g/kWh]	0.2	0.01	0.025
SO_2 [g/kWh]	$4.2 \cdot 10^{-3}$		

The fuel consumption of the riverboat engine was based on the work by Georgakaki and Sorenson (2004) prepared for the ARTEMIS project for the specific vessel class and operating (payload and water depth) conditions. Truck fuel consumption was obtained from EMEP/EEA (Ntziachristos *et al.* 2013a) taking also into consideration recently released manufacturer's data (Eurostat 2013), whilst that of the railway service was calculated according to the methodology adopted by Den Boer *et al.* (2011) for the European average (hilly terrain) and EMEP/EEA (Norris *et al.* 2013b). Similar to the riverboat's engine, the fuel consumption of the land-based engines (i.e. truck and rail) was representative of the vehicles' technology and operating conditions most relevant to the case under consideration.

Finally, as there is no EU CO_2 legislation for freight transport (exempt for vans), the values for the CO_2 emission coefficient, Net Calorific Value (NCV) and the density of the diesel/gas oil were assumed according to the default values of the 2006 IPCC guidelines (Eggleston *et al.* 2006). The summary of the fuel and CO_2 relevant parameters are shown in Table 4.

Table 4. Engine fuel parameters and CO_2 factor per transport mode

Parameter	Riverboat	Truck	Rail
Fuel consumption [lit./km]	14.8	0.35	5.75
CO_2 [g-CO_2/g-fuel]	3.1863		
Fuel NCV [MJ/kg]	43.0		
Fuel density [kg/lit.]	0.85		

5. Results and Discussion

The energy and fuel consumed as well as the CO_2 produced during the single-leg (one-way) movement of 2000 tons of freight by the three alternative modes of transport are shown in Fig. 5.

Overall the waterway service was found to be significantly superior to that of the road and slightly better than the rail. More specifically, the fuel consumed by the road service was almost double to that of the waterway, whereas the latter was 13.5% less fuel thirsty than the rail service. Taking into account that all transport modes use fuel of identical specification, the consumed energy (MW·h) and the amount of produced CO_2 emissions followed the comparison of the fuel consumption.

The energy and carbon efficiencies of the three services are shown in Fig. 6, where the waterway and railway services maintain their superiority in comparison to the road. It is important to note that although this efficiency ranking is consistent with the results of various studies comparatively presented in the work by McKinnon and Piecyk (2010), the observed CO_2 efficiency of the examined waterway, road and diesel railway service is lower than the reported average of 31, 62 and 37 g-CO_2/ton-km, respectively. This difference is mainly attributed to the vehicles' capacity utilisation, which in the current analysis was assumed to be 100% for aiding the comparison across all transport modes, whilst real-world load factors range between 55–65% depending on transport mode, cargo type and most importantly on the prevailing market conditions.

In an effort to distinguish between the produced CO_2 emissions which have a global impact and those emissions which are important with regard to local and regional air quality (i.e. SO_2, PM and NO_x), the latter are presented separately in Fig. 7. The waterway service produces the lowest SO_2 emissions, although they do not offer a sizable advantage in comparison to the road and rail alternative. In terms of PM and NO_x emissions, the road service is by far the best option, whilst that of the railway has an improved performance in comparison to the waterway service. This is mainly attributed to the stricter PM and NO_x emission limits enforced on the new truck and diesel locomotives, as opposed to the more relaxed which are applicable to new riverboat engines.

In addition to this specific observation, it is important to note that in general the comparative picture of the air pollution performance of inland navigation is even worse. As the introduction of emission limits in transport discriminates between existing and new engines, under real-world circumstances, the emission profile of the existing waterway fleet in Europe falls very short of the post-2006 limits of the Directive 2004/26/EC applied in this analysis. This is attributed to the slow rate of replacement of riverboat engines, as it is usually limited to retrofitting rather the replacement of the vessel. There are numerous pre-1974 riverboats having NO_x and PM emission coefficients, which are nearly double the currently permissible standards for post-2007 riverboat engines. At the same time, the renewal of the truck fleet is

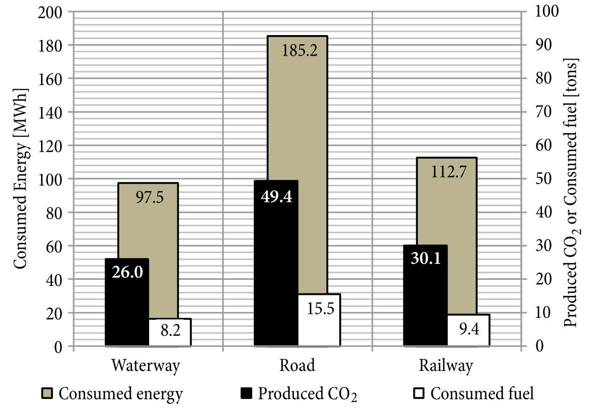


Fig. 5. Energy consumption and CO_2 emission per mode of transport service

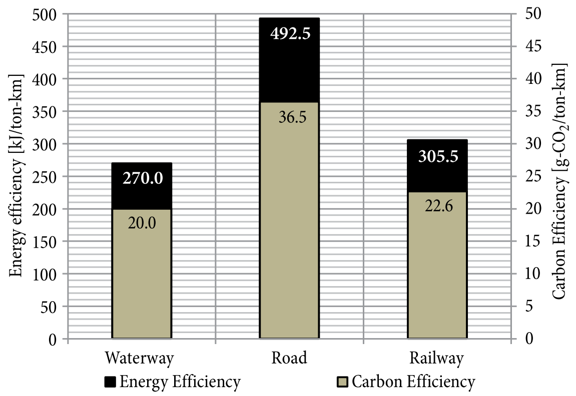
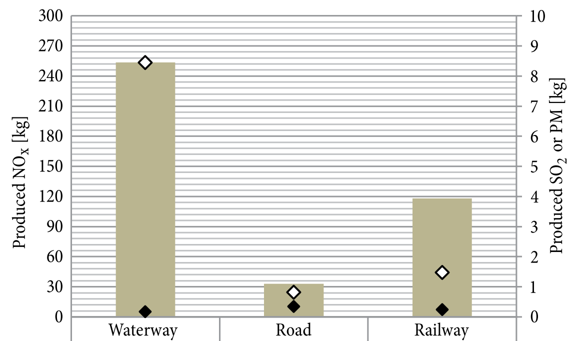


Fig. 6. Energy and carbon efficiency per mode of transport service



	Waterway	Road	Railway
NO_X [kg]	253.50	32.99	117.99
SO_2 [kg]	0.18	0.35	0.25
PM [kg]	8.45	0.82	1.47

Fig. 7. Air pollutants per mode of transport service

much faster and the on-going expansion of rail electrification is bound to shrink the share of diesel traction.

The improvement of the air quality performance of inland navigation is very important, because the air pollutant receptors are closer and hence more vulnerable to damage than those exposed to the coastal and ocean-going ship operations. Of course, similar to the case of short sea shipping, reducing the exhaust emissions of riverboats requires the use of 'cleaner' fuels and/or the introduction of exhaust treatment technologies (e.g. scrubbers).

However, the additional investments required to improve the environmental (atmospheric) performance of inland navigation are bound to increase the cost of the waterway services and make them commercially disfavoured in comparison to the other competing modes of transport. In an effort to avert the reverse modal-shift for inland navigation, it is necessary to realize that the attainment of sustainable transport in Europe requires an approach, which will engage all stakeholders in sharing the risks and opportunities, and amongst them governments have a 'governing' role to play in providing the correct policies (incl. appropriate incentives) to meet this challenge.

Conclusions

Inland waterways can make a significant contribution towards achieving transport sustainability in Europe and the EU in particular, and within the economically growing region of South-Eastern Europe, their unused potential needs to be fully explored.

It has been shown that the Axios–Morava waterway through its connection with the Danube River offers the ability to link the eastern Mediterranean with Central Europe in an energy and carbon efficient manner. However, its impact on the regional and local air quality must be significantly improved in order to successfully compete against its land-based alternatives of road and rail freight transport.

The paper reveals the need to develop European transport policies, which will provide transport operators with the economic incentives and financial mechanisms to support the necessary infrastructural and operational investments for the utilization of waterway services. This will not only make these services commercially sustainable, but also it will accelerate the establishment of green logistics particularly in environmentally sensitive areas, which provide access to and from the European hinterland.

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