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Justification of location of LNG infrastructure for dual-fuel locomotives on the railway network in Kazakhstan

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Abstract

The article performs the justification of the dislocation place of the main infrastructure facilities of production, stations of equipment and filling station of liquefied natural gas (LNG) on the network of diesel traction of the Republic of Kazakhstan to provide the park of dual-fuel locomotives by LNG. The structural levels of the railway network on diesel traction are considered, the regional gravity zones are determined and the method of identifying the location of the main infrastructure objects of LNG with consideration of the volumes of transported cargo flow, the length of haul maintenance service and zoning run are developed. In addition, during identification of the locations of LNG infrastructure facilities, the location of the natural gas pipeline network in the territory of the Republic of Kazakhstan is considered.

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Keywords: LNG (liquified natural gas); Locomotive; LNG infrastructure; Locomotive equipment points; Dual fuel; Diesel traction network

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1. Introduction

The growing trend towards the transition to alternative fuels in transport, dictated not only by technological innovations and limited resources of oil reserves, but also by regulators to protect the environment and emissions of harmful substances into the atmosphere, affected not only road transport, but also the railway transport. Many railway companies in the world, as well as manufacturers of locomotives, are in constant search of alternatives to diesel fuel, which not only pollutes the air, but also gradually ceases to be cost-effective for some regions. Among the acceptable alternative fuels for locomotives are compressed natural gas (CNG), liquefied natural gas (LNG), and hydrogen fuel.

For example, in 2017 in Germany, the Alstom Company introduced the first hydrogen-powered train for passenger service [1]. A USA railroad BNSF, together with the General Electric company, conduct tests of diesel locomotives of Evolution and Dash series with the engine running on dual-fuel by GE's NextFuel® technology using LNG for freight trains [2].

In this article, the authors consider LNG as the most suitable fuel for the locomotive on the diesel traction network in the Republic of Kazakhstan. The choice of the authors of LNG as a fuel is caused by further reasons. The first reason is the presence of its own gas reserves on the territory of the Republic of Kazakhstan. The second is the possibility of delivery of additional volumes of natural gas from the Russian Federation, which is included in the 10 main suppliers of natural gas in the world [3]. In addition, the experience of Russian engineers in the transfer of locomotives to LNG and the successful testing of American railway companies with GE NextFuel® technology allows us to consider the option of using LNG as fuel for the locomotive as the most probable.

Considering the presence of existing research and papers on the use of LNG as a diesel replacement fuel for marine vessels [4], development of translation diesel engine to gas engine [5], the pros and cons of LNG to other alternative fuels [6-7], the effect of LNG as a fuel on the environment [8], as well as the standards of the environmental protection Agency [9], the authors are not going to describe in this paper the process of transferring the locomotive to natural gas, its characteristics and the structure of the engine and fuel system.

This article is intended to fill the gap between ready-made solutions for LNG production at factories of natural gas liquefaction and new solutions developed for the use of LNG as fuel in rail transport. It also provides a methodology for justifying the location of infrastructure facilities on the example of diesel traction of freight trains in the Republic of Kazakhstan, which can also be applied to other railway networks on diesel traction.

2. Background comment on structural levels of facilities

Placement of infrastructure facilities on the railway network of the Republic of Kazakhstan, including infrastructure facilities for production, provision, storage and equipment of LNG is a set of tasks. The validity of the tasks is closely related to the size of cargo flows in the regions and throughout the railway network, where transportation is carried out by locomotives. The structure of the country's natural gas pipeline network is also of equal importance.

For example, while considering the issue of deployment of LNG infrastructure that includes, (1) complex for the liquefaction of natural gas (CLNG), (2) filling complex of liquefied natural gas (FCLNG), (3) items of equipment and the storage of tenders for LNG (EST). This infrastructure provides LNG to locomotives of a nearby base and transfer locomotive depots and creates transport cluster of depot maintenance of transparent section level.

At the polygon rail level, the boundaries of individual local clusters are connected and merged by railway lines and railway sections and natural gas pipeline networks to form a single, higher-level transport cluster, ensuring the interaction of various local-level facilities in the region.

In addition, the need to maintain dead-end siding railway sections on the diesel traction network leads to the formation of a separate cluster – the level of dead-end sidings maintenance of the base depots (dead-end siding, transparent section or partially transparent section type), for traction maintenance of which appropriate conditions should be provided.

Hence, the consequence is that the network transport cluster of LNG provision for dual-fuel locomotives can have a complex multi-level and hierarchical structure. The optimization of providing fuel to dual-fuel locomotives is expected to be performed at each of the considered levels.

This means that the procedure for justifying the location of LNG infrastructure facilities on the diesel traction network of the Republic of Kazakhstan should be preceded by the stage of determining the number of LNG infrastructure levels.

In general case, the elements of the LNG infrastructure network on diesel traction of Kazakhstan (as part of the railway network of the country is served by electric locomotive traction), can be divided by the hierarchy into levels, considering the role that they perform in the process of train flow traction service.

These are the following levels:

- Level of transparent section maintenance– the level of the railway haul maintenance of main depot locomotives, defined by a set of transparent consecutive stages and separate points between two technical stations, which are located on the base (or transfer) locomotive depot
- Level of polygons rail maintenance - the level of locomotives maintenance at the site, defined as the merging of multiple transparent railway sections (railway hauls of locomotives maintenance) on railway stations and in the region
- Level of dead-end sidings sections – defined as a set of railway sections located on dead-end lines and sections on the diesel traction network of the railway of the Republic of Kazakhstan

Now it is necessary to consider that certain transparent and dead-end sidings sections and polygons of maintenance of diesel traction of railways is geographically distributed in regions of Kazakhstan. Then the proposed gradation of the levels of the diesel traction network should be transformed into regional clusters, considering the gravity zones of these sites and polygons.

This leads to the following regional zones of gravity on the network of diesel traction of railways of Kazakhstan (see Fig.1):

- “North – West” gravity zone is a cluster of diesel traction network, in the gravity zone of the railway sections and polygons of the Western and Northern regions of Kazakhstan are included;
- “Center – West – South” gravity zone is a cluster of diesel traction network, in the gravity zone of the railway sections and polygons of the Central and Western regions (considering the newly built railways) and a part of the Southern region of Kazakhstan are included;
- "East – South" gravity zone is a cluster of diesel traction network, gravity zone of the railway sections and polygons throughout the Eastern and Southern regions of Kazakhstan are included.

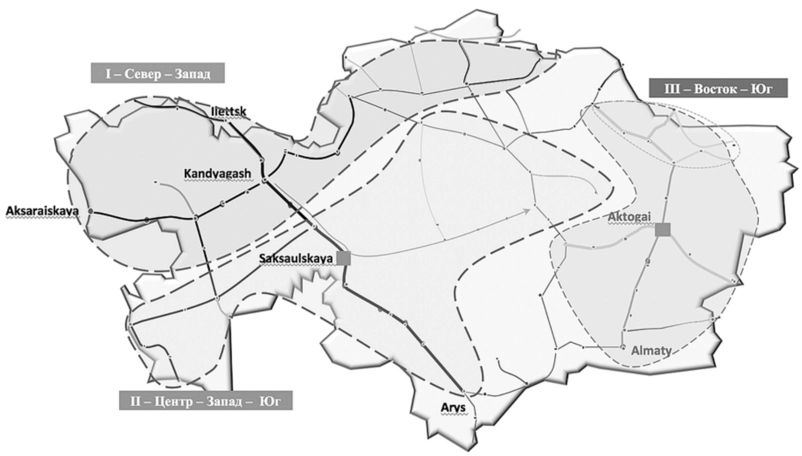

Fig. 1. Schematic location of regional gravity zones on the diesel traction network of the Republic of Kazakhstan.

According to the results of the analysis, Table 1 shows the distribution of the total volume of the cargo turnover, the total length and consumption of diesel fuel on the elements of the diesel traction network of Kazakhstan by gravity zones.

Table 1. Distribution of volumes of cargo turnover, total length and consumption of diesel fuel on zones of gravitation of the diesel traction network of the Republic of Kazakhstan.

Name of cargo flow gravity zone	Share, %		
	Cargo turnover	Total length	Consumption of diesel fuel
North – West	38.0	32.6	36.7
Center – West – South	32.7	39.5	32.1
East – South	29.3	27.9	31.2
Total	100	100	100

Thus, the whole network of diesel traction of the Republic of Kazakhstan is divided into 3 zones. It is obvious that the LNG infrastructure facilities (CLNG, FCLNG, and EST), will provide LNG to dual-fuel locomotives of the nearby base and transfer locomotive depots, and will have to be located within the boundaries of these zones.

3. Applicable quantitative methodology for the research

In this section, the actual task is to justify the "points", or rather, the railway station locations of LNG infrastructure objects. At first, the structural levels of facilities for dual-fuel locomotives will be discussed. Then the methods of calculation and evaluation for each type of sets will be provided in order to justify the points of LNG infrastructure on the diesel traction network.

3.1. Formulation of the LNG infrastructure facilities placement problems

First, we note that each of the considered structural elements of gravity zones (sections and polygons) on the diesel traction network is characterized by:

- Belonging to one of the three designated gravity zones
- Length (distance between points determining its position on the transport network of diesel traction)
- The value of the cargo traffic, which is the total volume of cargo traffic p for the period under review in the zone in both directions

For traction maintenance of the transported volume of cargo transportations, locomotives have to consume some volume of fuel.

Considering that each element of a separate gravity zone on the diesel traction on the network has its own specific fuel consumption value per 1 t-km gross of transportation work, the value of the total fuel consumption G by locomotives at these levels also differs.

Considering these structural and technological features to refer structural elements of the dual-fuel consumption (diesel and LNG) symbols $a_i (i = 1,2,...,N_A)$ on diesel traction network on the railway sections, $b_i (i = 1,2,...,N_B)$ on polygons, and $c_i (i = 1,2,\ldots, N_C)$ on dead-end sidings are used.

The set of all a_i elements forms a set A that characterizes the level of the transparent maintenance section of the diesel traction network, the set of elements b_i forms a set of polygons B, and the set of elements c_i forms a set of dead-end sidings sections C.

Since each of the elements of the set A, B, and C is characterized by the length l_i and volume of fuel consumed by locomotives g_i for traction service of cargo flow p_i, the listed characteristics can be considered as the coordinates of the elements on the plane $g0l$.

Then the elements on the network of diesel traction can be described by a set of elements (points on the plane):

$$\begin{cases} a_i(l_i^A, g_i^A)(i = 1,2, \dots, N_A); \\ b_i(l_i^B, l_i^B)\ (i = 1,2, \dots, N_B); \\ c_i(l_i^C, l_i^C)\ (i = 1,2, \dots, N_C), \end{cases} \tag{1}$$

where $N_A + N_B + N_C$ is the total number of structural elements on the entire diesel traction network.

Then it is possible to build a field for absolute values g_i and l_i belonging to the sets A, B, and C in the coordinate system $g0l$.

However, in the future, such a graphical representation does not allow to clearly identifying the limits of the structural levels, and is not acceptable for subsequent decisions related to the task of choosing the location of LNG infrastructure facilities.

This is primarily due to the incompatibility of the length l_i values and magnitude of the fuel g_i consumed by the various structural elements of the diesel traction network, and such a plane begins to "spread", not allowing determining the limits of the levels.

To solve this problem, it is necessary to include another tool, namely, methods of qualitative mathematical theory. The suitable instruments are the methods of Theory of sets [10] and Algebraic (combinatorial) topology [11-13].

In other words, the solution of the problem brings to the creation of a method of quantitative evaluation of qualitative criteria and the corresponding calculation algorithms that allow abandoning the visual evaluation of the relative position of the elements of the sets A, B, and C on the plane $g0l$.

That is, it is necessary to conduct the initial data based on the use of values g (t/year) and l (km) with the specified dimension to dimensionless characteristics.

To do this, the coordinates of the elements belonging to the set A should be converted (or conduct "renormalization" of coordinates):

$$\begin{cases} x_i^A = \frac{l_i^A - l_{min}}{l_{max} - l_{min}}; \\ y_i^A = \frac{g_i^A - g_{min}}{g_{max} - g_{min}}. \end{cases} \tag{2}$$

where:

- l_i and g_i - the length and magnitude of the fuel consumed by the element of the set A, B and C
- l_{max} - the maximum length of the transport element among all elements belonging to the sets A, B and C
- l_{min} - the smallest length of the transport element among all elements belonging to the sets A, B and C
- g_{max} - the maximum volume value of fuel consumed among all elements belonging to the sets A, B and C
- g_{min} - the minimum volume value of fuel consumed among all elements belonging to the sets A, B and C

Similarly, the coordinates of the elements of sets B and C are converted.

Note that now the use of the variable replacement procedure leads to the fact that all elements of the sets A, B and C will be located within a square with a side equal to one.

Note that the procedure of transformation of variables simplifies the procedure of quantitative assessment of the structural (qualitative) relative position of the elements of sets A, B and C, constituting different levels on the network of diesel traction of Republic of Kazakhstan.

Thus, the definition of limits and the assessment of the relative position of individual sets characterizing the structure of the transport network is an important step in the analysis, the results of which determine the essence of the subsequent actions related to the optimization of the placement of LNG infrastructure.

3.2. Methods of calculation and evaluation of the relative location

In accordance with the existing representations, the measure of proximity of individual elements of the set is the distance between them, which, depending on the nature of the problem to be solved, is determined in different ways [14].

Since in the future there is a need to assess the relative position as separate elements of the set A, B, and C, representing a set of elements reflecting a different structural level of the network of diesel traction of the Republic of Kazakhstan, all tasks should be considered and solved sequentially.

Considering the set of elements as a set of a finite number of points on the Y0X plane, we note that the choice of a metric or measure that allows estimating the proximity becomes an obligatory stage of structural analysis.

The proximity of the elements $a_i = (x_i^A, y_i^A)$ and $a_j = (x_j^A, y_j^A)$ belonging to the set A can be estimated by means of the Euclidean distance defined on the Y0X plane as follows:

$$d_{i,j}^A = \sqrt{(x_i^A - x_j^A)^2 + (y_i^A - y_j^A)^2} \tag{3}$$

In this case, the concept of the proximity of individual elements coincides with their geometric proximity on the Y0X plane, and the characteristic of such a set consisting of N_A transport elements of the network of diesel traction is the maximum distance D_A between the points:

$$D_A = \sup_{x,y \square A} d(x, y) \tag{4}$$

In the future, to estimate the "area of sets "of individual levels of the network of diesel traction, it is necessary to introduce the concept of" diameter of the set", which means the upper edge of the distances between pairs of points of the set. This means that a single set of transport elements $a_i (i = 1, 2, ..., N_A)$ on the Y0X plane can be "covered" by a circle with a diameter D_A.

There is another approach to determine the "diameter of the set" [14], when, for example, to determine the center of gravity of a system points on the plane, the centroid acts as the center of the set, that is, a point C_A on the plane with coordinates:

$$\bar{x}_A = \frac{\sum_{i=a}^{N_A} x_i^A}{N_A}; \quad \bar{y}_A = \frac{\sum_{i=1}^{N_A} y_i^A}{N_A} \tag{5}$$

In general, the characteristics of the set have the following features:

- With a large number of elements, joining to a set of several points within a circle D_A with the center at a point C_A does not lead to a noticeable change in the position of the center – the feature of stability of the centroid position
- Changing the diameter of the set does not occur if the coordinate values of each of its elements increase (decrease) by the same number – the feature of diameter independence from the origin of coordinates
- Adding to the set of the new element leads to an increase in its diameter only if the maximum distance between the elements happens

These listed features of the set of A, B and C allows us to consider the parameters D_A, $\bar{x}_A$ and $\bar{y}_A$ as important characteristics, necessary in the future to describe the group features of the structural elements that make up these sets (levels of network of diesel traction).

The concept of the distance between groups of objects (between different structural levels of the network of diesel traction) is necessary in the development of the procedure for their classification and is associated with the assessment of the relative position on the plane of sets of different nature. In this case, the similarity measure of the individual sets may be a distance defined on the principle of "nearest-neighbor", using a potential function [14], etc.

Since the center of an individual set is determined by the position of the centroid on the Y0X plane, the distance between the sets A and B that contain the elements N_A and N_B ,respectively, is defined as the Euclidean distance between the centroids C_A and C_B:

$$D_{AB} = \sqrt{(\bar{x}_A - \bar{x}_B)^2 + (\bar{y}_A - \bar{y}_B)^2} \tag{6}$$

If the sets A and B are characterized by the values of diameters and, in the future, such sets are evaluated as "non-overlapping" when the inequality is satisfied

$$D_{AB} < \frac{D_A}{2} + \frac{D_B}{2} \tag{7}$$

After transformations, this condition is formulated as follows:

$$\eta_{AB} = \frac{D_A + D_B}{2D_{AB}} - 1 > 0 \tag{8}$$

In this case, the criterion η_{AB} should be taken as an indicator of the pair proximity of the set A and B. It takes positive values when the sets are removed on the Y0X plane and there is no "mixing" of their elements. Otherwise, the criterion η_{AB} has a negative value $(\eta_{AB} \leq 0)$. In this case, the gradual mutual removal of "non-overlapping" sets A and B will be accompanied by a continuous growth of positive values.

Thus, from a practical point of view, only positive values η_{AB} are of interest, since it is in this option that the analyzed transport system has separate structural levels (in our case, the service area, the training ground service, the network of diesel traction).

Note that the formula (8) is suitable only for 2-level transport structures, so it is necessary to develop this technique further and will offer the next stage of modeling.

The network of diesel traction of Republic of Kazakhstan has a 3-level structure (railway district, polygon and dead-end siding), i.e. there are 3 sets A, B and C with the number of transport elements N_A, N_B, N_C and diameters D_A, D_B, D_C. In this case, the formula (6) is pairwise distances between sets A, B and C – D_{AB}, D_{AC} and D_{BC}.

Similarly, the formula (8) are indicators of pair proximity between sets η_{AB}, η_{AC} and η_{BC}. The condition of their non-negativity is checked. Since the number of transport levels is 3, the unit cubic space in the system of rectangular coordinates $(\eta_{AB}, \eta_{AC}, \eta_{BC})$ is now considered.

Next, we consider the radius vector ρ, which will be inside the considered unit cubic space.

The maximum possible value of the module reaches the radius vector ρ when the point characterizing the relative position of three sets coincides with the top of the cube, the most distant from the origin:

$$|\rho|_{\max} = \sqrt{3} \tag{9}$$

This position of the radius vector corresponds to the case of the greatest distance of all three sets considered from each other. In addition, to assess the mutual proximity of the three analyzed sets, it is necessary to apply the indicator:

$$\mu = \frac{1}{\sqrt{3}} \sqrt{\eta_{AB}^2 + \eta_{AC}^2 + \eta_{BC}^2} \tag{10}$$

The implementation of the normalization set $1/\sqrt{3}$ in the formula (10) leads to the fact that the proximity index in the three-dimensional topological space can vary in the range of values $0 \le \mu \le 1$. Therefore, it can be concluded that the proposed proximity index in the three-dimensional topological space μ of several "non-overlapping" sets is based on the account of paired proximity indices of individual sets and is equal to their mean square value.

Note that the value μ=0 corresponds to the case of the limiting convergence of all three sets without their mutual overlap. The value μ=1 corresponds to the case of mutual removal of sets at the maximum possible distance. At the same time as the mutual removal of sets on the plane, Y0X will occur and the continuous increase in the corresponding value μ.

On the other hand, the need to build the field of elements of different structural levels of the network of diesel traction of Railways of Kazakhstan in the normalized topological space Y0X was noted above. These sets will have centers C_A on the plane Y0X (with coordinates $\overline{x_A}$ and $\overline{y_A}$), C_B (with coordinates $\overline{x_B}$ and $\overline{y_B}$) and C_C (with coordinates $\overline{x_c}$ and $\overline{y_C}$).

If you connect these centers, you get a triangle, and the area S of the triangle is the same characteristic of the mutual arrangement of sets A, B and C, as an indicator μ. Then the increase in the area of the triangle S can be interpreted as a measure of removing the centers of the sets on the Y0X plane: the more becomes, the areas of different sets "scatter" on the Y0X plane, i.e. become more "isolated" from each other.

Thus, the qualitative (topological) features of the network of diesel traction of the Railways of the Republic of Kazakhstan, as a 3-level transport network, will be most evident when the "non – overlapping" sets (structural levels – railway district, polygon and dead-end sidings) are sufficiently removed from each other. In this case, the value of the indicator μ tends to one $(\mu \to 1)$, and the value of the area of the triangle S tends to the maximum $(S \to \max)$.

4. Results of calculation and choice of locations

After the development of a method of quantitative evaluation of the criteria for the relative location of different levels of the network of diesel traction and the creation of appropriate calculation algorithms, calculations are made based on the data of the network of diesel traction of the Railways of Kazakhstan for 2016.

When calculating the consumption of diesel fuel and LNG for diesel locomotives on gas motor fuel, the following parameters of such recalculation are also considered:

- The coefficient that considers the effect of reducing the specific fuel consumption in the transition to dual-fuel (LNG and Diesel fuel)
- Share ratio in the specific consumption of dual-fuel between diesel fuel and LNG

Further, considering all these conditions, the calculation of the consumption volume of individual fuels-diesel fuel and LNG for the network elements and each zone was done.

Since the article considers the placement of only LNG infrastructure facilities on the network of diesel traction of the Railways of the Republic of Kazakhstan, for subsequent calculations, the values of the length of the individual element of the diesel network l_i and the value of the consumed individual elements of LNG g_i^{LNG} are considered.

Fig. 2 shows the location of the elements of the set A, B and C on the plane (in the coordinate system Y0X) for the transformed system of input data for sections and polygons of the entire network of diesel traction of the Republic of Kazakhstan. It shows the relative positions of the elements of all three sets consisting of 20 elements.

On Fig. 2 it can be seen three sets A (transparent railway sections), B (railway polygons) and C (dead-end railway sidings) are "non-overlapping": their boundaries are clearly marked in the Y0X coordinate system.

In Table 2 the values of the index of mutual proximity μ of the entire diesel network and 4 analyzed zones are given according to the developed methodology. The analysis of the results performed in Table 2.

While considering the whole network of diesel traction, as expected, all structural levels are most extremely "mixed" with each other and the index of mutual proximity μ has the lowest value (μ=0,244). Here, on the plane X0Y, there are many "local" areas of attraction consisting of a polygons, transparent and dead-end lines and sections. Some railway sections are combined into large railway lines. Such railway lines, as a rule, are included in the international transit corridors on the territory of the Republic of Kazakhstan.

The most important value of this indicator is the zone "North-West" (0,703). This is because in the area under consideration, the main volumes of cargo turnover are concentrated in several main railway polygons, which are of network importance. Therefore, there is a significant "gap" in the X0Y plane between the “polygons” and “transparent and dead-end sidings sections” in this zone.

More revealing, indicator value μ, zone "East – South" (0.305).

Although the size of the entire diesel network and this zone are not comparable, the structural elements (polygons and areas) of this zone are also more distant from each other, as in the network of diesel traction. This indicates the uniqueness of the diesel network and the structure of cargo traffic in the area. Such circumstance also speaks about “isolation” on the considered characteristics of the zone" East – South» from other zones of gravitation.

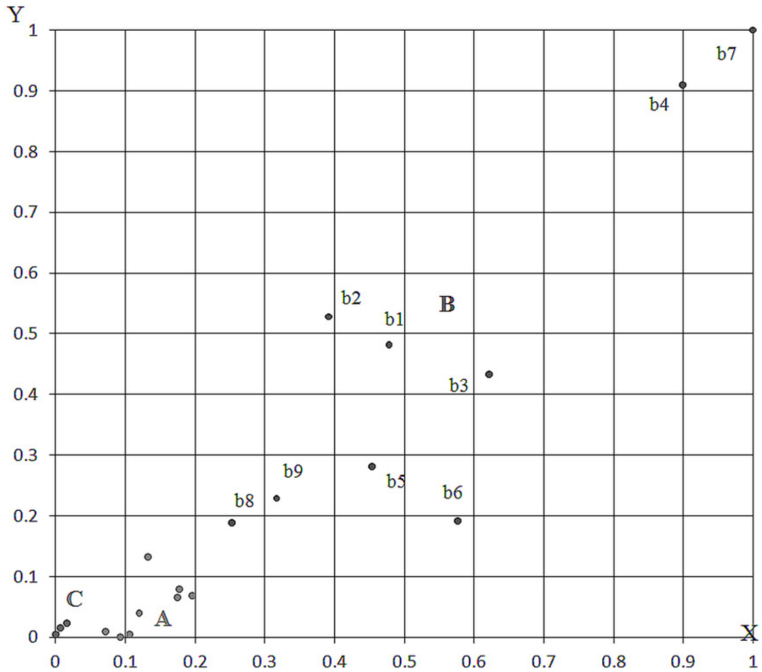

Fig. 2. The distribution of the elements of the set A, B and C on the plane X0Y of the whole network of diesel traction.

At the next stage, based on the analysis and evaluation of the attraction areas of individual polygons and sections of the network and various zones of attraction on the X0Y plane, the stations with the greatest "gravity" of the cargo turnover, and hence the volume of LNG consumption for locomotives on dual fuel was determined. In the future, it is planned to place the main LNG infrastructure facilities (CLNG, FCLNG and EST) at such stations on the diesel traction network of the Railways of Kazakhstan.

It is also revealed that there are several competing stations of "gravitation" in the considered zones. Therefore, further ranking of such stations in descending order of their rating is made.

Table 2. Values of an indicator of mutual proximity of the diesel network and separate zones of gravity.

Name of the zone of the railway network on diesel traction	Steam indicator of proximity sets μ
Network of diesel traction	0.244
North – West	0.703
Center – West – South	0.478
East – South	0.305

In addition, a special role in the assessment and selection of the location of the main LNG infrastructure facilities on the network of diesel traction is played by the scheme of the existing natural gas pipeline network in the territory of Kazakhstan. It is considered that natural gas pipeline networks in the territory of the Republic of Kazakhstan have the status of different levels – mainline (including international) and local.

Thus, while choosing the "gravitation" station and the location of the main LNG infrastructure facilities, the factor of availability of the natural gas pipeline network near these stations, their capacity and selling price of raw materials for further fuel liquefaction is considered.

4. Discussions about further research

The justification methodology of LNG infrastructure facilities location for locomotives on dual-fuel on the example of diesel traction of the railway network of the Republic of Kazakhstan includes all the necessary parameters for effective placement of CLNG, FCLNG and EST.

The only minor changes that may affect the possible recalculation of the "points" of infrastructure facilities location, according to the authors, are technological and technical solutions of diesel locomotive engine manufacturers. Providing a decrease or increase in the proportion in the value of the specific consumption of diesel and LNG fuels between diesel fuel and LNG or technical solutions for the tender of the locomotive, there will be a difference in the maximum mileage without refueling.

In addition, minor changes in the location of "points" may be due to changes in traffic flows and, as a consequence, changes in the load inside the zones.

The authors do not deny the need for further research on this issue and the possibility of applying the methodology for justifying the placement of CLNG, FCLNG and EST for locomotives on dual-fuel on other railway networks of diesel traction.

In addition, the authors allow the possibility of expanding the parameters considered by the model to accurately determine the “points” of LNG infrastructure location on railway transport.

5. Conclusion

As can be seen from the obtained results, on the example of the diesel railway network of the Republic of Kazakhstan, the zones of possible use of LNG for diesel traction are almost identical to the zones with passing natural gas pipelines. However, considering the length of non-electrified railway lines in Kazakhstan, the effective location of CLNG, FCLNG and EST through the network of diesel traction can significantly optimize the social and economic effect for all participants in this process.

They are the owner of the natural gas pipeline, LNG producers (high marginality of LNG and affordable price of natural gas due to the proximity of the natural gas pipeline), the railway (the optimal allowable price of LNG with the calculation of the main locomotive use, based on its operation (load capacity of the polygon)) and the environment (transition to a more environmentally friendly and safe type of fuel compared to diesel fuel).

Moreover, the authors of the justification methodology of the location of the main LNG infrastructure facilities for locomotives on dual-fuel considered the main parameters of the locomotives themselves, as well as the technical and technological functionality of the railway stations and depots.

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