In view of growing competition in the freight market in recent years, shipowners are forced to take active measures aimed at improving the efficiency of their own fleet. In this connection, there is a need for a deeper analysis of the trends in the structure of freight flows and a more accurate choice of the fleet development strategy. Of great importance is timely replacement of vessels and replenishment of the fleet with such vessels, which would allow to work as efficiently and flexibly as possible in conditions of tough competition and uneven structure of cargo traffic.

The basic principles of modern oversized project cargo transportation, stowage and securing technologies are discussed in articles [1, 2]. The issue of optimum terms of purchase and sale of vessels and other equipment was considered in [3–7], taking into account the factor of uncertainty. The issue of optimal time to enter the shipping market was studied in [8–10]. One of the key methods aimed at shipping efficiency improvement is concerned with lowering fuel consumption by reducing ship speed. Papers [11, 12] examine the dependence of vessel’s operation efficiency indicators on ship speed. The profitability of ship speed reduction and fuel consumption of seagoing bulk carriers was examined in [3, 8–12].
The purpose of this paper is to propose a justification methodology for the selection of a replenishment project of a shipping company with regard to the peculiarities of the cargo flow structure, considering the possibility of slow steaming.

In order to compare the efficiency of acquisition and operation projects of vessels with significantly different deadweight and market value, along with NPV, we will also consider the profitability index (PI). The NPV value of the acquisition and operation project is determined by the following formula

\[ NPV = \sum_{t=1}^{T} \frac{F - R^{\text{var}} - R^{\text{perm}} - R^{\text{cred}}}{(1+p/100)^t} + \frac{l_{\text{sale}}}{(1+p/100)^T} - I_{\text{own}}, \]  

where, \( T \) – the period of the vessel’s exploitation, years; 
\( F \) – average income earned by the vessel per year, USD; 
\( R^{\text{var}} \) – vessel’s annual average variable operating costs, USD; 
\( R^{\text{perm}} \) – average annual permanent costs during the operation of the vessel, USD; 
\( R^{\text{cred}} \) – loan expenses, USD. 
\( p \) – discount rate, %; 
\( I_{\text{own}} \) – volume of investments from own funds, USD; 
\( l_{\text{sale}} \) – the estimated cost of the vessel’s sale after exploitation during \( T \) years, USD.

PI is calculated as a ratio of all discounted cash flows to the initial costs of acquisition of a vessel:

\[ PI = \frac{l_{\text{sale}}}{I_{\text{own}}} \frac{\sum_{t=1}^{T} \frac{F - R^{\text{var}} - R^{\text{perm}} - R^{\text{cred}}}{(1+p/100)^t}}{1 + \frac{p}{100}}. \]

Consider several options to replenish the fleet of a shipping company by purchasing various types of ships and assess the efficiency of these vessels, if in one direction they will carry bulk cargo, and in the reverse direction – oversized project cargoes. Principal particulars of the five applicant vessels are presented in Table 1.

Fig. 1 shows that the highest NPV values are achieved for projects of acquisition and operation of Vessel2, Vessel5 and Vessel3 provided these vessels are used at optimal speeds specified in Table 2. Maximum NPV and PI values, which can be achieved at optimal selection of applicant ships speed, are presented in Table 2.

### Table 1

| Principal particulars of applicant vessels |
|------------------------------------------|
| **Ship’s type** | Vessel1 | Vessel2 | Vessel3 | Vessel4 | Vessel5 |
| **Year of build** | 2006 | 2009 | 2003 | 2007 | 2011 |
| **Deadweight, t** | 6500 | 16800 | 28611 | 35000 | 32134 |
| **DWCC \((D_{cc})\), t** | 6200 | 16000 | 27800 | 34151 | 31200 |
| **Cubic capacity \((W)\), m³** | 8285 | 21648 | 35762 | 44183 | 39509 |
| **(NRT), per.Τ** | 2303 | 5507 | 10098 | 11251 | 10570 |
| **(GRT), per.Τ** | 4655 | 11927 | 16980 | 22115 | 24025 |
| **LOA, m** | 118,60 | 148,00 | 169,26 | 193,84 | 193,90 |
| **IFO consumption at sea, tons/day** | 6,0 | 8,2 | 13,0 | 19,0 | 35,5 |
| **IFO consumption in port, tons/day** | 0,0 | 0,0 | 2,5 | 2,5 | 3,0 |
| **Purchasing cost, thousand USD** | 4000 | 8000 | 9500 | 11000 | 15800 |
| **Selling cost, thousand USD** | 2300 | 6300 | 6100 | 7500 | 8100 |
| **Permanent expenses, USD per day** | 1100 | 1400 | 1700 | 1900 | 2500 |
Fig. 1 and Fig. 2 show graphs of NPV and PI values depending on speed of applicant vessels.

![Graph of NPV and PI values](image)

**Table 2**

Maximum NPV and PI values that can be achieved with the optimal ship speed selection

| Applicant vessel | Optimal speed, kns | Average running time in one direction, days | Maximum values with optimal ship speed selection |
|------------------|--------------------|--------------------------------------------|-----------------------------------------------|
| Судно1           | 11,1               | 31,1                                       | NPV, thousand USD.                             |
|                  |                    |                                            | 1000,94                                       |
|                  |                    |                                            | PI                                            |
|                  |                    |                                            | 2,25                                          |
| Судно2           | 9,4                | 36,4                                       |                                              |
|                  |                    |                                            | 2222,00                                       |
|                  |                    |                                            | 2,39                                          |
| Судно3           | 10,6               | 32,4                                       |                                              |
|                  |                    |                                            | 2063,50                                       |
|                  |                    |                                            | 2,09                                          |
| Судно4           | 10,5               | 32,7                                       |                                              |
|                  |                    |                                            | 1219,17                                       |
|                  |                    |                                            | 1,55                                          |
| Судно5           | 12,1               | 28,5                                       |                                              |
|                  |                    |                                            | 2116,14                                       |
|                  |                    |                                            | 1,67                                          |
The smallest NPV value is achieved for Ship1. If to estimate efficiency of projects of acquisition and operation of the considered vessels from the point of view of profitability index, the most preferable projects are those connected with acquisition of Vessels2, Vessel1 and Vessel3, i.e. vessels with low tonnage (fig. 1). Comparing Fig. 1 and Fig. 2., it can be seen that at optimal speed selection, the Vessel5 has a sufficiently high NPV value, which slightly differs from the maximum NPV value for the Vessel2. However, the PI value for the Vessel5 is noticeably inferior to the PI value for all the considered vessels except for the Vessel4, at any choice of speed mode. This is explained by the fact that the acquisition project of a Vessel5 requires a much larger capital investment than acquisition projects of other applicant ships.

Therefore, despite the fact that the Vessel5 allows to earn the largest freight, the profitability level of the project of acquisition and operation of the Vessel5 is rather low even with an optimal speed selection. At the same time, for the Vessel1, on the contrary, a high PI level is observed, while the NPV value of the project of her acquisition is very low in comparison with other applicant vessels. This is due to the fact that the market value of the Vessel1 is much lower than the value of the other vessels considered. Despite of small freight amounts in comparison with other applicant vessels, it turns out that the ratio of income earned to expenses for the Vessel1 is quite satisfactory with optimal speed selection. Thus, under condition of usage of the considered vessels for carriage of the specified cargoes on the stipulated directions and taking into account an optimum speed selection of vessels, maximum NPV values for projects of purchase of the Vessel5 and the Vessel2 appear almost identical. However, in this case the project of acquisition of Vessel5 is noticeably inferior to the project of acquisition of Vesselp2 in terms of efficiency index of investments PI.

Conclusions. Calculations showed that efficiency of maritime shipping could be significantly improved by selecting the optimal ship speed. It was also shown that under conditions of heterogeneous cargo flow structure the use of large tonnage bulk carriers and specialized vessels designed for transportation of oversized cargoes is less effective than the use of mini bulk carriers.

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OPTIMIZATION OF OPERATION MODES BULK ELECTRIC POWER GRIDS

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UKRAINE

The problem of optimizing the parameters and modes of power transmission and distribution systems is very complex and multifaceted. The tasks of optimizing the parameters of objects have to be solved at the design stage of the development or construction of the electrical grid. The current optimization of the modes is carried out during the operation of the grid [1].

Design, construction of electric grid facilities and their operation are associated with high material costs. Therefore, it is important that these costs are used most efficiently. It should be borne in mind that the correctness of decisions on the development of power transmission and distribution systems, taken at some point can occur after a sufficiently long time, when the mistakes made is impossible or very difficult to fix. Additional difficulties in developing a solution are related to the fact that usually there is uncertainty and insufficient reliability of the initial information. For example, the prospective load at some grid nodes is usually not known in advance exactly [2]. With a simplified approach to solving such a problem, three levels of load are set (the highest possible, the lowest and the average possible) and parameters are selected for all these levels.