BSR ELECTRIC

Interreg Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

GDAŃSK

BALT YARD

Technical, economic, environmental and practical aspects of

introducing electric ferries to the urban transport system of Gdansk

The study is part of the BSR Electric project, co-founded by the EU under the Baltic Sea Region Programme

Balt Yard Sp. z o.o.

Technical, economic, environmental and practical aspects of introducing electric ferries to the urban transport system of Gdansk

Executive summary

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2018-11-30

PREREQUISITES FOR UNDERTAKING THE STUDY

Although first attempts to introduce electric vehicles to maritime transport were made as early as in the first half of the nineteenth century, the electric drive has been significantly improved in the second decade of the twenty-first century. A symbolic milestone was implementation the first fully electric ferry called *Ampere*. It started operating in Norway on the Sognefjord in May 2015. Nowadays, ferry shipping is a pioneering sector in which electric propulsion systems are being developed most dynamically. There are two main reasons for that: (i) ferries usually operate on short routes and they can be served using the amount of energy stored in batteries, (ii) they sail between the same harbours equipped with charging appliances. The electrification process is progressing in urban, regional and even international scales. Some fleet modernisation programmes have already been introduced in the cities like Copenhagen or Amsterdam. A general trend is to enhance basic performance of batteries – capacity, life and charging time as well as to decrease their unit production costs, what allows to cover longer distances and exploit the vehicles more intensively and less costly at the same time.

In 2012, thanks to the EU funds, there were two water tram lines established in Gdansk. However, their routes, seasonality, frequency and location of the stops have made them mainly of tourist and recreational importance. The number of passengers served by the water trams had been systematically growing and it reached almost 66 thousand in the summer of 2018. The EU co-founded project finished in June 2017 and some new possibilities are now available for modifying the offer and the system itself. It was the first prerequisite to undertake this study. The second one was the fact that in May 2016, after almost 40 years of operation, the line from Nowy Port to Twierdza Wisłoujście was closed. It was a result of opening a new tunnel under the Martwa Wisła river. The citizens living in Nowy Port have already articulated the necessity to reopen the line, in a form tailored to the current needs.

THE MAIN OBJECTIVE AND SCOPE OF THE STUDY

The main objective of this study is to provide expertise on technical, practical, economic and environmental conditions of introducing electric ferries to the urban transport system of Gdansk. On the basis of the good practices analysis and a wide spectrum of differentiated conditions, several possible options of the ferry and cruise vessels lines have been prepared. Moreover, some basic characteristics of vessels, which could be used to serve the lines, have been provided in the study as well as potential financial, environmental and socio-economic results of the proposed solutions.

PROPOSED CONNECTIONS, LINES AND TYPES OF VESSELS

DESCRIPTION OF CONNECTIONS AND LINES PROPOSED

Structure of the proposed connections deeply modifies the existing transport system. In the case of line F5 the location of stops has been changed – new stops are Wałowa, Polski Hak and Westerplatte

(fig. 1). Total length of the water tram line as well as the number of stops depend on the adopted option of the ferry crossing in Nowy Port (Nabrzeże Zbożowe – Westerplatte). Taking the basic option (IA) under consideration, which assumes that the crossing is open all year long and it is limited to only two stops on the opposite banks of the Vistula River, the vessel serving line F5 will stop at Twierdza Wisłoujście where passengers can take a ferry heading to Falochron Zachodni.

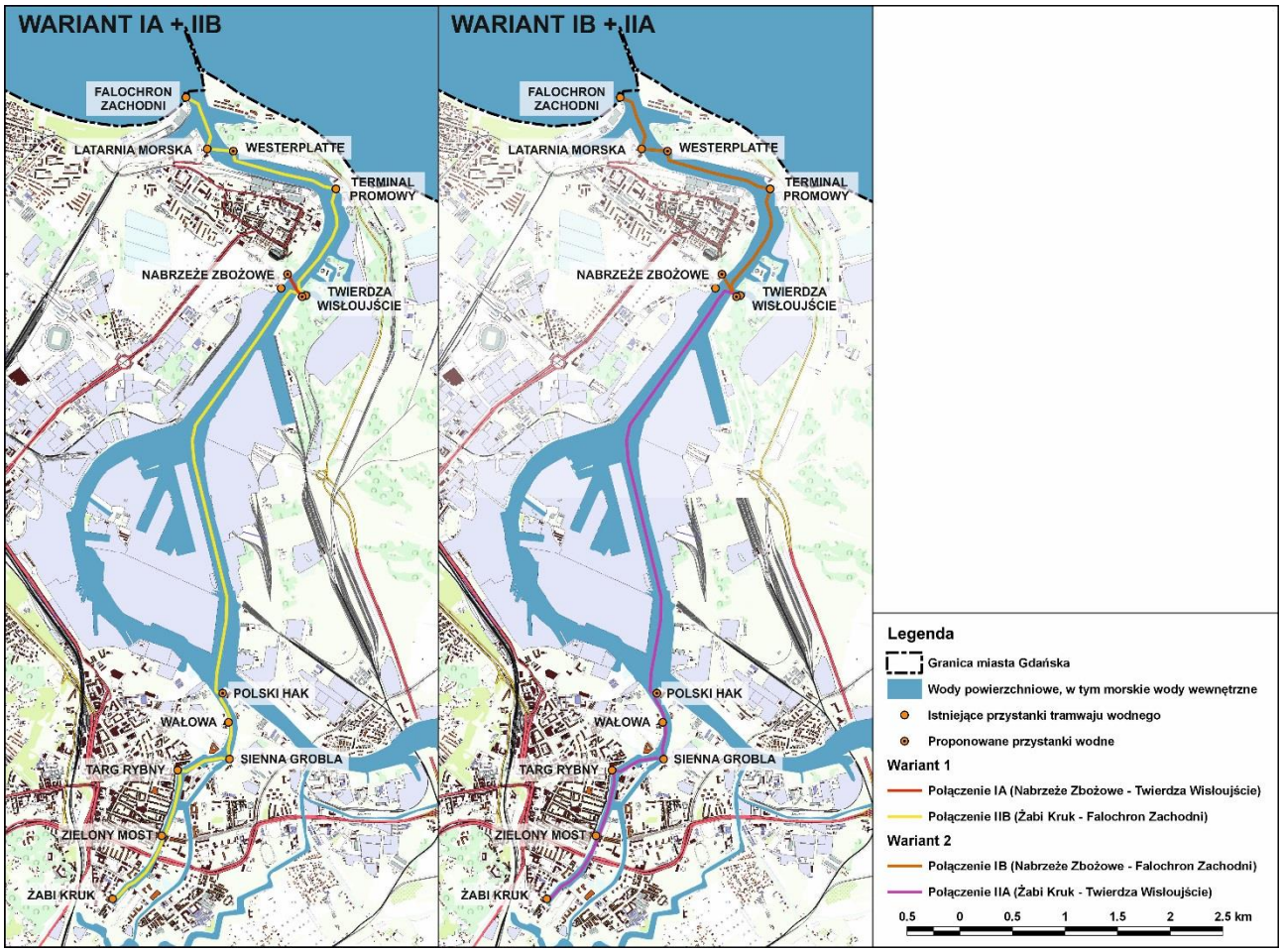
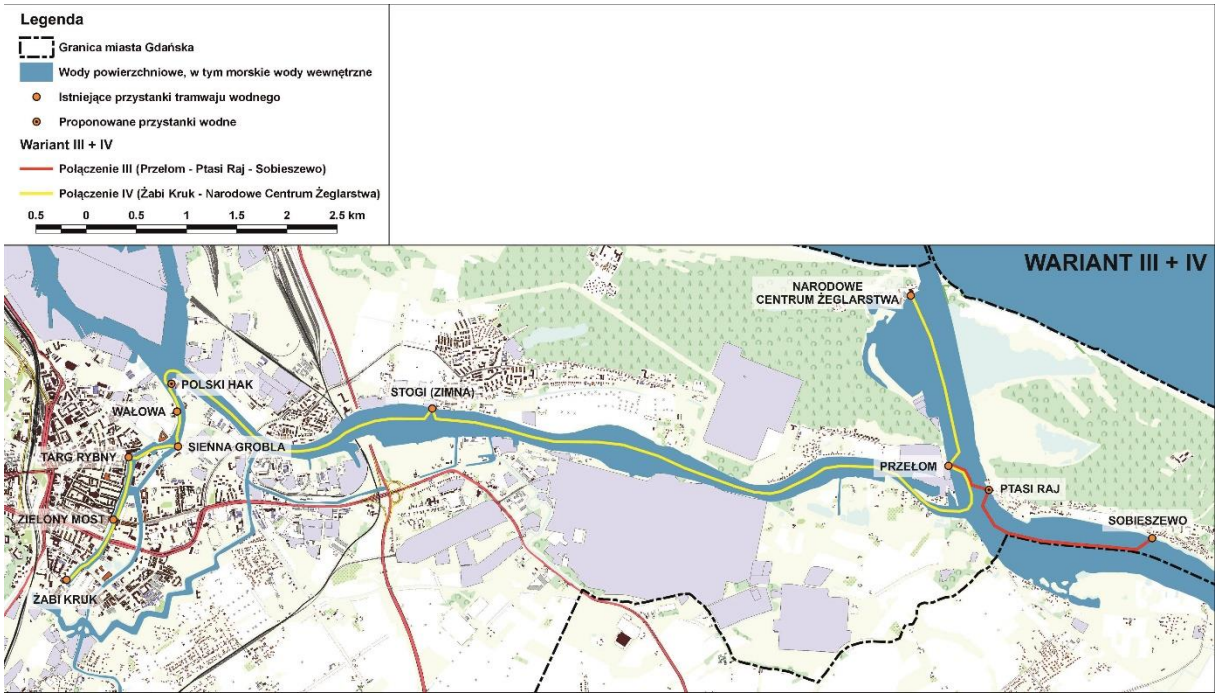


Fig. 1. Proposed options of the water tram line from Gdańsk Główny to Westerplatte and Brzeźno.
Source: own elaboration.

Connection IB expands the area of the ferry operation, including all the stops located towards the mouth of the river. This solution significantly decreases frequency of vessels operating on the line from Nabrzeże Zbożowe – Wisłoujście, but it incrases frequency of vessels serving the most attractive tourist spots like: Twierdza Wisłoujście, Westerplatte, Latarnia Morska and Falochron Zachodni. The additional stops, not included in the basic option will be served only in summer (May – September). Establishing connection IB will allow to shorten the distance covered by a water tram connecting Śródmieście with Twierdza Wisłoujście (IIA) as well as to increase the frequency of services provided on this line.

The course of the water tram line towards Narodowe Centrum Żeglarstwa in Górki Zachodnie will be the same as the course of line F5 in the Motława section. Then, it will go along Martwa Wisła and further to Wisła Śmiała (connection III). In the new proposed option the Przełom stop plays a significant role (fig. 2). It will serve both passenger vehicles operating on line F6 and ferries serving the section from Przełom through Ptasi Raj (a new stop) to Sobieszewo (connection IV). This connection will significantly increase attractiveness of the area in the mouth of Wisła Śmiała River,

allowing the passengers to explore interesting objects and sites on both banks of the river. It will also be an interesting alternative route for cyclists travelling along the international cycling route R10.



Ryc. 2. Proposed options of the water tram line from Gdańsk Główny to Górki Zachodnie and Sobieszewo.
Source: own elaboration.

All the proposed connections, excluding the one from Nabrzeże Zbożowe to Twierdza Wisłoujście which is planned to operate all year long, are assumed to be seasonal (May – September).

VEHICLES AND THEIR CARRIAGE POTENTIAL

Two types of vehicles are planned to serve the proposed lines and connections. The first one will serve lines IA, IIB and III – it is a double-ended bicycle-passenger ferry with an option to carry one privileged medium-sized vehicle. The second type of the vehicles will serve lines IIA, IIB and IV. It will be similar to the *Sonica* vehicles which operate on line F5 and F6 now, yet with enhanced exploitation parameters, including vehicle dynamics and various technical parameters. Both mentioned types of vehicles can carry passengers and bicycles.

The electric double-ended ferry, which will serve the all-year lines, shall be capable of operation in ice covered waters. The stern and bow shall be identical (both allowing to load and unload the vehicle) and it should have enough space to carry a privileged vehicle (e.g. ambulance) in case of emergency. In such a case there are no passengers carried at the same time.

As for the passengers, the vessel shall be equipped with protective shields on the board, sides, bow and the stern in order to protect passengers from rain and wind, especially in winter. In the winter the passengers' rooms shall also be heated. The vessel shall also allow passengers to quickly embark and disembark. It is assumed that the vessel will be served 24 hours a day by 2 crew members in a 12/24 cycle, if not stated otherwise by the legal provisions. The vehicle engine power shall be at least 250 kW and it should be equipped with batteries having capacity of approximately 180 kWh. The

capacity of batteries could be decreased only when choosing option IA. The vessel shall have the carriage capacity of 30 people and 10 bicycles.

The passenger vehicle serving lines IIA, IIB and IV does not have to be equipped with systems allowing to operate in ice covered waters as those lines are planned to be in use only from May to September. However, the vessel shall be adopted to the conditions of the rivers in Gdańsk – low bridges, shallow and polluted waterways. The space for passengers and bicycles shall be covered from above. There should also be some removable side shields with windows allowing tourists to observe the view. The vessel shall also have entrances on both sides. It is assumed that it will be served by 3 crew members. The vehicle engine power shall be between 200 and 250 kW and it should be equipped with batteries having capacity of 120-150 kWh. Taking the line length and the lack of time to charge the batteries under consideration, it is recommended to introduce a hybrid drive system. The vessel shall have the carriage capacity of 50-60 people and 30 bicycles.

Taking all the speed limits, scheduled time of stops allowing the passengers to embark/disembark, the necessity to recharge the batteries and the carriage capacities of the vessels under consideration, frequency of services and maximum carriage potential have been assessed in the study. In the case of line F5 it is assumed that it will be served by 2 or 3 cruise ships. As for line F6, it will be served by one ship and two ferries – one for each ferry crossing (tab. 1).

A key determinant for the whole system to be efficient is to provide charging stations on the river banks allowing to fully charge the batteries during the night break in operation. In order to implement the proposed solutions, 600 kW unified bank chargers shall be installed which allow fast charging during stops and slow charging during night breaks in operation. Depend on which option will be chosen, 6 or 7 stops shall be equipped with such chargers.

Tab. 1. Proposed water tram connections and lines in Gdansk

Connection name	Route	Period of operation	Approximate route length (one way) [in m]	Approximate time of one-way journey [min]	Approximate maximum speed [knt]	Potential one-way daily frequency	Type/number of vessels	Maximum daily one-way carriage potential	Maximum daily both ways carriage potential
IA	Nabrzeże Zbożowe - Twierdza Wisłoujście	12 months a year January-December	255	10	7 – all the route	20	Double-ended ferry (1)	600 pas. 200 bikes	1200 pas. 400 bikes
IB	Nabrzeże Zbożowe - Twierdza Wisłoujście - Terminal Promowy - Westerplatte - Latarnia morska - Falochron zachodni (Brzeźno)	seasonal May-September	3355	25	7 – all the route	12	Double-ended ferry (1)	360 pas. 100 bikes	720 pas. 200 bikes
IIA	Żabi Kruk - Zielona Brama - Targ Rybny - Sienna Grobla - Wałowa - Polski Hak - Twierdza Wisłoujście		7010	60	4 - From Żabi Kruk to Polski Hak, 7 - remaining	10	Ship (2)	550 pas. 300 bikes	1100 pas. 600 bikes
						15	Ship (3)	825 pas. 450 bikes	1650 pas. 900 bikes
IIB	Żabi Kruk - Zielona Brama - Targ Rybny - Sienna Grobla - Wałowa - Polski Hak - Twierdza Wisłoujście - Terminal Promowy - Westerplatte - Latarnia Morska - Falochron zachodni (Brzeźno)		10115	80	4 - From Żabi Kruk to Polski Hak, 7 - remaining	8	Ship (2)	440 pas. 240 bikes	880 pas. 480 bikes
						12	Ship (3)	660 pas. 360 bikes	1320 pas. 720 bikes
III	Przełom - Ptasi Raj - Sobieszewo		2470	20	7 – all the route	11	Double-ended ferry (1)	330 pas. 110 bikes	660 pas. 220 bikes
IV	Żabi Kruk - Zielona Brama - Targ Rybny - Sienna Grobla - Wałowa - Polski Hak - Stogi (Zimna) - Przełom – Narodowe Centrum Żeglarstwa (NCŻ)		13660	90	4 - From Żabi Kruk to Polski Hak, 7 - remaining	4	Ship (1)	220 pas. 120 bikes	440 pas. 240 bikes

Option IA+IIB Option IB+IIA Option III+IV

Source: own elaboration.

MAIN SPATIAL, SOCIO-ECONOMIC AND REGULATORY CONDITIONS OF THE PROPOSED OPTIONS

Course of a particular line, speed limits and, therefore, frequency of services is affected by the existing waterways system (tab. 2). However, settlement patterns, spatial distribution of workplaces and tourist attractions as well as characteristics of the transport system usually determines a tourist-recreation function of the line.

Tab. 2. Main spatial, socio-economic and regulatory conditions of the proposed options

Kategory	Main features
Waterways network structure	The main barriers for ferries and cruise ships operating on Motława, Martwa Wisła and Wisła Śmiała Rivers result from low bridges and low speed limits for cruising. The main barriers for development of water tourism: maladjusted shores, inaccessible riverbanks and bridge structures with limited ground clearance. Dominating functions: industrial and recreational; inland waterway transport plays a marginal role.
Spatial distribution of the main areas of socio-economic life	Waterways connect Śródmieście with less densely populated districts. Waterways connect the area with a high density of workplaces (Śródmieście) with less significant areas. Waterways connects areas with high tourist attractiveness.
Connection with the urban transport system	The waterway network in Gdansk connects parts of the city which are already served by other means of transport, thus, the network has a low competitiveness potential. Some stops should be better connected with cycle routes and stations of the metropolitan bike.
Spatial policy	The areas of Gdansk through which the waterways run through are usually covered with master plans. Most of the master plans include some provisions regarding port activity and water transport. Arrangements, recommendations and information regarding construction some new or modernisation of the already existing waterways can be found in seven master plans. However, only one of them mentions construction of a new canal accessible to a water tram.
Organisational and legal conditions	Strong EU pressure to develop a low-emission public transport system is clearly visible in the funding programmes (POIiŚ, regional operational programmes). On the national level, the financing and legal solutions regard mainly spreading the idea to drive electric cars yet it seems that supporting implementation of zero-emission or low-emission ferries in possible.

Source: own elaboration.

Spatial policy usually creates opportunities to increase quality of waterfront areas development, although it often concentrates more on modernisation of the stops and their vicinity and less on modernisation and development of the waterways themselves. As the analysed good practices show, there are some EU funding opportunities for such development projects. The national regulations also create possibilities for co-financing undertakings of this kind.

POTENTIAL FINANCIAL EFFECTS

The economic and financial analysis has shown that operation of an electric ferry on line IA will be loss-making each year. The 2026 loss is predicted to be 3 705 612 PLN, thus each hour of the ferry

operation will make a loss of 846 PLN. Total loss generated by the ferry connection IA in the period 2020-2032 will be 34 435 047 PLN.

The network of connections including IA+IIB+III+IV will generate a loss of 17 995 697 PLN in 2026 while the option IB+IIA+III+IV – 17 861 393 PLN.

All the proposed options are loss-making ones. It is a result of large investment expenditures (high cost of repaying credit instalments) and rather low incomes generated by the services themselves. Assuming the highest possible annual level of potential carriage usage, the income generated by connection IA (tickets sold) covers only 33% of the operating costs and 15% of the total costs. In order to increase the incomes, some promotional actions shall be taken – promotion is a small fraction in the structure of total expenditures. However, the price of tickets is too low, to significantly contribute to the total incomes, no matter how popular the line will become.

It is possible also to reduce the expenditures, especially in the area of labour costs. The assessment shows that in 2026 the labour costs for line IA will constitute 48% of the total expenditures – it is 908 668 PLN. In the case of the seasonal connections (IIA, IIB, III, IV) it is even more. In such a situation employing the crew for the period of May-September shall be considered, although it may be difficult to find qualified employees willing to work only for several months a year.

In order to increase the line profitability, some external funding opportunities can be used, especially the donations from external sources. The analysis has shown that if the European Union covers 50% of the investment cost, it will be possible to decrease the loss by 736 475 PLN. It is a direct result of lower annual credit instalments and lower annual costs of the principal repayment.

Another cheaper solution is to implement internal combustion engine powered vessels. Although they generate higher operating costs, resulting mainly from the continuously growing fuel prices, they do not generate such high investment costs, regarding both purchasing new vessels and modernising the infrastructure. When connection IA is served by a traditional diesel vessel, total loss in 2026 will be 2 649 498 PLN.

Nonetheless, it should be emphasised that not all the costs incurred by the operator are of monetary nature. Let's take amortisation costs – they are not direct expenses. The financial analysis takes this aspect into account as well. In 2026, if connection IA is chosen, the Municipality of Gdańsk will provide 2 793 010 PLN to support the ferry operation. When the already-mentioned 50% of the investment cost covered by the EU is taken under consideration, the additional sum of 2 056 535 zł PLN shall be added to the calculation for 2026. If the connection is served by a traditional diesel ferry, the Municipality of Gdansk will provide 2 298 888 PLN a year. Therefore, during the whole period of 2020-2023, connection IA served by an electric ferry will have to be subsidised by a total amount of 25 309 031 PLN. If the 50% co-founded by the EU is taken under consideration, the total subsidy needed will be 17 551 434 PLN. Introducing a diesel ferry will require a subsidy in the amount of 22 156 618 PLN.

The proposed option IA+IIB+III+IV served by electric ferries and hybrid water trams will require a total subsidy of 118 090 167 PLN in the period of 2020-2032 while the option IB+IIA+III+IV – 116 371 440 PLN.

POTENTIAL ENVIRONMENTAL EFFECTS

The assumed supply of transport services served by electric and hybrid vessels will allow to reduce the level of pollution in the area of their operation (no matter the chosen connection option for the route from Śródmieście to Nowy Port) in comparison to 2018. The proposed solutions may have a positive effect on the environment, especially on air quality in Gdańsk. It has been assessed that in the one year period the electric and hybrid vessels will produce 18-30% of pollutions emitted by traditional diesel vessels. However, in comparison to 2018, during which the supply of transport services was significantly lower, it is possible that the proposed option will not contribute to increasing the air quality at all. Launching connections III and IV served by electric and hybrid vessels will result in reducing the level of pollution by approx. 64% in comparison to 2018, during which water trams were operating on line F5. At the same time, the supply of transport is assumed to be higher by approx. 89%. Unfortunately, the proposed option for the route Śródmieście - Nowy Port (connections IB and IIA served by 3 ships) will result in increasing the level of pollution by 51% in comparison to 2018. The supply of transport for this option is assumed to be higher by approx. 263%.

POTENTIAL SOCIO-ECONOMIC EFFECTS

When analysing possible socio-economic effects of implementing electric ferries and hybrid passenger ships, the authors referred to the operational programmes for 2023 which supplement the current development strategy for Gdańsk. The analysis has shown that those documents share the same objectives (Tab. 3). The proposed solutions may contribute to achieving the objectives mentioned in eight, out of nine operational programmes. At the same time, the scale and nature of the project reduce the power of this contribution. The infrastructure, mobility, transport and public spaces are factors may exert the strongest impact and they may contribute to achievement of the goals set in the analysed documents. The only operational programme in which there are no converged objectives it is the one regarding education.

Tab. 3. Introducing electric ferries and hybrid water trams in Gdansk as a way of achieving objectives set in the operational programmes for 2023.

Operational programmes and their goals	How the project contributes to achieving the goals
Public health and sports	
II.2. Increasing the participation of the inhabitants in physical culture.	Increasing attractiveness and accessibility of leisure infrastructure what fosters taking up sports.
Social integration and active citizenship	
III.1. Increasing the development potential of local communities, families and individuals.	Increasing attractiveness and accessibility to leisure infrastructure can be a tool shaping health potential and cooperation spirit.

Culture and leisure	
IV.1. Increasing the participation of the inhabitants of Gdańsk in culture and cultural activity.	Increasing accessibility to cultural institutions, public spaces having some culture-forming functions as well as to cultural events.
Innovativeness and entrepreneurship	
V.3. Increase in innovation and competitiveness of enterprises in Gdańsk.	Gdańsk companies may take part in construction of electric ferries and hybrid trams. The necessity of implementing advanced technologies may increase the companies' experience and competitiveness.
V.4. International expansion of companies and organisations in Gdańsk.	Knowledge and experience regarding construction of electric and hybrid vessels opens the still-growing market of global transport services.
Investment activeness	
VI.3. A lasting global recognition of Gdańsk and the metropolitan area as a centre of economic success.	Projects assuming electrification of ferries are perceived innovative and interesting for many companies and local authorities all around the world. Gdansk companies taking part in such projects may gain a global recognition. The assumed reduction of air pollution may be considered a success.
Infrastructure	
VII.1. Reducing greenhouse gas emissions and air pollution emissions.	Introduction of electric ferries contributes to eliminate greenhouse gas and other pollutant emissions in area of the vessels operations. Using hybrid water tram contributes to reducing the emissions.
VII.6. Water protection, including the protection of waters of the Gulf of Gdańsk.	Introducing electric ferries reduces the risk of surface waters pollution to virtually zero. Introducing modern hybrid water trams significantly reduces the risk of surface waters pollution.
Mobility and transport	
VIII.1. Improving the conditions for pedestrian and bicycle traffic.	Replacing the already used units by modern and efficient electric and hybrid vessels will directly contribute to all the enlisted goals.
VIII.2. . Increasing the attractiveness of public transport.	
VIII.3. Improving internal and external transport accessibility.	
VIII.4. Promoting sustainable transport and active mobility.	
Public space	
IX.1. Higher quality of public space.	Increasing accessibility to public space. Supporting actions aimed at reviving the waterfront, developing and restoring public spaces located near the river.

Source: own elaboration based on: Programy Operacyjne… (2015).