SECTION 4 – YOUNG RESEARCHERS' PAGE

MODERNIZATION OF TRANSPORT AND CUSTOMS INFRASTRUCTURE FOR THE SUPPLY OF LIQUEFIED NATURAL GAS MARKET IN UKRAINE

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Abstract

In the scientific paper the evaluation of the development directions and increasing the efficiency of the logistics network of Liquefied Petroleum Gas terminals in the Trans-Dnieper region as elements of the regional energy transport and Customs infrastructure has been made. As a result of the statistical analysis of the fuel market in Ukraine it has been determined that the growing market of liquefied gas does not have a sufficient level of infrastructure to carry out operations of transshipment and storage within the Customs territory of Ukraine.

The key role of efficient freight traffic handling for the successful functioning and integrated development of both the state economy and the regions has been identified. The development of regional energy transport and Customs infrastructure has been defined as one of the key factors for achieving energy independence. Based on the proposed approaches to the development of the Liquefied Petroleum Gas transport and Customs terminals, the possibility of creating an appropriate infrastructure on the example of the Dnieper region of Ukraine has been shown.

The main scientific outcome of the paper includes designing principle approaches to the development of the Liquefied Petroleum Gas infrastructure of the region in the context of its infrastructure support on the basis of a logistics approach.

The obtained results and elaborated recommendations represent a methodological basis for the development of the transport and Customs infrastructure of the Liquefied Petroleum Gas market in the context of infrastructure provision in the region. The results that are of the greatest practical importance involve proposals for the procedure of conducting a situational assessment of the regional transport system development, usage of the territorial approach to the analysis of the improving the transport system in Ukraine and its regions as well as a sequence of actions to apply a logistics approach to the transport system enhancing in the region.

The proposed methodology can be applied at various administrative and territorial levels and allows potential investors to make deliberate decisions as for the placement of elements of the logistics transport and Customs infrastructure, taking into account the assessment of the infrastructure state in the region while defining its location and significance under the conditions of the domestic and foreign goods exchange expansion.

Keywords: logistics terminal, diversification of supplies, cargo traffic handling.

Introduction

The experience of developed countries and leading companies shows that logistics is a strategic factor of success in modern business. The use of a logistics approach in management is a necessary condition for increasing competitiveness and business efficiency (Sheikh Ariful 2013).

For today, transport takes one of the main places among the factors determining the effectiveness of the economy of the state as a whole and a particular region. A reliable transport infrastructure ensures efficient transportation of cargo flows, which is one of the prerequisites for the successful operation and integrated development of the regional economy (Skowron-Grabowska).

The economic security of any state is based on the maximum autonomy of its activities to ensure the stability of the national economy (Iksarova 2010).

A fundamental condition for this is to provide the economy with various types of resources in a sufficient volume. Energy resources are among the most important and necessary factors for reliable operation of enterprises. All indicators associated with their use, to more or less degree, affect the cost of production, manufacturing profitability and completely depend on the state of the energy system. Thus, the fuel and energy system is the basic sector of the economy, where an important resource is produced that ensures the inclusion in the production process of all other resources of the state such as machinery, raw materials, stuff, human resources, high technologies.

Under the conditions of dependence of the state on the import of oil products and the search for ways to diversify supplies, the problem of energy independence arises. As the world practice shows, the receipt of energy resources of more than 30% from one source, from the point of view of ensuring reliable energy supplies and the possibility of economic and political pressure on the country, already threatens the loss of energy independence.

The state of the regional transport and Customs infrastructure of Ukraine at the present stage is characterized by uneven regional division together with out-of-date technical and technological facilities and inadequate level of interaction between various modes of transport (Pasechnik 2016). The disproportion between the growing demand for logistics services in the regions and the available capacity of the infrastructure necessary for its implementation is the reason for high logistics costs, which does not meet the country's strategic goals connected with creation of a single economic space (Pasechnik 2016).

The fuel and energy sector of Ukraine was mainly developed in the 1960s and 1970s, which met the requirements of that time. Basically, it was aimed at storing and manipulating light (gasoline, kerosene, diesel fuel) and dark (residual oil, lubricant, tar) oil products and natural gas.

In the context of economic instability and increased price of gasoline and diesel fuel, Liquefied Petroleum Gases (LPG) have taken leading positions in the market of motor fuel.

1. Analysis of the liquefied gases market in Ukraine

The Ukrainian LPG market is developing at a rapid pace. This, mainly, happens due to increased popularity of this type of fuel among car owners. There is a significant potential for growth in the public utility as well as petrochemicals sectors. LPG is a fuel used primarily for automobiles and municipal services. LPG is composed of gases such as propane, propylene, isobutane, isobutylene, n-butane and butylene, which are mainly derived from associated petroleum gas. The most common motor mixture is propane-butane.

The advantage of LPG is nontoxicity, lack of corrosion, high octane number (102-108 depending on local conditions). In addition, it burns much cleaner than gasoline or diesel   fuel.
Since 2008 due to a significant increase in gasoline and diesel fuel prices, the share of LPG

at the motor fuel market in Ukraine has increased from 671 thousand tons in 2008 to 1115 thousand tons in 2016. The dynamics of growth of LPG market of Ukraine in the period from 2008 to 2016 is presented in Figure 1 (http://www.ukrstat.gov.ua).
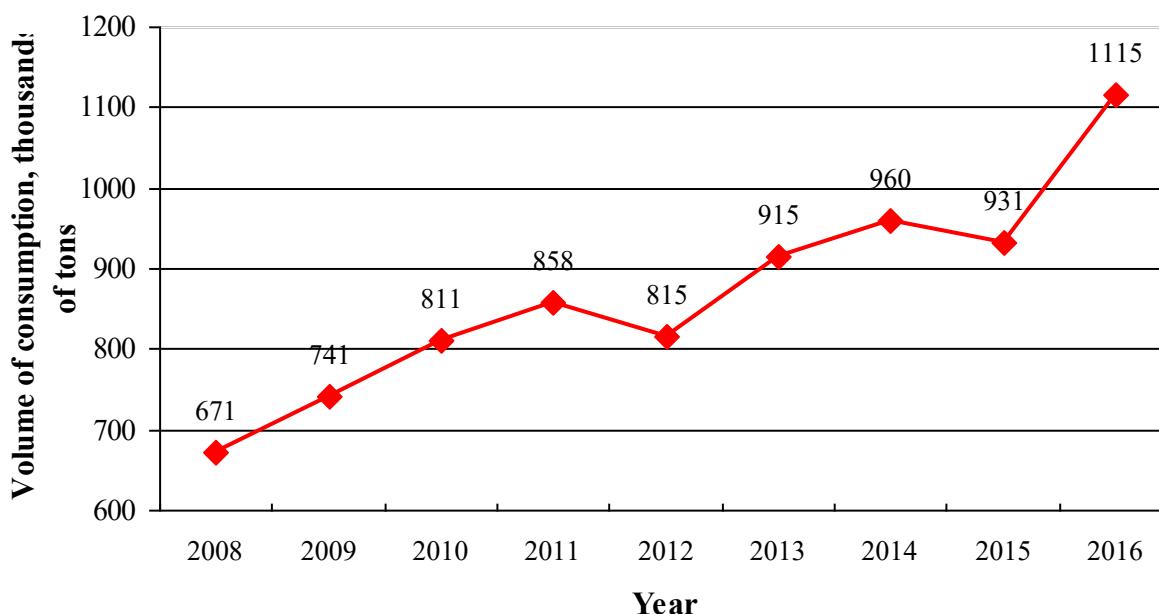

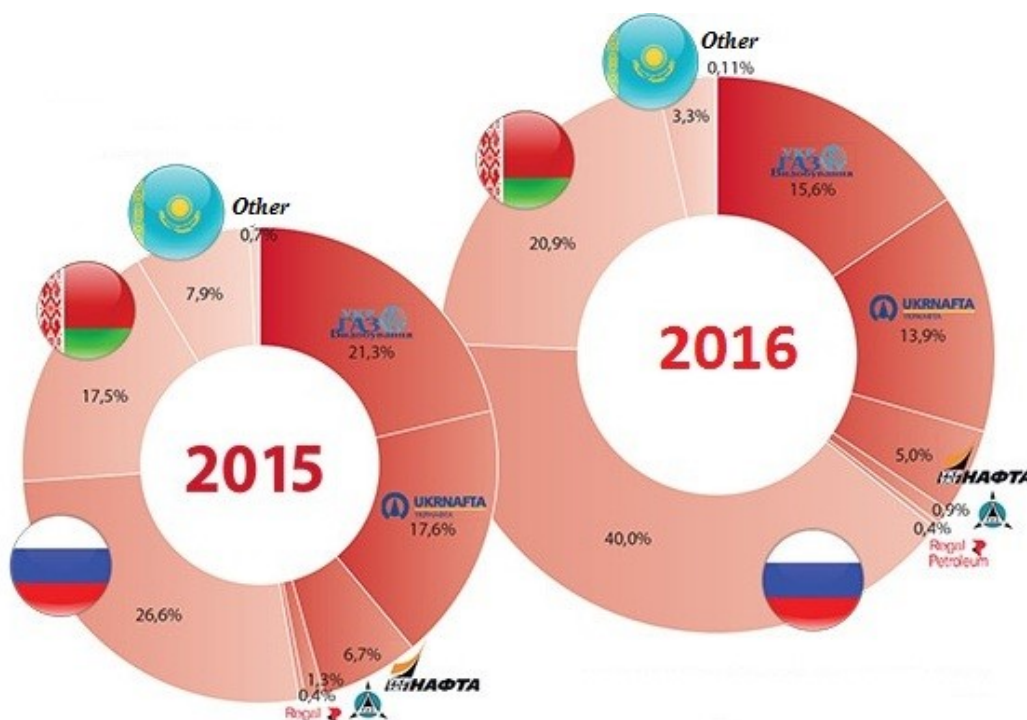*Figure 1. Dynamics of growth of the liquefied gases market in the period from 2008 to 2016.*

Figure 2. The structure of liquefied gas supply to the Ukrainian market.

In recent years, there have been no significant changes in the structure of LPG suppliers to the Ukrainian market. The main suppliers of LPG in Ukraine are the Russian Federation and Belarus (http://officevp.sfs.gov.ua).

Despite the growth and dynamic development of the LPG market in Ukraine and taking into account the statistical data, the absence of diversification of foreign supplies becomes more and more obvious. An orientation towards Russia and Belarus threatens the emergence of crisis. The dependence of the Ukrainian LPG market on Russian producers against the backdrop of tense relations between the two countries presents significant risks, since the lack of diversification negatively affects the market.

Another problem is a lack of capacity for LPG storage and reloading. To date, the storage capacity of LPG-terminals is about 30% of monthly consumption. The limited volume does not allow having an acceptable stock in case of force majeure.

In fact, the Ukrainian LPG market works "from the wheels", which in turn increases logistics costs in the final price of fuel by an average of 3-6%, compared to gasoline and diesel fuel (Fig. 3) (http://oilnews.com.ua).
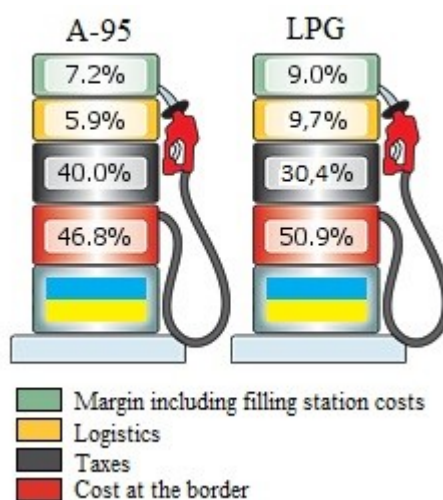

Figure 3. Comparative analysis of petroleum products prices calculation in Ukraine according to February 2017 data.

One of the ways to increase the efficiency of the LPG market is to develop a regional logistics transport and Customs infrastructure in the direction of rational use and allocation of resources, which is one of the main issues in logistics.

The creation of an efficient logistics transport and Customs infrastructure of the LPG market will help:
- solve the problem of accumulation and storage;
- decide the problem of interaction of various modes of transport and improve the quality of integrated services;
- reduce the cost of transportation.

2. Improving the infrastructure of LPG transport and Customs terminals

The main approaches to the development of the LPG transport and Customs terminals system will be considered on the example of building the similar infrastructure in the Trans-Dnieper region of Ukraine.

An LPG transport and Customs terminal is a transport facility with an appropriate infrastructure that ensures effective technologies for transportation, Customs clearance, processing, storage, distribution and flows management.

An LPG transport and Customs infrastructure, in its essence, operates by means of multimodal transportation and performs the function of sea and rail freight volumes transshipment to internal destinations.

The issue of placing elements of an LPG transport and Customs infrastructure depends on many factors, but among the defining ones we can distinguish the following:

- market availability and capacity;
- investment attractiveness of a region;
- region's proximity to international transport corridors;
- state of the transport infrastructure;
- efficiency of operating modes of transport.

The movement of material flows within the logistics network is impossible without the concentration of necessary reserves in certain places (Vasyliev 2017). The key role in the development of the LPG logistics transport and Customs infrastructure in the Trans-Dnieper region plays the choice of an optimal location of the logistics terminal in terms of logistics costs and profits while servicing the cargo flows. The LPG terminal must cover a wide geographical area and therefore be located in the center of the distribution area. The effective location of the logistics terminal will help reduce empty container trips, fuel costs, increase the use of lifting capacity and cargo capacity of a vehicle as well as also create a so-called "Hub" for storing and transshipping LPG within an industrial scope.

Most of the existing approaches to optimizing the location of logistics facilities allow defining the effective location of the elements of a transport and logistics infrastructure taking into account only transportation costs, considering only such factors as traffic volume, distance, cost of shipment (Pasichnyk, Vitruh & Kutyrev 2013).

At the moment, the transportation of the primary volumes of liquefied gas is carried out by multimodal means (Fig. 4) (http://officevp.sfs.gov.ua). Since export-import operations with such goods require Customs clearance (Pasechnik, Moroz & Dobrynina 2012), this makes the regions of departure and transshipment of goods crucial for building an effective logistics transport and Customs infrastructure. Demand and supply for quality logistic terminals depends on the purchasing power and population in the region servicing the terminal.

Figure 4. The structure of liquefied gases imports to Ukraine by mode of transport.

Now the author wants to consider the task of locating the LPG terminal in the Trans-Dnieper region (on the example of the Poltava region, Kirovograd region, Dnepropetrovsk region and Cherkassy region), based on the statistical data of the Energy Customs of the State Fiscal Service and consumption of the population, taking into account the geographical location of the largest cities-consumers in 2016.

To solve the given problem, we use the method of laying a grid of coordinates on a map with existing LPG terminals location and largest consumers (Pasechnik, Sohackij, Kuz'menko & Halipova 2012). The initial data for determining the placement is shown in tables 1 and 2.

Table 1. Output data on the volume of supplies and coordinates of the largest consumers

Customer location	Coordinate X	Coordinate Y	Population (thousands)	% Consumption	Consumption (thousand tons a month)
Piryatin	78,00	108,00	46,62	5,72	0,28
Gadyach	110,00	109,00	24,00	2,95	0,14
Mirgorod	101,00	97,00	65,32	8,02	0,39
Lubny	83,00	97,00	56,60	6,95	0,33
Poltava	116,00	84,00	310,42	38,09	1,83
Globino	98,00	73,00	17,49	2,15	0,10
Kremenchug	102,00	62,00	280,81	34,46	1,66
Mashevka	122,00	78,00	13,64	1,67	0,08
Kanev	61,00	96,00	25,30	5,33	0,16
Cherkassy	59,00	82,00	284,00	59,88	1,76
Smela	59,00	72,00	68,00	14,34	0,42
Chigirin	75,00	69,00	11,00	2,32	0,07
Uman	20,00	60,00	86,00	18,13	0,53
Zvenigorodka	40,00	71,00	8,00	1,93	0,06
Svetlovodsk	100,00	60,00	46,00	11,10	0,37
Alexandria	91,00	50,00	82,00	19,78	0,65
Znamenka	81,00	55,00	23,50	5,67	0,19
Kropivnitsky	71,00	48,00	240,00	57,90	1,92
Gayvoron	10,00	41,00	15,00	3,62	0,12
Dnipro	129,00	42,00	987,00	44,74	2,83
Kamenskoe	119,00	59,00	241,00	10,92	0,69
Krivoy Rog	96,00	28,00	642,00	29,10	1,84
Nikopol	121,00	11,00	118,00	5,35	0,34
Pavlograd	151,00	42,00	110,00	4,99	0,32
Pokrovsk	165,00	28,00	35,00	1,59	0,10
Novomoskovsk	135,00	48,00	73,00	3,31	0,21

Table 2. Output data of processed cargo volumes and coordinates of LPG terminals

Placement of an LPG terminal	Coordinate X	Coordinate Y	Processed cargo volume (thousand tons)
Sencha	96	111	0,523
Selyeschina	120	80	1,478
Poltava	116	84	0,423
Kremenchug	102	63	0,947
Kanatovo	74	43	0,642
Lelekovka	65	70	0,624
Gayvoron	10	41	0,582
Solenoe	125	32	0,962
Dnipro	128	43	1,378
Uman	20	60	0,672
Smela	60	72	0,839
Kanev	61	97	0,582

The use of a coordinate grid makes it possible to estimate the cost of delivering goods to the end user. In addition, in order to solve the tasks set the author determines the optimal location of the LPG terminal using a "center of gravity" method. The "center of gravity" approach allows the LPG terminal to be located at a point minimizing transportation costs.

Analyzing the existing network and the state of the roads throughout the Trans-Dnieper region and the distance between the major consumer cities, it is obvious that the distribution areas, taking into account a geographic factor, should be divided into two parts within the right and left banks of the Dnieper.

The coordinates of LPG terminals location can be calculated using the following formula:

$$M = \frac{\sum\limits_{i=1}^{m} R_{M_I} Q_{M_I} + \sum\limits_{i=1}^{n} R_{C_I} Q_{C_I}}{\sum\limits_{i=1}^{m} Q_{M_I} + \sum\limits_{i=1}^{n} Q_{C_I}} \tag{1}$$

where M is the center of mass or the center of equilibrium of the system;

R_{Mi} is the distance from the beginning of the coordinate axes to the point determining the location of an i-th LPG terminal;

R_{Ci} is the distance from the beginning of the coordinate axes to the point determining the location of an i-th consumer;

n, m – number of suppliers and consumers;

Q_{Mi} is the mass of the cargo entering an LPG terminal;

Q_{Ci} is the mass of the cargo delivered to a consumer.

The next task is to calculate the following parameters:
1. The total freight traffic due to the location of an LPG terminal:

$$\sum_{i=1}^{m} R_{M_I} Q_{M_I} \tag{2}$$

For the left-bank part of the Trans-Dnieper region

Along axis X $-\sum\limits_{i=1}^{m} R_{M_I} Q_{M_I} = 96*0,523 + \ldots + 128*1,378 = 549,614 \text{(thousand km)}$

Along axis Y $-\sum\limits_{i=1}^{m} R_{M_I} Q_{M_I} = 111*0,523 + \ldots + 43*1,378 = 330,74 \text{(thousand km)}$

For the right-bank part of the Trans-Dnieper region

Along axis X $-\sum\limits_{i=1}^{m} R_{M_I} Q_{M_I} = 74*0,642 + \ldots + 61*0,582 = 313,42 \text{(thousand km)}$

Along axis Y $-\sum\limits_{i=1}^{m} R_{M_I} Q_{M_I} = 43*0,642 + \ldots + 97*0,582 = 283,114 \text{(thousand km)}$

2. Total cargo traffic through the location of consumers:

$$\sum_{i=1}^{n} R_{C_I} Q_{C_I} \tag{3}$$

For the left-bank part of the Trans-Dnieper region

Along axis X $- \sum_{i=1}^{n} R_{C_I} Q_{C_I} = 78*0,28+...+ 135*0,21 = 1329,31$ (thousand km)

Along axis Y $- \sum_{i=1}^{n} R_{C_I} Q_{C_I} = 108*0,28+...+48*0,21 = 669,02$ (thousand km)

For the right-bank part of the Trans-Dnieper region

Along axis X $- \sum_{i=1}^{n} R_{C_I} Q_{C_I} = 61*0,16+...+ 121*0,98 = 1037,67$ (thousand km)

Along axis Y $- \sum_{i=1}^{n} R_{C_I} Q_{C_I} = 96*0,16+...+11*0,98 = 553,52$ (thousand km)

3. Coordinates of the optimal location of an LPG terminal:
For the left-bank part of the Trans-Dnieper region

Along axis X $- \dfrac{\sum_{i=1}^{m} R_{M_I} Q_{M_I} + \sum_{i=1}^{n} R_{C_I} Q_{C_I}}{\sum_{i=1}^{m} Q_{M_I} + \sum_{i=1}^{n} Q_{C_I}} = \dfrac{1329,31+549,614}{10,82+4,75} = 120,68.$

Along axis Y $- \dfrac{\sum_{i=1}^{m} R_{M_I} Q_{M_I} + \sum_{i=1}^{n} R_{C_I} Q_{C_I}}{\sum_{i=1}^{m} Q_{M_I} + \sum_{i=1}^{n} Q_{C_I}} = \dfrac{669,02+330,74}{10,82+4,75} = 60,21$

For the right-bank part of the Trans-Dnieper region

Along axisX $- \dfrac{\sum_{i=1}^{m} R_{M_I} Q_{M_I} + \sum_{i=1}^{n} R_{C_I} Q_{C_I}}{\sum_{i=1}^{m} Q_{M_I} + \sum_{i=1}^{n} Q_{C_I}} = \dfrac{1037,67+313,42}{12,58+4,9} = 77,28.$

Along axis Y $- \dfrac{\sum_{i=1}^{m} R_{M_I} Q_{M_I} + \sum_{i=1}^{n} R_{C_I} Q_{C_I}}{\sum_{i=1}^{m} Q_{M_I} + \sum_{i=1}^{n} Q_{C_I}} = \dfrac{553,52+283,11}{12,58+4,9} = 47,85.$

The calculations have shown that the coordinates of an LPG terminal on the left bank of the Trans-Dnieper region (X = 120,68, Y = 60,21) correspond to the territory in the area between Kamenskoye and Magadalinovka of the Dnepropetrovsk region, while the coordinates of an LPG terminal on the right bank of the Trans-Dnieper region (X = 77, 28, Y = 47,85) relate to the territory in the area of Kropivnitsky, Kirovograd region. The geographical location of the calculated LPG terminal locations is shown in Figure 5.

3. Determination of the optimal location of an LPG terminal

Having analyzed the results of calculating the optimal locations for an LPG terminal, the existing transport infrastructure of the Trans-Dnieper region and prospective directions of supply diversification, it has been determined that there are two most suitable places to locate LPG terminals. First, within the left-bank part of the Trans-Dnieper region it covers
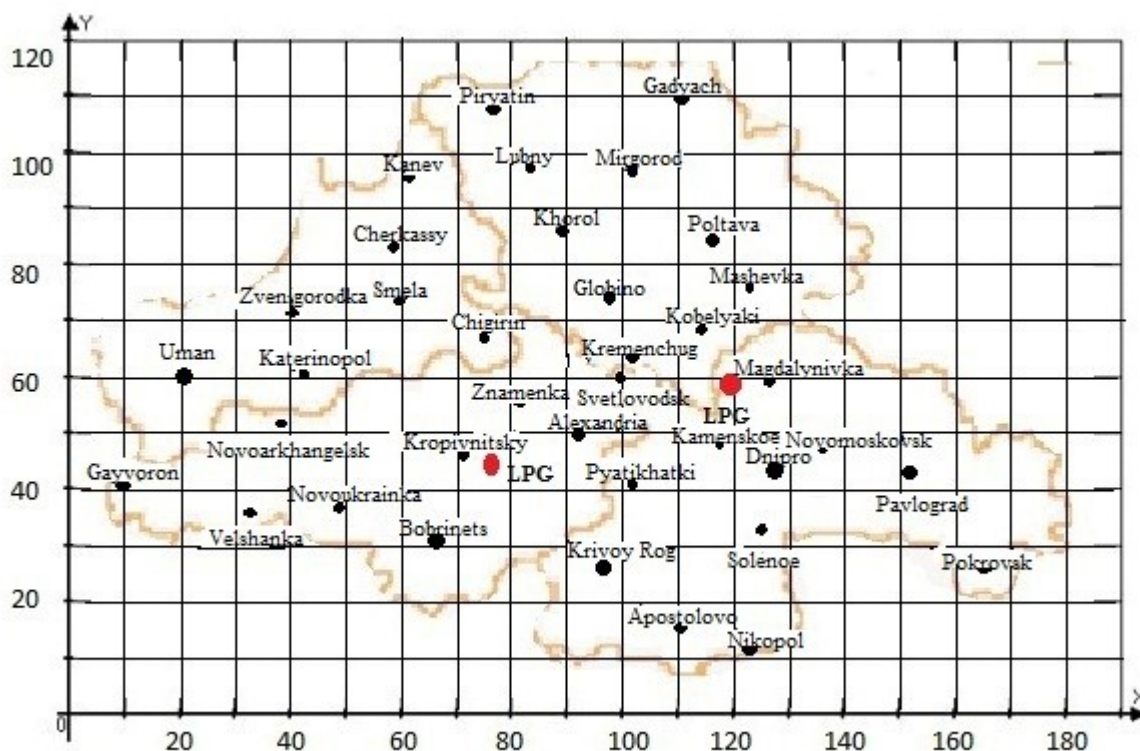
Figure 5. The calculated location of an LPG terminal.

the city of Kamenskoye, Dnepropetrovsk region. The main advantage of choosing this location is a developed transport and industrial infrastructure of the region. Furthermore, within the city there is the main railway line Znamenka – Pyatikhatki – Dnipro. There are also several cargo-passenger stations on the territory of the city (Bagli, Trituznaya, Dneprodzerzhinsk, Dneprodzerzhinsk – Levoberezhny), which in future will be able to handle about 80% of LPG delivery to the terminal. There is also a motorway of public significance Boryspil – Zaporozhye (H-08), which connects with the Dnieper (46 km) and is a key factor in a cargo delivery throughout the retail network to the end customer with the most efficient use of the capacities and advantages of various modes of transport.

Besides, another benefit of an LPG terminal location in the city of Kamenskoye is an availability of a river port. That in the short term can become a real alternative to diversification of supplies from near abroad through LPG transportation by river and sea transport.

On the right-bank part of the Trans-Dnieper region the calculated location coincided with the LPG terminal "Kanatovo". Within the terminal there is a main railway line connecting the city of Kropivnicki and Znamenka junction station, as well as the motorway of public significance Kiev – Znamenka – Izvarino. The development of the LPG terminal "Kanatovo" is the most prospective as the increase of the tank park and handling capacities in the already operating terminal will allow the creation of a logistics transport and Customs complex with a minimum level of capital investments.

Thus, taking into account the influence of all the above factors and also the fact that LPG is a dangerous cargo of the 2nd category, where loading and unloading, transshipment and transportation provide for increased safety requirements, the creation of so-called "Hubs" within the LPG market, which is dynamically changing, will minimize the costs of transporting products to the Trans-Dnieper region and create the necessary transport and Customs infrastructure to support the growing LPG market.

Summary and concluding remarks

The analysis of the LPG market has shown that the existing logistics infrastructure nowadays can not provide a full and efficient handling of goods under the growing market conditions. The lack of capacity for LPG storage and transshipment, as a consequence, leads to an increase in the share of logistics costs in the final price of fuel. The proposed concept of modernization of the LPG logistics infrastructure of the Trans-Dnieper region will create a network of regional logistics transport and Customs complexes (hubs) to optimize the entire supply chain. All existing LPG terminals, united by logistics centers, will receive proper loading. The system will manage the mechanism of cargo movement and search for the most optimal delivery route to the end user. These measures will allow uniting all the structures into a single whole and create a unified functioning mechanism that will reduce logistics costs and, based on the proposed logistics centers, create a strategic reserve to meet the needs of the region.

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