

## INLAND WATER TRANSPORT DEVELOPMENT POSSIBILITIES – CASE STUDY OF LOWER VISTULA RIVER

Tomasz Nowakowski<sup>1</sup>, Jan Kulczyk<sup>2</sup>, Emilia Skupień<sup>3</sup>, Agnieszka Tubis<sup>4</sup>,  
Sylwia Werbińska-Wojciechowska<sup>5</sup>

Wroclaw University of Technology, Faculty of Mechanical Engineering, Wroclaw, Poland

<sup>1</sup>e-mail: tomasz.nowakowski@pwr.edu.pl

<sup>2</sup>e-mail: jan.kulczyk@pwr.wroc.pl

<sup>3</sup>e-mail: emilia.skupien@pwr.wroc.pl

<sup>4</sup>e-mail: agnieszka.tubis@pwr.wroc.pl

<sup>5</sup>e-mail: sylwia.werbinska@pwr.wroc.pl

---

**Abstract:** *Among different transportation modes, inland water transport is recognized as a low-cost, environmentally friendly way of transporting. The use of this mode in Poland encounters many challenges. Thus, the investigation of development possibilities by analysing the revitalization profitability and navigability restoration of Lower Vistula river should be explored. Following this, the article includes the summary of obtained results of the project INWAPO carrying out and regards development of infrastructure and sea/river ports, demand forecast for transportation, external costs estimation and the main benefits from lower Vistula river revitalization. The main analysis is done with the assumption of IV (or higher) navigable class of the Vistula river.*

**Key words:** *Inland water transport, transportation, Vistula river*

---

### 1. Introduction

The main target of transport services performance is to provide national and regional development through the effective support to e.g. agricultural and industrial production, tourism, or regional integration (Milewski: webpage; Nam and Win 2014). Following this, transportation is perceived as essential sector in achieving the goals of sustainable development. Moreover, there are still considerations how to improve transport performance in terms of time, cost, and reliability.

The inland water transport (IWT) is a mode of transport that has the advantage of being cheap, energy efficient, relatively safe, and environmentally friendly (Sriraman, 2010). This mode includes navigable and regulated river, canalized sections of rivers, canals and other waterways, including navigable lakes and retention reservoirs, coastal creeks, and lagoons (CSO, 2014; Sriraman, 2010).

In Poland, the Regulation of the Council of Ministers (the Journal of Laws of 2002 No. 77, item 695) determines (table 1): the method of inland waterways classification and inland waterways class diversification. Classes from Ia to Vb can be divided into two main categories, i.e. of regional importance

(classes Ia, Ib, II and III) and of international importance (classes IV, Va and Vb).

The national inland waterways network covers 3655 km of which actually 3384 km of inland navigable waterways are being effectively exploited (CSO, 2014). The major inland waterways (rivers and canals) include rivers: Odra (713 km), Vistula (932 km), Warta (68 km), Noteć (187 km), Nogat (62 km), and canals: Bydgoski Canal (24 km), Gliwicki Canal (41 km). Major ports on inland waterways are river/sea ports: Szczecin, Świnoujście, Gdańsk, and river ports: Kostrzyń, Wrocław, Kozle, Gliwice, Bydgoszcz, Warszawa, and Elbląg.

Waterways of international importance (classes IV and V) represent only 1.9 and 3.0% of this length respectively. Most waterways (59%) are Class I, for a carrying capacity limited to 180 tonnes at a loading depth of 1.4 m. Inland waterway transport is mainly carried out on the Oder and Vistula, which are linked by Bydgoszcz Canal. Barges used on this route are considerably smaller than in Germany and the Scandinavian (up to 800 t) (INWAPO, 2012a).

Inland waterways belong to the most neglected elements of Polish transport system. Poland has a small share of inland waterways transport in total freight transport - around 0.1% while the share of

Table 1. Operational parameters of waterways according to Polish classification

Operational parameter	Parameters' values for waterways classes						
	Ia	Ib	II	III	IV	Va	Vb
<b>Minimum dimensions of navigable river trail [m]</b>							
width of river trail	15	20	30	40	40	50	50
transit depth	1,2	1,6	1,8	1,8	2,8	2,8	2,8
curve radius of the axis of the navigable trail	100	200	300	500	650	650	800
<b>Minimum dimensions of water canal [m]</b>							
width of navigable trail	12	18	25	35	40	45	45
the lowest depth of water in the water canal	1,5	2,0	2,2	2,5	3,5	3,5	3,5
curve radius of the axis of the navigable trail	150	250	400	600	650	650	800
<b>Minimum dimensions of navigable floodgate [m]</b>							
width of navigable floodgate	3,3	5,0	9,6	9,6	12,0	12,0	12,0
length of navigable floodgate	25	42	65	72	120	120	187
depth at the lower threshold	1,5	2,0	2,2	2,5	3,5	4,0	4,0

Source: Ministerial Council (2002).

inland waterways transport in the EU countries amounts to 34.7% in the Netherlands, 15.8% in Belgium, 12.6% in Bulgaria, 12.3% in Germany (CSO, 2014). In Poland the main cargo transported by inland waterway transport is: coal, metal ores, sand, gravel, stone, recyclable materials and municipal waste. The freight takes place mostly on the towed barges, which results from the structure of the existing river vessel fleet (INWAPO, 2012a).

However, in the time of growing importance of European inland waterways and integration of European transport networks based on the complementary services of different transport modes, decisive steps towards revitalisation of the entire system of Polish inland waterways should be soon taken (INWAPO, 2012a). Following this, the article is aimed at the investigations of development possibilities of inland water transport by analysing the revitalization profitability and navigability restoration of Lower Vistula river.

Following this, the structure of the article is as follows, in the next Section the importance of IWT is investigated. Later, the development possibilities of IWT are characterized. The study includes the summary of obtained results of the project INWAPO carrying out and regards development of infrastructure and sea/river ports, demand forecast for transportation, external costs estimation and the main benefits from lower Vistula river revitalization. The main analysis is done with the assumption of IV (or higher) navigable class of the Vistula river.

## 2. Inland water transport – importance

In the context of the growth of freight transport and advantages of this form of transport, Poland cannot afford to neglect the development of the inland navigation. Urgently there is a need for a strong impetus to initiate the development of this branch of transport in developing its long-term political considerations.

On the one side, this situation is confirmed by some interesting projects, innovative solutions, initiatives and practical implementations of IWT utilization, which were carried out in Europe recently (see e.g. NAIADES - Navigation and Inland Waterway Action and Development in Europe program (NAIDES: web page)), INLATRANS - Integrating Inland Waterway Transport System in the Baltic Sea Region (MARITERM: webpage), INWAPO - Upgrading of Inland Waterway and Sea Ports (INWAPO: webpage B). On the other side, the EU's expectation in the area of achieving EU's transport policy goals like the reduction of emissions of transport and increasing efficiency of transport (see e.g. Transport White Paper 2011: towards a competitive and resource efficient transport system), make the IWT more attractive solution (INWAPO, 2014; Milewski: webpage). The comprehensive analysis of current inland water transport infrastructure and the possibility of its development to adjust the EU's standards is given e.g. in works (ECORYS, 2011 ab), developed for the Ministry of Infrastructure in 2011.

The importance of IWT is also confirmed by many authors. For example, the importance of inland water transportation to integrate with other modes is considered in Notteboom (2008). In the same year, authors in their work (Wojewódzka-Król and Rolbieceki, 2008) investigate the main development directions of inland waterways in Poland according to e.g. EU's standards. Later, author in her work (Marciniak, 2013) analyses the lower Vistula river in the aspect of the E40 and E70 international shipping routes use. In article Wojewódzka-Król (2014), author analyses the possibilities of developing inland waterways to solve today's social and economic problems. In another work (Hann et al., 2014) authors present the qualitative assessment of the Oder Waterway (Odrzańska Droga Wodna) based on the Polish classification of inland waterways.

### 3. Perspectives for the development of inland waterway transport in Poland – INWAPO project

#### 3.1. General description

Central Europe has extensive inland waterways, which in most cases are characterized by too little utility for freight transport and their transport capacity is usually very low. The main reason is the lack of functional integration of ports with their logistic support, as well as with other ports being located outside Europe. Moreover, the volume of goods transported to Central Europe is still increasing. This situation obliges to intensify the activities for development of inland waterway transport in this region. As a result, to find the solution of this problems the project INWAPO has been initiated. Its aim is to activate unused potential of water transport in Central Europe, as well as river and sea ports. To achieve this goal, the project focuses on 3 major systems of waterways: the ports of the North Adriatic Sea (Venice, Trieste and Koper), dock on the river Danube (Vienna, Budapest, Bratislava, Komarno and Sturovo) and inland waterways in the Czech Republic and Poland (Elbe River basin, the Vistula and Oder) up to the ports on the Baltic coast (INWAPO: webpage A). The subject of authors' research was the development of inland waterways and inland ports on the Vistula river on Warsaw-Gdańsk tour.

The analysis takes into account the seaport of Gdansk and river ports in the following towns:

Tczew, Solec Kujawski, Plock and Warsaw. The section of the waterway Warsaw-Gdansk runs through the four voivodships of central Poland: Pomorskie Voivodship with its seat in Gdansk, Warmińsko-Mazurskie Voivodship with its seat in Olsztyn, Kujawsko-Pomorskie Voivodship with its seat in Torun and Bydgoszcz, as well as Mazowieckie with its seat in Warsaw (Fig. 1).



Fig. 1. Waterway of Vistula River Warsaw – Gdansk  
Source: INWAPO (2012b).

#### 3.2. The development of infrastructure and inland ports performance

Economic development of the area is closely linked with the development of the infrastructure. Expected development of inland ports have a significant impact on improving the transport net serving the area surveyed four regions. This phenomenon will result into improved routes passing through the region, and this will increase the interest of entrepreneurs in the area. The increased interest in the business will increase the level of employment among local residents, but also expand their career choices. These situations will contribute to increasing the level of citizen satisfaction, but also increase the level of wealth and economic development in the region.

The development of inland ports forces logistics infrastructure to adapt to the new structure of the flow of goods. There will be required investments in equipment handling, storage, computing, identity, etc. These investments will stimulate the activity of the providers of these elements and in the case of domestic suppliers will stimulate the development of Polish enterprises. The development of inland ports' impact on the socio-economic environment is presented in Table 2.

Table 2. The economic and social effects of activities of inland ports

The effects of activities of inland ports	
Economic	Social
The economic revival in the districts lying on the ports area.	Increase of road and rail traffic in the area of ports.
Development of companies cooperating with inland ports.	Increase of industrial and traffic noise in the area of ports.
Increase the availability of products and services, transported by inland and maritime transportation.	Increase of the region's road safety by reducing traffic (some cargo will be transferred to inland waterway transport).
New investments generating jobs - an increase in employment for the residents of regions.	Improving the quality of life through professional activation of local residents.
Increase in budget revenues of municipalities in respect of the activities of the ports.	The inflow of young people to the region, interested in working in the port.
Increasing the area of the transportation through the development of transport infrastructure, road and railway leading to ports and other communication areas such as port facilities, marinas, and structures for water transport.	Reduction of emigration inhabitants of the surroundings. Raising the "liveability" defined as the perceived level of satisfaction with life in the region because of the features that the place has.

### 3.3. Cargo forecast and fleet demand for Vistula river, relation Gdansk-Warsaw

Known in the literature forecasts of cargo imposed for river transportation in Poland is based in principle on the current structure of the Polish transport on waterways. It takes into account the assumptions of Polish transport policy. To the 2030 a significant share of inland waterway transport in the market is not provided. Currently, this share does not exceed 0.15%, calculated in cargo tonnes. In 2013, 2.23 million tons of cargo was transported in

domestic relations by river transportation (CSO, 2013). In international relations, this share increases to 0.9% of the total international cargo. Strategies and forecasts of the development of water transportation predict the share of domestic and international water transportation to a maximum of 0.9% (Burniewicz, 2009). In previous years and now, water transportation in Poland is focused on the Oder Waterway. Participation of Oder Waterway cargo, in entire Polish water transportation, ranged from 85 to 95%. Assuming that Vistula section from Warsaw to Gdansk, will meet the parameters of the waterway class IV, cargo forecasts for the Vistula cannot be based on the current share of the Vistula cargo.

Cargo forecasts were based on the Vistula region's share in relation to gross domestic product. Division for regions were defined by adopting a similar policy. The calculations were based on CSO data relating to the year 2012. The share of these regions in the gross domestic product is therefore 33.7%. This share is the basis of the Vistula cargo forecast. Table 3 shows the known cargo forecasts for water transportation and the Vistula River, section: Gdansk - Warsaw.

Table 3. The Vistula cargo forecast in mln ton

Forecast	Minister of Infrastructure (2011)*	Burniewicz (2009)	Ecorys (2011a)
Maximum	14,4	20	15,4
Minimal	12	18	10,35
Vistula max. Share 0,337	4,8	6,7	2,7*
Vistula minim. Share 0,337	4,0	6,0	1,8*

\*Transport development strategy

These predictions do not take into account the service of Gdansk and Gdynia ports from the Vistula side. The share of the Vistula in service of Gdansk and Gdynia ports can be comparable with the ARA (Amsterdam, Rotterdam, and Antwerp) ports, assuming that the Vistula waterway and its waterway connections to the Eastern Europe and the Oder achieve class IV. In the case of existing restrictions (IV class on Gdansk-Warsaw section), this share can be estimated up to 10%.

In assessing the benefits of reviving of the Vistula River, the impact of Gdynia Port will be skipped. To assess the benefits of transport on the Vistula River, it is assumed that the share of water transport related

with the port of Gdansk service will be 1% (see e.g. Port Gdańsk, 2013: webpage, for demand forecast). This is a very conservative assumption. Still, as adopted forecast exceeds the forecasts contained in the Table. 3. Analysis of the benefits will be done for the optimistic variant - 10 million tonnes and 7 million tonnes if pessimistic. The assumptions differ significantly from the capacity of the Vistula as IV Class waterway. Capacity of the Vistula River from the mouth to Warsaw depending on the type of the fleet is in the range of 10 to 45 million tonnes per year. The lower limit refers to the fleet currently operated in Poland. Commissioning of transport on the Vistula River will require the construction of new generation fleet, adapted to the IV class waterway.

Taking into account the structure of the transport on the Europe waterways, and the structure of transshipping in ports of Gdynia and Gdansk, the following percentage structure of the Vistula River was adopted:

- Containers – 30%,
- Bulk – 45%,
- Liquid – 15%,
- Other – 10%.

Forecast founded as mentioned is shown in a Table 4. The capacity of container ships and terminals is described by TEU (Twenty-foot equivalent unit). This is equivalent to a standard unit of ISO 20 feet container volume.

According to the involvement of the regions in the creation of gross domestic product, the Table 5 shows the flow of cargo to various ports. It is assumed that the region of Warmia is supported by Tczew port. Plock located in a region of Mazovia participates in all of the liquid transportation on the Vistula River.

In ECORYS (2011b), containers freight's forecast for the ports of the Gdansk - Warsaw section was determined on 201 400 TEUs. This forecast is

similar to pessimistic forecast for the transport of containers.

Table 4. Vistula's load structure

Load type	Optimistic forecast	Pessimistic forecast
Container mln ton/TEU	3,0/300 tys TEU	2,1/210 tys TEU
Bulk mln ton	4,5	3,15
Liquid mln ton	1,5	1,05
Other mln ton	1,0	0,7
Sum mln ton	10,0	7,0

The fleet operating currently on Polish waterways is not adapted to the proposed parameters of the Vistula (class IV). To assess the capacity and transportation costs, the fleet's parameters adapted to the waterway class IV and above should be assumed. The proposal will be based on a fleet operating on the waterways of the Western Europe, and planned for the Vistula River in so called Vistula Programme, last century. The limitations resulting from the dimensions of hydraulic structures (locks) were taken into account:

- The length of the lock - 190 m,
- The width - 12m,
- The maximum depth at the threshold - 3.5 m.

According to the assumptions, the current lock at Wloclawek, 115 m length, will be extended to the standard length of 190 m. The basic parameters of the fleet taking into account the constraints of hydraulic structures are shown in Table 6. In the case of the pushed train, exploitation in single-row system with two barges (P + 2PB) is assumed. The width of barges 11.45 enables to loading 4 containers in a row. This solution was placed in service on the Rhine. Demand for the fleet for the entire Lower Vistula waterway is summarized in Table 7.

Table 5. The flow of cargo on Vistula River

Load	Port, distance from Gdansk in km							
	Tczew 40 km		Solec Kujawski 180 km		Plock 308 km		Warszawa 420 km	
	Optim.	Pessim.	Optim.	Pessim.	Optim.	Pessim.	Optim.	Pessim.
Container TEU	71 400	50 000	38 100	27 000	-	-	190 500	133000
Bulk mln ton	1,07	0,75	0,6	0,4	-	-	2,9	2,0
Liquid mln ton	-	-	-	-	1,5	1,05	-	-
Other mln ton	0,24	0,16	0,13	0,1	-	-	0,635	0,45

Table 6. Parameters of the fleet proposed for Vistula River

Type of a ship	Barge, small EUROPA*	Barge, large GMS*	Pushed Barge A III**	Pusher Tug Bawół II**
Lenght L [m]	85,0	110	82	22,35
Width B [m]	9,5	11,4/11,45	11,4/11,45	11,4
Max Draft T[m]	2,7	3,5	2,3/3,5	1,75
Capacity P <sub>L</sub> [ton]	1500	3000	1840/2600	-----
Containers TEU amount in 1 layer	3x9=27 max. 3 layers	4x13=52 max. 4 layers	4x10=40 Max. 4 layers	-----
Propulsion power [kW]	900,0	1100	--	2x690 =1380

\* according to VBD (2004)

\*\* according to The Ministry of Communication (1979)

Table 7. Summed fleet demand for cargo transport on Lower Vistula Waterway

Gdansk - Warszawa summed demand		Optimistic	Pessimistic
T=2,5	barges	223	165
	GMS	76	55
	pusher tugs	53	39
	pushed barges	147	110
T=3,5	barges	206	149
	GMS	69	51
	pusher tugs	49	35
	pushed barges	137	98

### 3.4. Operating and external costs in road, rail and inland transportation

Operating costs in inland transportation depend on the draft of the fleet, payload, transportation technology (motor barges, pushed trains, the COMBI system). German literature data, calculations for Oder Waterway conditions indicate significant influence of draft and payload (Kulczyk et al., 2011; VBD, 2004; PLANCO, 2007). Draft and payload is closely related to the basic parameters of the fleet. The structure of the size of the fleet in Europe for decades shows a clear upward trend in the fleet with a capacity of more than 3000 tons (CCR, 2014). It is also preferred COMBI system. It uses pushed barges, with different parameters from the currently built.

The proposed fleet for the Vistula River is part of the existing trends in the development of inland fleet in Europe. Accordingly, the costs will be defined on the basis of data relating to the German navy (PLANCO, 2007). Adopted for the calculation, unit costs are presented in Table 8. Cited literature, as well as other sources in terms of external costs

provide the minimum, maximum and average external costs. For further analysis average values of these costs were assumed. Also the division by components of external costs was not made. Costs are based on research and analysis of the first decade of the 21st century. The external costs to a large extent are determined by the amount of energy per unit of transport work. Forecasts for 2020 assume a reduction in energy consumption (compared to 2005) by 3%. In road transport, this reduction is estimated at 18%. However, taking into account such factors as road conditions, traffic flow suggests that energy consumption will increase slightly. All costs will be determined in EUR. Paper (PLANCO, 2007) presents a comparative analysis of operating and external costs for road, rail and inland transportation. The different routes, different technical parameters of means of transport were taken into account. It was assumed that part of the return trips are without a load. Based on these data, the average unit specified external costs and operating costs, as shown in Table 8.

Based on the above accepted unit costs, transportation costs were identified (Table 9) and the external costs (Table 10) of the Vistula waterway. Costs determined that way do not include the actual transportation work, taking into account the actual transport routes. For detail shipping costs and external costs, the costs per unit of transport work were determined. The costs of all transport means have been estimated based on German data contained in the paper (PLANCO, 2007). The same conversion from the costs in Euro per tonne of cargo on unit transportation work costs was used. With regard to the transport of containers it was assumed that the average gross weight of container is 12.5 tons.

Table 8. The unit costs of transportation and external costs for different means of transport.

Mean of transport	Exploitation costs		External costs (average)	
	Bulk (€/ton)	Containers (€/TEU)	Bulk (€/tone)	Containers (€/TEU)
Road	36,05	330,25	30,47	309,52
Rail	9,62	216,05	11,54	220,24
Inland navy	7,37	151,23	7,10	148,81

Table 9. Transportation costs for different means of transport.

Mean of transport	Bulk		Containers	
	Optimistic forecast mln €	Pessimistic forecast mln €	Optimistic forecast mln €	Pessimistic forecast mln €
Road	252,35	176,645	99,07	69,35
Rail	67,34	47,14	64,81	45,37
Inland navy	51,59	35,38	45,37	31,76

Table 10. External costs for different means of transport

Mean of transport	Bulk		Containers	
	Optimistic forecast mln €	Pessimistic forecast mln €	Optimistic forecast mln €	Pessimistic forecast mln €
Road	213,29	149,30	92,87	65,00
Rail	80,78	56,55	66,07	46,25
Inland navy	49,70	34,79	44,64	31,25

Taking into account the obtained results, should be stated that:

- Water transportation including external costs, generates the lowest total cost compared to other systems,
- On the water transportation cost a significant impact has fleet size and, above all, draft,
- No significant difference in transport costs between pushed system, and the use of motor barges,
- Comparing the difference between the cost of the optimistic and pessimistic option it can be assumed that the increase in the share of water transport will generate even greater financial benefits
- Comparing the difference between the cost of the optimistic and pessimistic option it can be assumed that the increase in the share of water transport will generate even greater financial benefits.

#### 4. Revitalisation of riverside areas

Riverside areas are important, often the only ones in selected metropolitan areas, open spaces, which may function as green parks and recreational areas. Unfortunately, these spaces are often degraded, polluted and unused. The concept of unblocking and stabilizing the Lower Vistula should be combined

with efforts to provide the river area for people to make it larger urban areas, green and aquatic systems. The idea of riverside revitalization is already the part of the strategy of selected cities located along the lower section of the Vistula, namely Bydgoszcz, Tczew, Gdansk and Torun.

What is important for prepared and performed projects is primarily their comprehensive approach, which should take into account the environmental, social and economic aspects, such as:

- quality of life in riverside agglomeration,
- community involvement of local residents,
- sustainable economy,
- safety and health,
- protection of water resources,
- environmental protection.

Revitalisation of riverside areas should include actions aimed at promoting water sports, recreation and education of the local community and small business development. Among the most implemented projects can be mentioned:

- construction of walking hiking, biking and horseback trails,
- construction of overpasses, bridges, harbours, marinas, boathouses,
- construction of recreational logs, bathing, recreational and sports complexes including the necessary infrastructure,

- catering and hostels bases development,
- creation of educational paths.

These activities, with the approval of local communities bring certain economic and social benefits (Table 11).

When analysing the economic aspects of the redevelopment of riverside areas one should also be aware of the incurred costs. It is important in this case to play two expense positions associated with the implementation of such a project, such as the cost of the project itself and the subsequent maintenance costs of this area. Among the negative social effects, there should be distinguished the increase of noise level at the revitalized areas, resulting e.g. due to organized entertainment and cultural events, or use of a motor-powered boats that are used for tourist and recreational purposes and which can generate noise at a very high level.

Table 11. Benefits from the riverside areas revitalization

Social benefits	Economic benefits
Creating opportunities for recreation and walks.	Increase in the value of real estate in and around riverside areas.
The ability of experiencing the contact with nature.	Improved flood protection with the potential use of natural retention.
The possibility of social education.	Economic activation of the local community.
Improvement of the local climate.	Development of small businesses catering, craft, industrial, and other services.
Increase of a sense of security of local community that uses the riverside areas.	Investment in the revitalization project.
The benefits of improving the groundwater status.	
Designing of places for meeting and resting.	
Improving local social interaction.	
Possibility of integration of selected social groups.	
The development of the concept of sustainable development.	
Raising awareness of the responsibilities for the environment.	
Ability to create environment-friendly playgrounds.	
Increase of physical activity of inhabitants of the surrounding areas.	
The ability to play water sports and tourism.	

### 5. Summary

Inland waterways shipping in BSR needs investments that would bring the waterways to the state that allows its usage. Development of container shipping on Polish inland waterways is primarily determined by:

- improving the performance of linear infrastructure
  - waterways (ultimately to the IV and V navigable class)
- commissioning of hour front inland water transport (shorter container delivery time).

Fulfilling those demands will create the conditions for effective competition of inland waterway transport with other modes of transport to support handling of container shipping on container terminals in the port of Gdansk and Gdynia port and its economic hinterland. Forecast for transportation volume made at these terminals mentioned in the perspective of 2030 and 2037 amounts to approx. 68 million tonnes (pessimistic)/approx. 100 million tons (optimistic) for the port of Gdansk, and 32 million tons for the port of Gdynia. As a result of the research, it was assumed that the share of water transport in the port of Gdansk will be 1%. Development of logistics schemes, therefore, was based on the assumption of optimistic condition - 10 million tonnes and pessimistic 7 million tonnes.

There should be also kept in mind, that the final forecasted volume of demand for freight transport by water was estimated based on the current data and the known current macroeconomic, sector, intermodal, technological, organizational, environmental and social conditions. However, the real size of this demand will be the result of changes in transport intensity of different sectors of the economy, policy action influence, changes in logistics concepts and lifestyle households. It should be expected that the current growth trends can expire, going in a downward phase and downward trends can be improved. Furthermore, there will be developed new types of transport services that have no counterpart in the past. It should also be remembered that transport demand trends in the decade of 2020-2030 will develop differently depending on the emerging new transport capacity of aviation, intermodal transport and inland waterways.

In addition, there have been defined requirements for fleet to manage such specific operations. Proposed water fleet was based on e.g. existing and

operating fleet on the waterways of Western Europe (the Rhine). Adopted capacity of the waterway transport is significantly higher than the forecast adopted in the study.

## References

- [1] BURNEWICZ, J., 2009. *The vision of the structure of transport and development of transport networks by the year 2033. With specific regard to a targeted structure of transport model (in Polish)*. Warsaw.
- [2] CCR, 2014. *Europäische Binnenschifffahrt, Marktbeobachtung 2014*. Zentralkommission für Rheinschifffahrt. Europäische Kommission.
- [3] CSO, 2013. *A large Polish Statistical Yearbook 2013*. Warsaw: Central Statistical Office of Poland.
- [4] CSO, 2014. *Inland waterways transport in Poland in 2010-2013*. Warsaw: Central Statistical Office of Poland.
- [5] ECORYS, 2011a. *Development Program of inland water transport in Poland (in Polish), Part 1*. Warszawa, Rotterdam: Ministry of Infrastructure.
- [6] ECORYS, 2011b. *Development Program of inland water transport in Poland (in Polish), Part 2*. Warszawa, Rotterdam: Ministry of Infrastructure.
- [7] HANN, M., PIOTROWSKI, L. and WOŚ, K., 2014. Adaptation of the Oder River for the purposes of inland water transport. *Logistyka*, 6, pp. 13313-13321.
- [8] INWAPO Webpage A, , INWAPO - informacje ogólne. Available: [www.armsa.pl/INWAPO,-informacje,ogolne,186.html](http://www.armsa.pl/INWAPO,-informacje,ogolne,186.html).
- [9] INWAPO Webpage B, INWAPO-project. Available: [www.inwapo-project.eu/](http://www.inwapo-project.eu/).
- [10] INWAPO, 2012a. *Market review analysis – overview and analysis of Inland waterway transport market on the Oder and Vistula rivers*. WP 5 5.2.4. Gdańsk: Maritime Institute in Gdańsk.
- [11] INWAPO, 2012b. *Report on the potential waterborne transport volume*. SWP 3.3.8. Warsaw: ECORYS Polska.
- [12] INWAPO, 2014. *Technical, economic and environmental studies of Vistula river revitalization and navigability restoration on Warsaw-Gdańsk tour*. WP 5 5.4.6. Gdynia: Gdynia Maritime University.
- [13] KULCZYK, J., LISIEWICZ, T. and NOWAKOWSKI, T., 2011. *Logistical conditions of coal of transport in the corridor of the Oder Waterway (in Polish)*. SPR-45/2011. Wrocław: Institute of Machines Maintenance and Operation, Wrocław University of Technology.
- [14] MARCINIAK, Ż., 2013. The lower Vistula in the aspect of the E40 and E70 international shipping routes. *Acta Energetica*, 2(15), pp. 153-161.
- [15] MARITERM Webpage, Available: [www.mariterm.se/inlatrans](http://www.mariterm.se/inlatrans)
- [16] MILEWSKI, D., Webpage, Inland water transport in the Baltic Sea Region (BSR) Transportation System [Homepage of TransBaltic], [Online]. Available: <http://www.transbaltic.eu/wp-content/uploads/2011/08/Inland-transport-in-the-BSR-Transport-System.pdf>].
- [17] MINISTER OF INFRASTRUCTURE, 2011. *Project of Transport Development Strategy until 2020 (with a view to the 2030)*. Warsaw: Minister of Infrastructure of Poland.
- [18] MINISTERIAL COUNCIL RP, 2002. *The Regulation of the Ministerial Council of 7<sup>th</sup> May 2002 on Inland Waterway Classification*. The Journal of Laws, No. 43, Item 695 edn. Poland.
- [19] NAIADES Webpage, Available: [www.naiades.info](http://www.naiades.info).
- [20] NAM, K. and WIN, E., 2014. Competitiveness between road and inland water transport: the case of Myanmar. *Transport Problems*, 9(4), pp. 49-61.
- [21] NOTTEBOOM, T., 2008. Bundling of freight flows and hinterland network developments. In: R. KONINGS, H. PRIEMUS and P. NIJKAMP, eds, *The Future of Intermodal Freight Transport, Operations, Technology, Design and Implementation*. . Edward Elgar edn. Cheltenham, pp. 66-88.
- [22] PLANCO, 2007. *Verkehrswirtschaftlicher und ökologischer Vergleich der Verkehrsträger Strasse, Bahn und Wasserstrasse*. Essen: PLANCO Consulting GmbH.
- [23] PORT GDAŃSK Webpage, 2013-last update, *Strategia Rozwoju Portu Gdańsk do 2027*.

Available: [www.portgdansk.pl/zmpg-sa/strategia-rozwoju](http://www.portgdansk.pl/zmpg-sa/strategia-rozwoju).

- [24] SRIRAMAN, S., 2010. Long Term Perspectives on Inland Water Transport in India. *RITES Journal*, 12(1), pp. 18.1-18.14.
- [25] THE MINISTRY OF COMMUNICATION, 1979. *Study of Transport Wisla, Synthesis (in Polish)*. Warsaw: The Ministry of Communication RP.
- [26] VBD, 2004. *Technische und wirtschaftliche Konzepte für flussangepasste Binnenschiffe*. . Bericht 1701. VBD Duisburg.
- [27] WOJEWÓDZKA-KRÓL, K. and ROLBIECKI, R., 2008. Development directions of inland waterways in Poland (in Polish). *Infrastruktura Transportu*, 3, pp. 14-19.
- [28] WOJEWÓDZKA-KRÓL, K., 2014. Inland water transport in the light of contemporary social and economic problems. *Zeszyty Naukowe/Akademia Morska w Szczecinie*, 37(109), pp. 89-94.