Journal of International Scientific Publications: Ecology and Safety

Volume 8, ISSN 1314-7234 (Online), Published at: http://www.scientific-publications.net

PROSPECTS AND RISKS THE TRANSFER OF MOTOR TRANSPORT AT THE GAS FUEL

Makarova I. V., Khabibullin R. G., Gabsalihova L. M., Belyaev E. I.

Kazan (Volga region) Federal University

Russia, Naberezhnye Chelny, pr. Syuyumbike, 10A

Abstract

Article is devoted to development of practical methods an assessment of prospects, risks and analysis of ecological efficiency of the actions connected with development of the automobile market on gas motor fuel. The assessment of negative influence of the motor transport on environment and advantages of its transfer to gas motor fuel is given. Preconditions for transition of public transport, and transport of utility services on gas fuel are analyzed. Advantages of use of gas motor fuel as safe and environmentally friendly type of alternative fuel are considered. Limiting factors of transition of the automobile transport on gas fuel are described and analyzed. Solutions of these problems for of providing a sustainable development of transport system and the cities are specified. High-quality risk analysis, characteristic for projects on expansion of a network of automobile gas-filling compressor stations and development of service of gas cylinder cars is carried out.

Key words: *gas motor fuel, risk assessment, risk analysis, ecological efficiency, card of risks, service of cars on gas motor fuel*

1. INTRODUCTION

According to one of the definitions of a transport - this is an industry that creates useful space, being one of the economy sectors that are critical from the point of view of satisfaction of public needs and ensure sustainable functioning and development of the economic complex as a whole. In addition, transport is a key sector in the context of energy and environmental security. Therefore during the last decades throughout the world the question of the alternative types of motor fuel does not lose its relevance, it becomes a key in terms of ensuring energy security of transport. Maintenance the level of oil production, which applies to non-renewable energy sources, in the same scale as now, in the near future its reserves will be completely exhausted.

The second serious problem connected with the increase of motorization is the negative impact of transport on the environment (Fig. 1). The emissions from vehicles are one of the most serious causes of air pollution in large cities. Thus in Moscow and in other large cities of Russia the share of automobile emissions is more than 90% of total emissions of polluting substances into the atmosphere. In cities with less developed industry the share of the contribution of automobile exhaust gases is not much smaller (about 80 to 90%). In Russia as a whole motor vehicle emissions in the atmosphere make up 42% of their total number (Konstantinov 2012; Smurov, Snakin, Komarova 2012).

According to the opinion of researchers from Cornell University forty percent of all deaths worldwide are caused by influence of pollution of air, water, soil. Toxic emissions into the atmosphere annually kill about three million people. The main causes of deaths caused by air pollution are cancer, congenital disorders, disruption of the immune system of the human body. The inhalation of the air, which contains the combustion products (sparse diesel engine exhaust), even for a short period of time, for example, increase the risk of coronary heart disease.

Vehicles, along with industrial enterprises, emits black smoke and greenish-yellow dioxide, which increase the risk of early death. Even relatively low concentrations of these substances in the atmosphere cause from 4 to 22 percent of the deaths of up to forty years. Very dangerous symptom for humanity is that air pollution increases the probability of birth of children with congenital defects (Dishisvobodno 2013).

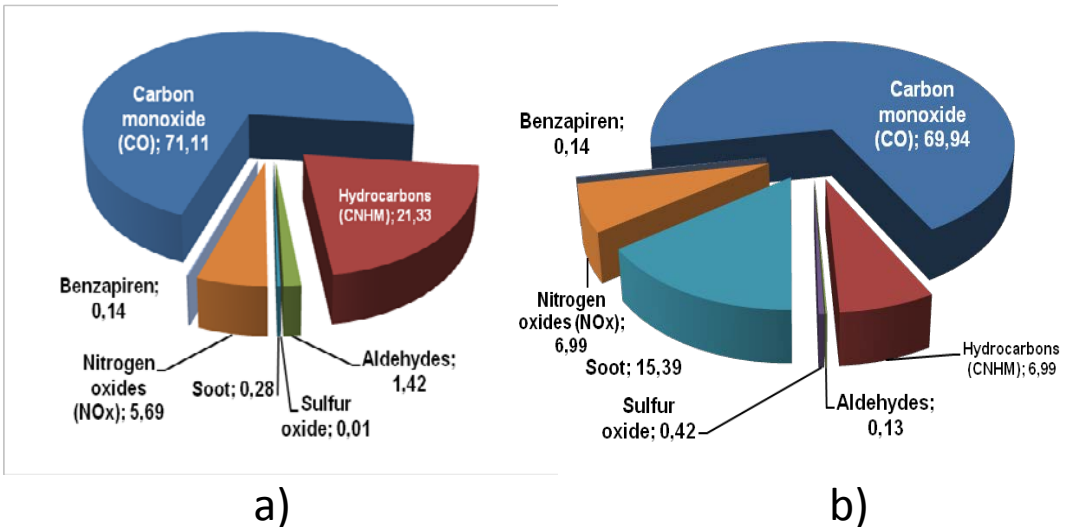

Fig.1. The pollutants in the exhaust gases of vehicles:

a) - with a gasoline engine; b) - with a diesel

According to the European Commission (Eurostat 2008), in 27 countries of the EU transport is the second largest source of greenhouse gas (GHG) emissions after the production sector, and dynamics of greenhouse gas emissions from transport are higher than in any other energy sector (Beuthe et al. 2007). Thus, the share of emissions of motor transport accounts for more than 90% of direct emissions of transport (Eurostat, 2009), and continues to increase in most countries due to growth in road transport.

2. POSSIBLE PROBLEM SOLUTIONS CAUSED BY THE INCREASING MOTORIZATION

The growing level of motorization is forcing the international community to find solutions to reduce the negative influence of motor transport on the environment: toughening requirements to environmental safety of vehicles, introducing strict standards of Euro-4, Euro-5, developing Euro-6. More economical and environmentally friendly transportation is a key element of the concept of transition to a low carbon economy, which is one of the priority directions of sustainable development of the socio-economic system of Russia facilitating the transition towards a «green» growth, reduction of the burden on the environment, increase efficiency of use of natural resources.

There are a number of ways in which energy consumption and, accordingly, emissions from the transport sector can be reduced. Article (Bertoldi et al. 2011) shows that the activities can be classified as follows, highlighting five categories:

1. Improvement of transport technologies. It implies new technical solutions for modes of transport, mainly, the use of alternative energy sources (electric vehicles, hybrids, hydrogen fuel cells and other), advanced fuels, improving the design of the vehicle and its technical and operational characteristics.

2. The use of low-carbon fuels. The expansion of the fleet of electric vehicles, the use of «second generation» biofuels as a sustainable alternative to fossil fuels. In works (Larivé et al 2004; Bringezu et al. 2009), the potential of reducing carbon emissions is explored.

3. Increase of efficiency of use of transport. In the sphere of passenger traffic – it is due to the common use of cars and improve fuel efficiency through eco-driving. In the sphere of freight transportation possible projects include improving logistics and training of drivers.

4. Providing the most efficient means of transport during any journey. Project supports more efficient modes of transportation organization (both passenger and freight) by improving information, ticket sales, planning trips to the place of work, study, etc. Such policy, as shown in article (Anable, 2005), is a cost-effective and reduces emissions.

Volume 8, ISSN 1314-7234 (Online), Published at: http://www.scientific-publications.net

5. Reducing the need for travel. As it is marked in researches, for realization of this direction there is less explicit political mechanisms. However, the use of information and communication technologies (ICTs) can increase the efficiency of planning routes, and also reduce the number of journeys, using such forms of organization of labor activity as teleworking, video-conferencing, the use of the Internet to make purchases, pay for services. In addition, you can use ICT for spatial planning purposes during the construction of new housing and business development. However, the reverse effect of such methods is noted: for example, communication through video conferencing with people around the world could lead to an increase in the need for further cooperation and personal meetings (Choo, Mokhtarian, Salomon 2005).

3. ADVANTAGES OF USING ALTERNATIVE SOURCES OF FUEL FOR VEHICLES

In works (Tzeng, Lin, Opricovic 2005; Petrović et al 2009) the opportunities of alternative sources of fuel for public transport are discussed. In article (Khan, Prior, Islam 2005a) electric cars, buses, hybrid and fuel cell (hydrogen) are compared. As a result of multifactorial expert evaluation of the alternatives it was found out that hybrid electric bus is the most suitable for Taiwan's urban areas, on short and medium routes. However, it is emphasized that at acceptable distances pure electric bus could be a better alternative. In article (Tzeng, Lin, Opricovic 2005) the economic and environmental aspects of modernization and renewal of the subsystems of public transport through the use of alternative fuels, natural gas and biodiesel fuel is analyzed. In article (Ribeiro et al 2004) a procedure of evaluation of efficiency of the hybrid drive Brazilian buses is proposed. The tests indicated the reduction of diesel consumption through the use of hybrid drive, which leads to lower fuel costs and carbon emissions.

The objective prerequisites for the growth of interest in the use of gas as motor fuel in recent years – are higher energy and environmental performance compared with petroleum fuels. From all massively used motor fuels and technologies the natural gas offers the most secure exhaust emissions, has a reduced impact on lubricating oils (30-40%). Thus, the conversion of vehicles from gasoline to gas allows to lower on average five times the harmful emissions and noise impact two times. In addition, the gas does not contain the main contaminant of gasoline - sulfur, so even the most refined petrol of «Euro-5» can't be compared in clean combustion with gas fuel. Another important factor is more stable than that of oil gas price and higher efficiency: at its lower price (two times lower than diesel fuel) the energy is almost the same - 0.95:1.

Natural gas as motor fuel, is used in several forms: Compressed natural gas (CNG), liquefied natural gas (LNG) Liquid propane gas - LPG, and attached natural gas (ANG) (Johnson 2003; Zhuang, Yodotani, Kato 2005). In this case, CNG-powered vehicles have been already used worldwide, and technology of its receipt, storage and use has been already developed. There are about four million vehicles to CNG in the world. Compressed natural gas as motor fuel is widely spread in the countries with its own natural gas reserves. These vehicles produce only small amounts of carbon dioxide and have a high octane value, so they are suitable for use as public transport (Sperling, Setiawan, Hungerford 1995) .In some countries, LPG is used in public transport. Thus, according to researches (Sperling, 1995), in Japan, Italy and Canada 7% of the buses use LPG as motor fuel, and some European countries plan to use LPGvehicles, to reduce the load on the environment. However, the most urgent issues that require further research, are organizing the production of natural gas (Dawe &Thomas 2007), its distribution and safety.

According to foreign experts, in the nearest years the CNG and LPG are the only real alternative to gasoline and diesel fuel. The most well-known foreign car producers have serial production of more than 180 models of motor cars, among which there are 112 models of cars, 35 trucks, 38 buses. The most widely gas-engine cars are represented by European producers (126 models).

World fleet of gas-engine vehicles since 2000 has increased more than three times. Nowadays 14.7 million vehicles work on CNG, representing 1.5% of world fleet (900 mln units). In recent years the world fleet of vehicles running on natural gas has been increasing by 25-30% annually. Today, there are already 20’746 automobile gas-filling compressor stations (AGFCS).

Due to its low cost (cost of CNG is about 50% of the cost of gasoline, LPG - 75%), natural gas is increasing interest of consumers, and CNG-powered buses, garbage trucks, public service vehicles are increasingly spreading in America, Europe and Asia. private taxi companies also use this fuel. According to the forecast of the International Gas Union, the trend of development of gas sector of the world market will remain: the growing fleet of bottle-gas driven vehicle will account for 50 million units by 2020, and more than 100 million units by 2030, the consumption of natural gas as motor fuel will grow up to 40-45 billion m3. Perspectivity of this direction for Russia is due to the fact that having the largest natural gas reserves in the world, it still ranks only the 5th place in the world in the number of LNG-powered cars (1.3 million) and divides 17th-18th places with the

Volume 8, ISSN 1314-7234 (Online), Published at: http://www.scientific-publications.net

USA in the number of CNG-powered cars (about 100 thousand). In addition, the fact that there are special programs of state support in Russia to transferring the public transport to gas fuel should be considered as a stimulating factor in the transition to alternative fuels. The Chairman of the Government of the Russian Federation Dmitry Medvedev, speaking at a meeting on the development of the automotive industry in the medium term, voiced the idea of the country's transition to natural gas (tsg66.ru 2013), and on the 13th of May, 2013, signed the Decree on mass (not less than 50%) public transport transfer on gas fuel.

When using methane gas as motor fuel, products of incomplete combustion are not formed, because there is an excess of oxygen. Nitrogen oxides are formed in smaller amounts, as the temperature of combustion poor mixtures is much lower. Parietal layer of the combustion chamber using poor air-gas mixtures contains less fuel than its wealthier gasoline-air. Thus, with correctly adjusted methane gas engine, emissions of carbon monoxide are reduced in 5-10 times in comparison with petrol, oxides of nitrogen aer excreted in 1.5-2.0 times less, and hydrocarbon - in 2-3 times less. In addition, when using methane the selection of so-called greenhouse gases is significantly reduced. The carbon content by weight in the composition of methane - 75%, in the composition of gasoline - 85%, so at complete combustion of natural gas carbon dioxide (CO_2) is formed by 13% less than the combustion of gasoline.

Taking into account that the average annual mileage of the KAMAZ vehicle is 80’000 km, and the average fuel consumption at the rate of 40 l per 100 km is 32 000 litres, it is possible to estimate the reduced emissions of toxic substances into the atmosphere per year, with the use of one car with his transfer to gas fuel (Fig.2).

High environmental effectiveness of this type of fuel is also confirmed by the fact that the amount of toxic emissions emitted by gas engines of KAMAZ, is significantly less than the acceptable standards of Euro-4: NMHC (non-methane hydrocarbons) - 1.9 times; CH4 (methane) - in 3,2 times; CO (carbon oxide) - 200 times; NOx (nitrogen oxide) - 1.6 times.

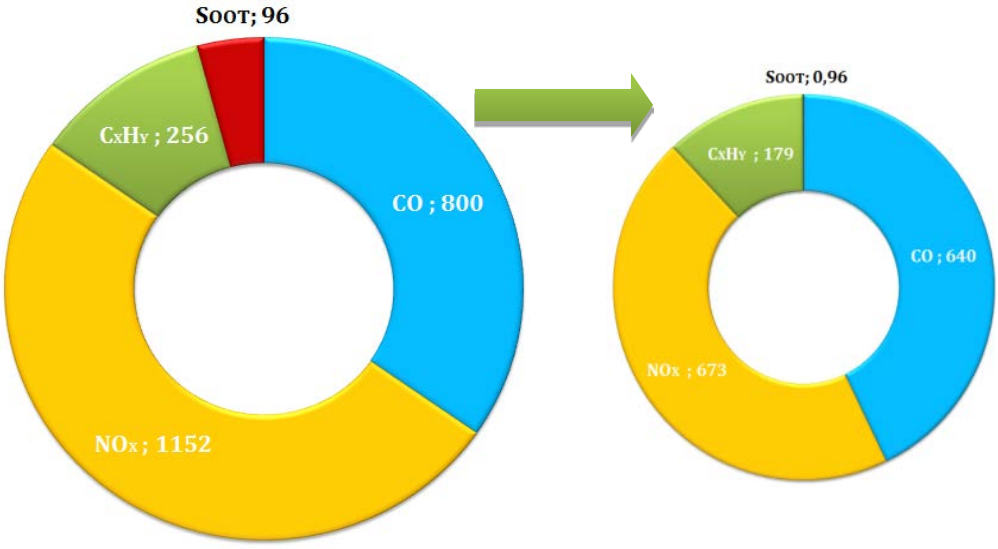

Fig. 2. Toxicity reduction of emissions of one of the KAMAZ vehicle with a gas engine in a year, compared with diesel

4. THE CONSTRAINTS AND RISKS OF THE USE OF NATURAL GAS AS MOTOR FUEL

The main constraint in the development of this direction is the lack of infrastructure for mass usage of equipment with gas engines. As gas-powered vehicles are different from traditional, there is a number of problems arising in the expansion of their share in the fleet. The peculiarity of NGV technology is that it requires more frequent refueling, which in turn requires more dense ring of gas filling stations (Gt-garazh 2010), and therefore infrastructure development envisages expansion of the network of automobile gas-filling compressor stations (AGFCS). Moreover, the expansion or modernization of the network of service centers is also necessary (Makarova et al 2012), which provided the areas of bottle-gas equipment service (BGE). The most important question, the quality of the decision of which determines the demand and satisfaction of the owners of vehicles, is reliability and development of a system of corporate service, especially in the warranty period of operation.

It is necessary to evaluate the risks in each sphere of infrastructure changes: the expansion of AGFCS network and the development of the service network, for which at the first stage logical risk map is usually constructed (Fig. 3). Causes of risk situations during the formation of the infrastructure as a system that enables the operation of vehicles (BGV), may be invoked as a separate reasons for AGFCS network and service network and common to both of them. In addition, the risks can be caused by external influences and changes in settings of the system, this may result in synergy effects as positively influencing the state of the system and its negative impact on the state of its subsystems.

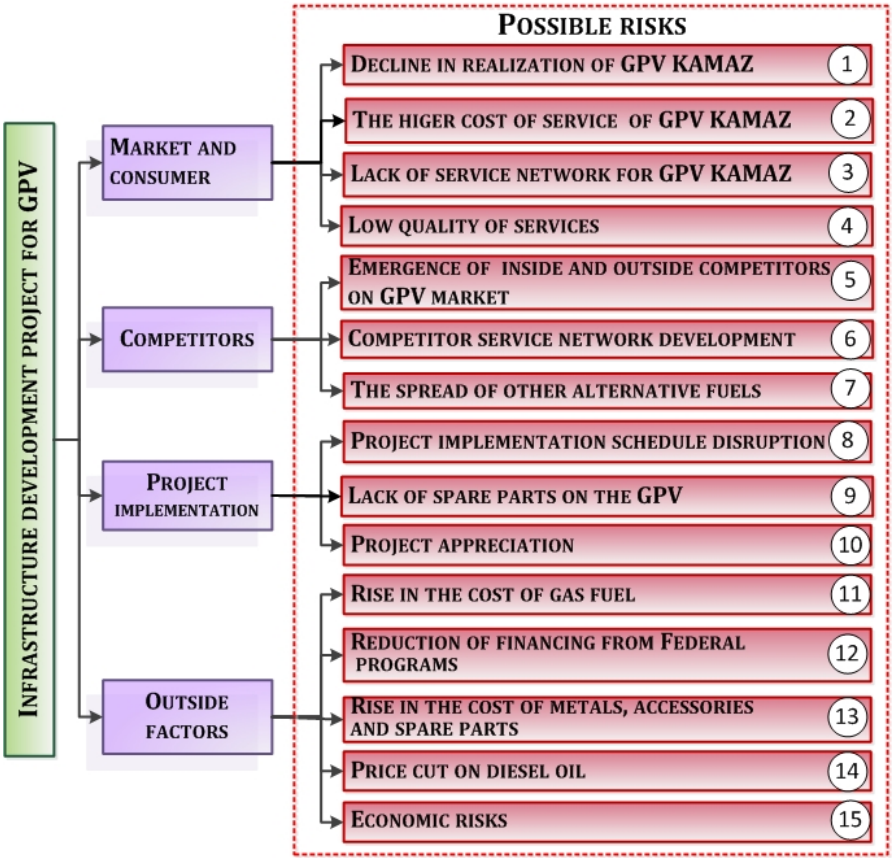

Fig. 3. Logical map of project risks of creation the infrastructure for gas vehicles of KAMAZ

The success of a new product depends on engineering solutions (reliability), and from a marketing policy (price, guarantees). Market risk represents the risk of choosing the wrong strategy of behavior in the market. This may be the wrong orientation to consumer product and services, errors in the range of choice, incorrect evaluation of competitors etc., the result of which will be the decrease of gas vehicles sales. Maintenance costs for guarantees depend on the reliability of the product, in its turn, the manufacturer may extend the warranty, if he is confident in the reliability of their products. Thus, the issues of reliability, price and warranty should be examined in conjunction (Huang, Liu & Murthy 2007).

Considering a question of the cost and duration of the warranty period, authors of research underline, that all models have to use the information on failures during the warranty period, and noted that the quality of information depends on the adequacy of the decisions (Lee, Moon 2009; Lee et al 2008; Last, Sinaiski, Subramania 2010; Xie, Liao & Zhu 2014). As the causes of failure can be due to various factors, that are dissimilar, it is necessary to have a tool for processing large data arrays, which can be, including text (Buddhakulsomsiri et al 2006). For forecasting the use of different methods of data mining, including neural network algorithms (Rai & Singh 2005).

Regional peculiarities of running vehicles (densely population of the territory, the degree of economic development of RF subject, the main sector of the national economy), the type of settlement (city, town, etc.), and other factors should be take into consideration. For convenient risk management factors can be imagined in

the form of multidimensional cube, using the technology of online analytical processing (OLAP), the simplest example of which is three-dimensional cube (Fig.4).

Customers' satisfaction and service quality largely depends on the quality of planning of the supply of spare parts. This is one of the questions that can be solved with adequate information (Kubat 2004). To collect information about how and when and under what parameters of the environment and the conditions in which the product can is used a variety of sensors installed on the product are used (Meeker, Hong 2014).Creation of a quality system, which allows to monitor the service system status on the basis of information, allows to increase efficiency of its functioning (Brah & Chong 2004; Weinstein et al 2009).

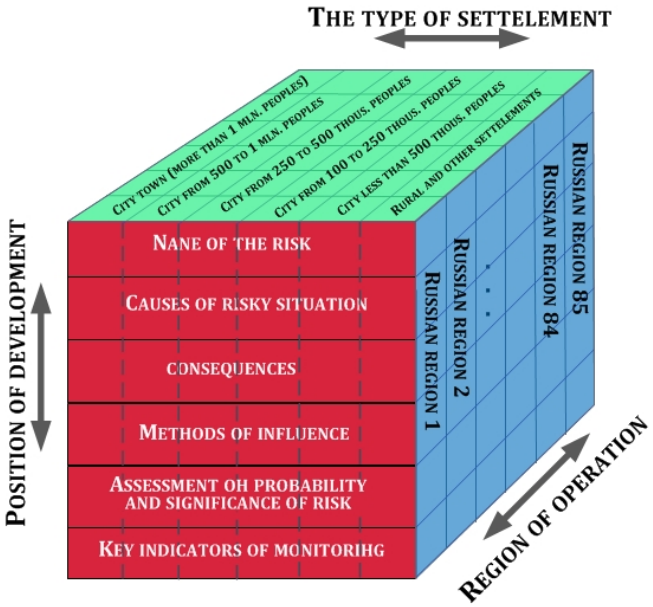

Fig. 4. - Three-dimensional OLAP cube for risk analysis

The first stage of qualitative risk analysis of service network expansion for BGV is the identification of all possible variants of risk situations, their causes and consequences and possible ways of their preventing or overcoming (table. 1).

Assessment of possible project risks of service network expansion for gas vehicles KAMAZ in the context of the region, including the type of settlement, was done by the method of expert estimates. The analysis was made by not less than 10 experts, competent in the given direction, each of whom assessed the probability of occurrence of risk situations from the provided list.

Table 1. Risks of development of the service for BGV

№	Risk	Causes of risky situation	Consequences	Methods of influence
1	Market risk	The mismatch between the characteristics of the vehicles to the needs of customers, a decline of purchasing power	The decrease of car sales and services	Reducing the cost of product Studying of consumer preferences The development strategy of a customer-oriented service
2	The higher cost of service organization	The inefficiency of service	The decrease of the volume of services	Measures to increase efficiency
3	The rise in the cost of gas fuel	The growth of world prices on oil products The rising	The slow growth fleet of BGV	Proposals on government measures for regulation of

		cost of gas production		prices on the market
4	The spread of other alternative fuels	Search and development of energy-efficient fuels The development of hybrid technology and electric vehicles	The transition to other fuels, a reduction to a fleet of BGV	Development of the ways of effective operation of gas vehicles Development of service and filling stations
5	Reduction of financing from Federal programs	Lack of budget funds Economic recession	The slowdown fleet of BGV	The inclusion of Federal target programs on gas vehicles in priority
6	Expansion of a spectrum BGV external competitors	Active promotion of external competition in the market	The decline in the share of KAMAZ vehicles on the gas market	Development and implementation of plans of action to combat competitors
7	The development of service BGV external competitors	The market entry of new dealers and service enterprises	The decrease in competitiveness, the volume of car sales and services	Development and implementation of plans of action to combat competitors
8	Growth Park BGV domestic competitors	Active promotion of competition of rents in the market, including their participation in Federal target programs The lag from the competitors on product quality	The decline in the share of KAMAZ vehicles on the gas market	Development and implementation of plans of action to combat competitors
9	A lack of spare parts on the BGV	Inefficient producers C/parts Incorrect calculation of stocks Inefficient work of logistics services	Customer dissatisfaction, loss of customers	Optimization of the logistics services Constant work with clients, attracting new customers
10	Failure warranty for BGV	The violation of the obligations dealer network	Customer dissatisfaction, loss of customers	The development strategy of customer-oriented service
11	Economic risks	The recession in the economic sphere The decline in oil prices	The sales decrease in the BGV	Measures of state support of the economy

Risks that may arise while extending the fleet of KAMAZ gas vehicles, were investigated on example of the Stavropol territory. Taking into account that for trouble-free operation of fleet expanding will be required under the power of AGFCS and service network to the growing needs of the fleet of BGV. Stavropol region was chosen for the reason that the region is a resort - and a special economic zone of tourist-recreational type «Grand SpaYutsa» (Resolution № 71 of the RF government on the 3rd of February, 2007) was created there, and therefore, increased demands on the environment are made to the region. The total number of fleet of vehicles in this region is 17’261 units.

The bus fleet of the Stavropol territory by the end of 2012 was 20.6 thousands of units, and the fleet is characterized by a significant deterioration (about 80% of the population of the fleet), which requires an update (Consultant plus n.d.).

Qualitative risk analysis, expressed in the form of a diagram risks (figure 5) showed that the most critical of all species in this region are marketing and increase in cost of service management.

To control the most critical risks KPI (Key Performance Indicator) were highlighted which allow to achieve to take appropriate measures to implement exit strategies from risky situations at a deviation of maximum level. The values of these indicators in the pessimistic scenario of development, expressed in the decline of a number of fleet gas vehicles of KAMAZ 50% from the projected, are the following: NPV - net present value – will fall

from 6943 up to 513 thousand roubles; PBP - discounted payback period - will increase from 10.55 years and will exceed the planning horizon (> 18 years); IRR - internal rate of return - will decrease from 25.9% to 15.1%.

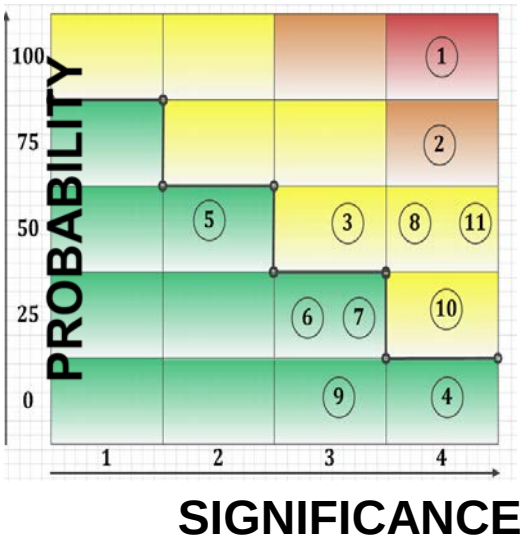

Fig. 5. Risk map extension service for BGV

The risk caused by the mismatch of the dynamics of expansion of fleet of BGV with the forecasted values, is to make the pessimistic and optimistic scenarios for the expansion of the fleet and predicting the likelihood of each of them, i.e. the control of dynamics of growth of the fleet of BGV. The critical value of the number of fleet of BGV is determined with reference to its predictive values for the pessimistic variant, and the greatest possible critical deviations from this value, at which the performance indicators will be positive and expansion project network of AGFCS and to expand the service network. Any numbers of fleet of BGV, in the interval between the density of the fleet according to the pessimistic forecast, and taking into account the maximum deviation, will be in the normal range, while the performance indicators will be positive.

As a qualitative risk analysis indicates sufficient severity of the risk associated with the change in the dynamics of population growth fleet of gas vehicles KAMAZ and the reduction of this indicator can lead to substantial losses in developing the strategy, it is necessary to provide appropriate incentives to expand the number of fleet of gas vehicles KAMAZ. On the one hand, it is the removal of all subsidies for compensation of fuel for municipal auto transport, and on the other hand, the promotion and implementation of NGV vehicles and buses, and also spare parts and LPG equipment through the existing dealer and service network (DSN) of KAMAZ, when the stimulation of subjects of the DSN to the creation of the posts and sections for service of BGV (KAMAZ 2012). In particular, Director General of JSC "KAMAZ" Sergey Kogogin said that with the expansion of gas production of KAMAZ the company is ready to organize all their technical centers, services of gas car modifications. The basis of the state order may be introduced by the Federal and Republican authorities requirements for budgetary organizations to increase by 2020 the share of natural gas in the balance of motor fuels until at least 30 percent (National Natural Gas Vehicle Association 2013).

5. CONCLUSIONS

Despite the obvious environmental and economic benefits of using natural gas as engine fuel, there are constraints for the implementation of projects of motor transport conversion to gas, as well as the risks that may arise during the implementation of similar projects. Therefore, a set of stimulating measures of the state to support them is important. In addition, the timely determination of the risk assessment and control allow to reduce losses, to prevent the adverse events associated with the onset of risk situations. Monitoring of system parameters is necessary for rapid reaction to the changing in situation and for making reasonable decisions.

REFERENCES

Anable, J 2005, 'Soft Measures: Soft option or smarter choice for early energy savings in the transport sector?', European Council for an Energy Efficient Economy (ECEEE*)* Summer Study, Mandelieu, France, May 30–June 4.

Bertoldi, P, Rezessy S, Anable, J, Patrick Jochem & Vlasis Oikonomou 2011, 'Energy Saving Obligations and White Certificates: Ideas and Considerations for the Transport Sector', *International Journal of Sustainable Transportation*, vol. 5, Issue 6, pp. 345-374.

Beuthe, M, Gasca, J , Greene, D, Lee, DS, Muromachi, Y, Newton, PJ, Plotkin, S, Sperling, D, Wit, R, Zhou, PJ 2007, *Transport and its infrastructure. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, viewed 25.03.2014, <http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter5.pdf>

Brah, SA a & Chong W.-K 2004, 'Relationship between total productive maintenance and performance' *International Journal of Production Research*, vol. 42, no. 12, pp. 2383–2401.

Bringezu, S , Schutz, H , ÓBrien, M , Kauppi, L , Howarth, RW , McNeely, J 2009 . *Assessing biofuels*. United Nations Environment Programme, Paris.

Buddhakulsomsiri, J, Siradeghyan, Y, Zakarian, A& Li, X 2006, 'Association rule-generation algorithm for mining automotive warranty data', *International Journal of Production Research*, vol. 44, No. 14, pp. 2749–2770.

Choo, S , Mokhtarian, PL , Salomon, I 2005, 'Does telecommuting reduce vehicle-miles traveled? An aggregate time series analysis for the U.S', *Transportation*, vol.32 (1), pp.37 – 64.

Consultant plus, *The resolution of the Government of the Russian Federation of 03.02.2007 N 71 "About creation in the territory of Stavropol Krai of a special economic zone of tourist and recreational type"*, viewed 01 October 2013, <http://www.consultant.ru/document/cons_doc_LAW_65969/>.

Dawe & S.Thomas, R.A. 2007, 'A Large Potential Methane Source—Natural Gas Hydrates', *Energy Sources*, part A (29), pp. 217–229.

Dishisvobodno 2013. *Air pollution in Russia*, viewed 12 April 2013

<http://www.dishisvobodno.ru/zagryaznenie-vozdukha-v-rossii.html>.

Eurostat 2008. *Energy and Transport in Figures*. Luxembourg: EC, viewed 10 April 2010

Eurostat. 2009. Eurostat database. (viewed 1 April 2010)., <http://www.ec.europa.eu/eurostat>

Gt-garazh 2010. *Pour gasoline*, viewed 30 June 2010,

<http://gt-garazh.3dn.ru/ news/slivaj_benzin/2010-06-30-575>

Huang, HZ, Liu, ZJ & Murthy, D.N.P.2007, 'Optimal reliability, warranty and price for new products', *IIE Transactions*, vol. 39, pp. 819–827.

Johnson, E 2003, 'LPG: A secure, cleaner transport fuel? A policy recommendation for Europe', *Energy Policy*, vol. 31 pp.1573–1577.

KAMAZ 2012, *Prospect of development of gas engine cars KAMAZ on natural gas*, viewed 01 October 2013 <http://tomskautogaz.ru/upload/health/files/RariTEHK___perspektiva_razvitija_GBA_KAMAZ_na_metane_2012_file_53_40_614.pdf >.

Khan, MM., Prior, D., and Islam, M. 2005a, 'Zero-waste living with inherently sustainable technologies', Jordan International Chemical Engineering Conference V. Paper no. JICEC05-ENV-1-18-0. Amman, Jordan, September 12–14.

Konstantinov, AP, 2012, 'Ecology and health: risks mythical and real', *Ecology and life*, № 9, pp. 82–86.

Kubat, C. 2004, 'The database management system for Sakarya automotive suppliers and supply chain', *Production Planning & Control*, vol. 15, No. 7, pp. 719–730.

Larivé, JF , Edwards, R , Mahieu, V , Griesemann, JC , Rickeard, DJ 2004, 'Well-to-wheels analysis of future automotive fuels and powertrains in the European context, project report'. *EUCAR, CONCAWE and JRC*, viewed 25.03.2014. <http://ies.jrc.ec.europa.eu/uploads/media /WTW_Report_220104.pdf>

Last, M, Sinaiski, A, Subramania, HS 2010,' Predictive Maintenance with Multi-target Classification Models', I*ntelligent Information and Database Systems. Lecture Notes in Computer Science*, vol. 5991, pp 368-377.

Lee, S, Lee, D, Park, C, Lee,J, Park S,Moon, K, Kim, B 2008, 'A Fuzzy Logic-Based Approach to Two-Dimensional Warranty System', *Advanced Intelligent Computing Theories and Applications. With Aspects of Artificial Intelligence. Lecture Notes in Computer Science*, vol. 5227, pp. 326-331

Lee, S, Moon, K 2009, 'Fuzzy Failure Analysis of Automotive Warranty Claims Using Age and Mileage Rate', *Emerging Intelligent Computing Technology and Applications. With Aspects of Artificial Intelligence. Lecture Notes in Computer Science*, vol. 5755,pp. 434-439.

Makarova, I., Khabibullin R, Belyaev A, Belyaev E. 2012, 'Dealer-service center competitiveness increase using modern management methods', *Transport Problems*, vol.7, Issue 2, pp. 53-59.

Meeker,WQ, Hong, Y 2014 'Reliability Meets Big Data: Opportunities and Challenges' *Quality Engineering*, vol.26, pp. 102–116.

National Natural Gas Vehicle Association 2013, *All transport of Tatarstan on gas*, viewed 12 March 2013, <http://www.ngvrus.ru/>.

Petrović, J, Ivković I, Vujačić, I, Žeželj, S 2009, 'Possibilities of buses on alternative fuel in public urban transport in Belgrade' Technological and economic development of economy, *Baltic Journal on Sustainability*, vol. 15 issue 1, pp.78–89.

Rai, B & Singh, N 2005, 'Forecasting warranty performance in the presence of the 'maturing data' phenomenon', *International Journal of Systems Science*, vol. 36, No. 7, pp. 381–394.

Ribeiro, SK, Ma´ Rcio De Almeida D'agosto 2004, 'Assessment of hybrid-drive bus fuel savings for brazilian urban transit', *Transportation Planning and Technology*, Vol 27, Issue 6 , pp. 483-509.

Smurov, AV, Snakin, VV, Komarova, N, 2012, 'Modern condition of atmospheric air', *Ecology of Russia*, Educational publication, pp. 12-33.

Sperling, D 1995, *Future Drive—Electric Vehicles and Sustainable Transportation'*, Island Press, Washington, DC.

Sperling, D, Setiawan W, Hungerford D 1995, 'The target market for methanol fuel', *Transportation Research*, Part A, 29A (1), pp. 33–45

Tsg66.ru 2013, *Medvedev decided to transition all cars in the country on the gas*, viewed 10.04.2013, <http://www.tsg66.ru/novosti/v-mire/medvedev-zadumal-pereves-vse-avtomobili-v-strane-na-gaz.html>.

Tzeng, GH, Lin, CW, Opricovic, S 2005, 'Multi-criteria analysis of alternative-fuel buses for public transportation', *Energy Policy*, vol. 33, pp.1373–1383.

Weinstein, L, Robert J. Vokurka & Gregory A. Graman 2009, 'Costs of quality and maintenance: Improvement approaches', *Total Quality Management*, vol. 20, No. 5, pp. 497–507.

Xie,W, Liao, H & Zhu, X 2014, 'Estimation of gross profit for a new durable product considering warranty and post-warranty repairs', *IIE Transactions*, vol. 46, pp. 87–105.

Zhuang, Q., Yodotani, J., and Kato, M 2005, 'Accurate measurement method for the residues in liquefied petroleum gas (LPG), *Fuel* 84 pp. 443–446.