

ANALYSIS OF THE DNIPRO RIVER CARGO TURNOVER

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Introduction.

The Dnipro is the fourth-longest river in Europe. This river has the longest channel within the Ukrainian borders. The length of the Dnipro in its natural state was 2,285 km. The river was not very suitable for safe navigation, due to its shallow depths and dangerous currents. However, the favorable location of the river became the reason for the emergence of a large trade route - "From the Varangians to the Greeks". From the Swedish port cities, it lies along the Baltic Sea, the Gulf of Finland, Lake Ladoga, the Volkhov River and Lake Ilmen, further following the Lovat River, then via the Dnipro tributaries to the Dnipro River, finally reaching the Black Sea, to the shores of Byzantium. [1]

The route experienced the highest load during the period between the 10th and 13th centuries. At that time traders had to cross the areas between river basins and riffles by land. Cargo turnover included the following:

- Import of weapons, whale skin and walrus bone from Scandinavia;
- Export of fur from Veliky Novgorod;
- Import of wines, silk and spices from Byzantium; - wine, silk and spices.

The Trade Route from the Varangians to the Greeks lost its significance in the 13th century, due to the change in the geopolitical situation.

During the next period, the Dnipro River was used for the transportation of wood, grain, sugar and salt to sea on rafts and small wooden ships - Chaikas. However, land routes continued to be used to ensure complete and permanent cargo transportation, due to unpredictable tides and rocky seabed. By the 19th century, when technology made it possible to build steam-powered ships, the Dnipro had become one of the shipping development centers. One of the first ships on the Dnipro was the wooden ship "Nadezhda" (1823), later used on the Odesa - Kherson passenger route. [3]

The year of the foundation of the first shipping company on the Dnipro is 1835. Having two steamships at its disposal, it was engaged in the transportation of stone for the castle construction in Kyiv. In 1858, the Dnipro Shipping Company was founded, which dealt with passenger transportation. The main routes were Kyiv - Kremenchug - Ekaterynoslav, Kyiv- Chernihiv, along the Sozh to Gomel and Pripyat to Pinsk. However, the shipping company was limited in routes, due to the fact that for relatively large ships it was not possible to cross the rapids, thus the river was divided into upper and lower parts. [3]

For many years, the natural rapids located in the lower part of the river have been limiting cargo transportation. The issue could be solved by the construction of dams. The first attempts were made in the middle of the 19th century. However, due to the technical complexity, it was only after the building of the Dnipro hydroelectric power station in 1932, that the possibility of managing natural barriers emerged. [5] Dnipro HES played a huge role in the connection of the upper and lower flows of the river, so that it became possible to deliver goods from Kyiv to the Black Sea ports by ships using the power plant gateway.

From 1900, the cargo turnover was relatively low, for example in 1912, around 2,260,000 tons of various cargoes were transported along the river per year (about 5% of the river traffic, and about 2% of Ukraine's cargo turnover). In addition, around 2,400,000 people were engaged on passenger cruises. The main types of cargo transported included wood (55%) and grain (27%). By 1940, the mentioned values decreased slightly to 32% and 14%, respectively. After the First World War and the Civil War, the cargo turnover decreased significantly to about 752,000 tons in 1928. The recovery took several years; pre-revolutionary values were reached in 1932 – about 2,960,000 tons of cargo. Further figures were 5,800,000 tons in 1935 and 10,000,000 tons in 1940 with about

4,800,000 passengers. In the middle of the previous century, the main port on the Dnipro was Kyiv - having 50% of the river cargo turnover, the second place was taken by port of Kherson, where oil had been transshipped for import and wood, grain and metals for export. [1]

By 1990, the Dnipro's cargo turnover reached 60 million tons per year and was the largest artery in Ukraine. Furthermore, the Dnipro River was useful for traveling between coastal cities, the development of infrastructure provided a passenger turnover of 20 million people a year. After the collapse of the USSR in 1991, cargo the turnover began to drop and reached 3 million tons by 2021, in 30 years it decreased by 20 times. With respect to the passenger turnover, the figure was limited to 500 thousand people, which is 40 times lower than 30 years ago. [4]

One of the reasons for the decrease in cargo turnover and passenger turnover on the Dnipro was that declared depths were not provided in the fairway (fig. 1). According to the documents, it was supposed to be 3.65 meters along the entire length of the Dnipro, while the actual depth was 3.0 meters. [4] Under these conditions, the cargo capacity for ships did not exceed 1.5 thousand tons, whereas with depth of 3.65 meters they could carry up to 5 thousand tons on board.

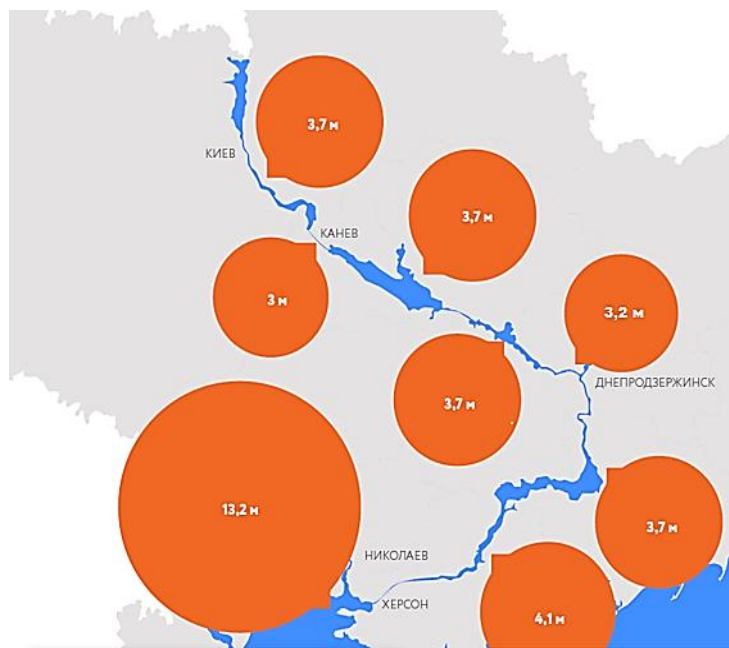


Fig. 1 – Declared depths the Dnipro River

To maintain the declared depths, a modern dredging fleet is required. In order to ensure 3.65 meters of depth along the entire river, it is necessary to extract about 1.5 million tons of sand and 20 thousand cubic meters of stones. [2] Moreover, the navigation and radio equipment has to be modernized, as most of the buoys were installed in the 1950s, and at the moment about 1,100 buoys must be professionally maintained and repaired and 125 must be replaced, which requires sufficient funding.

These days, the most popular cargo transported along the Dnipro is construction materials - 64% of the total cargo, the second is grain 25% and 11% presented by metal products. The comparison of the equivalent periods in 2020 and 2021 demonstrates that the volume of freight traffic increased by 61%. Meanwhile, railway transport alone carries 305 million tons of cargo per year with prevailing iron ore - 79.7 million tons, followed by construction materials - 60.4 million tons, coal - 48.6 million tons and grain - 35.2 million tons. [4] The container transportation market is monopolized by rail and road transport and amounts to about 700 thousand TEU per year.

Several types of cargo could be transported by vessels of river-sea or non-self-propelled type along the Dnipro river. Unfortunately, due to the low development of the river transport as well as lack of the government support, shippers prefer land means of transportation. At present, the agro company “Nibulon” provides cargo transportation support with a turnover of about 20% of the total number of transported goods. Regardless of the fleet belonging to “Nibulon”, the average age of

vessels, operating on the Dnipro, is approximately 35 years, which requires critical control of their technical condition. One of the possible solutions for this issue could be the establishment of favorable conditions for private carriers and good conditions for logistics companies operating on the Dnipro.

The transport network in its present state remains almost in the same condition as in the days of the USSR. In the past 30 years, no reformations have been carried out in order to develop river transportation. On a yearly basis, the government allocates the funds for the maintenance - UAH 72 billion. From them, UAH 36.5 billion is spent on the network development, UAH 13.5 billion is used to cover loan obligation. In addition, UAH 39 million is allocated every year to maintenance the gateway infrastructure, not including the cost of repair works. This is the standard amount allocated for the State Enterprise "Ukrvodshlyakh". The deterioration of locks reaches significant values, which negatively affects the dynamics of river cargo transportation. The difference between the costs of road restoration and maintenance of the river's navigation varies significantly. However, the river's potential is not used at its full capacity, locks are idle most of the time, the official data on the use of the river's potential is 18.5%, the design number of locks per day is 36, in fact, 34 are carried out in a month's time, which sets a barrier for traffic improvement. [6]

Grain transportation. Four barges and one pusher tug carrying 8,000 tons of grain along the river is the equivalent of a hundred railroad carriages or five hundred trucks. The total volume of transported grain cargoes in Ukraine in 2020 amounted to 82 million tons, river transport transported approximately 2.5 million tons, which is approximately 3%. In case 30% of cargo turnover traffic is transferred from land to river, the road network would be discharged by about 700 thousand trucks. For instance, on the route Dnipro – Odesa with a cargo weight 2000 tons, 3rd class grain. The price per ton for transportation by road will be about \$ 45 / ton, with a duration of 1-2 days. Railway transportation - \$ 16-17, up to 3 days, by the river - \$ 14, approx. 4 - 7 days, depending on the type of vessel. Delivery by the last option can be effective for non-urgent delivery of goods.

Transportation of metal structures. Transportation by road is unprofitable due to the high specific weight of the cargo, so this option is not considered. Transportation by the river will cost \$ 8 per ton, which is slightly less than by the railway.

The general idea of progressive marine infrastructure has to unload highways in Ukraine (Kyiv-Odesa, Kyiv-Mykolaiv, Kyiv-Dnipro). To achieve greater benefits, carriers often overload cars, which affects the condition of the road surface, and as a result, affects the budget. Shipping allows avoiding the mentioned negative effects. Furthermore, the development of the river and sea shipping industry could create a large number of jobs for graduates of Ukrainian maritime universities.

Additional cargo transportation problems of the Dnipro River.

Amur bridge in Dnipro city has a height limit of 14 m. This restriction does not allow many types of ships to pass safely under the bridge and implies delays in granting permission for passing. The navigable section of the bridge is open once a day for 1 hour. This allows the height to be increased up to 20 meters. For such a passage, the shipowners face expenses not only for the vessel's delay but also for the bridge opening. One of the options to eliminate this problem could be the opening of the bridge by the prior order of the shipowner, the expansion of the opening schedule of the bridge, or the bridge reconstruction.

Technical condition of the locks:

1) When locking lifting buoys often fall, it complicates the locking process and exposes the ship, cargo and crew to danger. In case a sufficient number of buoys break down, sluicing off becomes impossible.

2) The hydraulic mechanism of the Zaporizhzhia lock is extremely worn out, which causes delays in the opening of the lock gates, affects the work schedule of the lock and the ship itself.

3) The water pumps are outdated causing a decrease in the rate of water intake into the lock chamber, so the process can take more than an hour.

4) Lack of lighting on the lower tier of the Kakhovsky lock, which affects the safety of

operations.

The above listed issues may be solved by overhauling the gateway network. The funding of approximately \$ 4 million is required to restore each lock. To open a three-tiered non-working lock of Zaporozhe will cost around \$ 6 million.

To implement the project, it is necessary to improve the existing infrastructure: to improve ports infrastructure in Kyiv, Kanev, Cherkasy, Kremenchuk, Svetlovodsk, Kamenskoe, Dnipro, Zaporizhzhia, Nikopol, Kherson, Novomoskovsk, etc. Furthermore, the development of automobile and container terminals could be a benefit for the following ports of: Kyiv, Cherkasy, Kremenchuk, Dnipro, Zaporizhzhia, Kherson. In the present time, containers and vehicles are delivered by roadway. Their transportation by marine transport would be a profitable alternative, in case of non-urgent delivery of the goods - the cost is lower, the risk of damage is lower, although it will take more time.

In addition, the option of buying a new fleet suitable for the transportation of various goods along the Dnipro is considered below. The crew completion is limited, with the maximum number of 6 persons on tug-barge. The fuel consumption is lower, the speed is higher and the majority of the automation class is A1, which allows reducing the cost of engineering. At modern freight rates, these vessels could be more profitable in operation in comparison with the vessels of the current fleet [4].

Table 1 - Fleet

Ship particulars	Containership	O-class hold barge of P110 project for transportation vehicles	Project 2731 M-SP3.5 oil barge	Project Europa-2	Tanker project RST27	Self-propelled dry-cargo vessel project RSD49	Tug SHOALBUSTER 3815 ultra-shallow draught (YN571738)
LOA	82m	99,7m	90,9m	76.02m	140,85m	139,95 m	38,35m
Breadth	11,8 m	17,3 m	16,24m	11.44m	16,7m	16,5 m	15,9m
Draft Loaded	2,58 m	2,1 m	3,81m	3.10m	3,6m	3,6 m	1,6m
Draft light	1,26m	0,81 m	0,73m	0.56m	2,7m	2,6m	1,2m
Speed	11,2 knots	non-self-propelled	non-self-propelled	non-self-propelled	10 kn	11,5 kn	8 knots
Deadweight	1000t	400 cars	4100 t	2033t	5378t	4518t	249t
Depth	9m	3,1 m	4,7m	3,90m	6m	6m	2,7m
Air Draft	11,2 m	7,3 m	5 m	6m	18m	18m	4m
Freeboard	4m	1m	1,1m	3.20m	2,4m	2,5m	2,2m
Displacement load/light	2004t/899t	2593t/1125t	5000t/862t	3000t/ 915t	7900t/2500t	7900t/2500t	750t/501t
Bow thruster	n/a	n/a	n/a	n/a	230 kWt, Shottel STT0170FP)	200 kWt	n/a
Holds, capacity	2	3 decks	5 tanks	1 hold	6 tanks	3, 10920 m3	n/a
Main engine	2 x 441 kWt, 8NVD 36/24 A-1	n/a	n/a	n/a	2 x 1200 kWt, 6L20 "Wartsila"	2 x 1200 kWt (WARTSILA 6L20)	4x Caterpillar C12-TA

Ballast tanks volume	600m ³	n/a	n/a	n/a	4123m ³	3959 m ³	---
Autonomy	12 days	n/a	n/a	n/a	12 days	20 days	5 days
Crew/cabins	10/13	n/a	n/a	n/a	12/13	10 /12	7/11
Class	M (ice)	O	M-SP3.5	I3/3E side tank vessel loading and unloading in two runs /NP NI2 ice	KM ⊕ Ice1 R2 AUT1-ICS OMBO VCS ECO-S Oil tanker (ESP)	KM ⊕ Ice2 R2 AUT1-C	Bureau Veritas I□HULL □ MACH Tug (Unrestricted navigation, with wind strength and wave height limitation)
Purpose	20-foot containers, general cargo, timber, bulk cargo	Vehicles transportation	Oil transportation	Bulk or general cargo transportation	Oil transportation	Bulk or General cargo	Pushing, towing of non-self-propelled ship

This paper considers the main problems and opportunities for the development of river transport in Ukraine. It can be concluded that the transfer of cargo flows from land to water could significantly reduce the load on land transport routes, saving funds allocated for road repairs, to be used more efficiently elsewhere. Thus, employment opportunities for graduates of maritime colleges and universities can be expanded in Ukraine. As for the disadvantages of the proposed project, the required investments and timelines can be noted. To summarize, it should be mentioned that for the successful development of cargo transportations along the Dnipro River it is necessary to create favourable conditions, which means governmental support and investors engagement.

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