Development of liquefied natural gas transport and creation of energy infrastructure for its functioning in Russia

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Abstract. This is as a monitoring result of the actual scientific literature in the field of using liquefied natural gas as a motor fuel. The ecological and technological advantages of using liquefied natural gas in this area are considered. Based on this, conclusions are drawn about the competitiveness of liquefied natural gas relative to other types of motor fuel. Analyzed the current energy strategy of the Government of the Russian Federation in the field of promoting and popularization of liquefied natural gas as a motor fuel and the development of energy and filling infrastructure. Based on the identified shortcomings of the strategy, an alternative option is proposed that relies on local gas filling systems, mini-gas liquefaction plants, and mobile gas stations. An assessment of the technical and economic parameters of the project for the creation of such an infrastructure was carried out because of which a conclusion was made about its overall efficiency. Options for implementing the concept of alternative development of the energy and refuelling infrastructure of liquefied natural gas and its integration into the state energy policy are proposed.

1. Introduction

In the conditions of the actively gaining pace of development of the sixth technological order and the beginning of the fourth energy transition in terms of energy consumption, energy efficiency and environmental friendliness of the resources used are in the first place with the possibility of replacing classical energy carriers with more efficient ones. In particular, the use of liquefied natural gas (hereinafter LNG) as an automobile and ship fuel, the feasibility of which is confirmed by numerous studies. Despite the fact that LNG is not a product of renewable energy and its use does not fit into the classical ideas of the fourth energy transition, the lack of an objective possibility of widespread introduction of electric vehicles, the high cost of technological solutions in this area and a number of other factors make LNG one of the few alternatives allowing to provide at the same time a sharp decrease in the level of emissions into the environment, as well as economic benefits for transport owners due to the availability of relatively simple technical solutions for its widespread use.

However, despite all the advantages, the introduction of LNG-fueled transport in Russia is hampered by the complete absence of a filling infrastructure, the appearance of which is advisable when a critical level of consumers is formed [1-2]. Thus, the lack of infrastructure makes the rapid development of LNG transport impossible.

2. Materials and methods

Based on the study of Russian and foreign publications, the authors concluded that the vast majority of researchers note the exceptional advantages of this type of fuel in all respects over traditional
petroleum products and the availability of ready-made technical developments for trucks and cars on LNG [3-5], which made it possible to conclude about the need to create a network of cryo-filling stations for vehicles powered by LNG. According to the state program «Development of Energy» (as revised on August 26, 2020), it is planned to subsidize the creation of 130 filling stations in the amount of 3 billion rubles by 2024 and by 2030 it is planned to reach the target of 200 operating stations [6], which, according to authors, for a country of such a scale as Russia, is a half measure, since it will allow transferring to LNG a small part of public transport.

For this reason, the authors made an attempt to analyze the factors influencing the decision of the carriers to switch to LNG and propose an alternative version of the state strategy. Based on the results of the analysis of materials from open sources, the authors were able to propose a project for a mini-plant for liquefaction of gas and a filling network with a special territorial positioning.

3. Results
Currently, the main areas of search for alternative fuels and improvement of existing types are:

- Deeper refining of oil products and stricter fuel quality standards;
- Creation of a transport operating on electric energy or having a hybrid engine;
- Wider distribution of biological fuels [2-7].

All three areas have a solid history of scientific research from a technical, environmental and economic point of view, as well as extensive practical experience in their development [4]. In this regard, the development of transport on LNG is a new practice, which has received scientific and practical development only in the last 5-10 years [2]; however, the exceptional characteristics of LNG make this technical direction very attractive. First, it should be noted the excellent performance of LNG from an environmental point of view (figure 1).

Figure 1. Environmental characteristics of LNG as a type of motor fuel relative to some other types of motor fuel [2].

Despite the fact that environmental standards for petroleum products are tightening every year, the potential for improving gasoline and diesel fuel is technologically limited and significantly affects their cost. While there are technologies that increase the environmental characteristics of natural gas [8], which suggests that, there is a potential for improving the environmental characteristics of LNG. At the same time, one of the main advantages of LNG as a fuel is its low cost (figure 2).
Data from Russian sources indicate that the cost of a kilometer for a truck running on LNG is approximately 8.9 rubles versus 17.8 rubles for a diesel vehicle [2]. In addition, experts note that the use of LNG reduces the wear of engine mechanisms [9]. At the same time, vehicle owners can receive additional benefits from tax incentives: now, in 21 subjects of the Russian Federation, a tax deduction is provided for an average of 50% of the transport tax for vehicles with installed gas equipment [8]. Taking into account the energy policy of the Russian state [3], in the future it can be expected that the system of benefits will be introduced in all regions.

However, as noted earlier, the transfer of transport to LNG limits the infrastructure factor. It is not advisable for transport owners to switch to a new type of fuel until a wide refueling infrastructure has been created throughout the territory of the intended use of transport. At the same time, the created infrastructure will be unprofitable until a certain minimum volume of consumption occurs. The Russian Government sees a way out of this situation in subsidizing the construction of cryo-filling stations and the production of vehicles powered by LNG, as well as a wider distribution of tax incentives for owners of LNG vehicles [3; 10]. It should be emphasized that most of the projects in this area are expected to be implemented by PJSC «Gazprom» and PJSC «Novatek» [2]. At the same time, the companies’ own vehicle fleet [11] will provide the initial demand for cryo-filling stations.

An alternative option for the development of infrastructure, contributing to the widespread use of LNG transport, is the use of mobile filling systems (figure 3).

Placement of a mobile filling system on the example of a specific commercial proposal, including a tank for storing LNG, a device for sale (filling station), a fire extinguishing system and auxiliary
elements (pumps, etc.), with a total cost of $ 36,000 [13] can be carried out on existing gas stations under a lease agreement.

In turn, the gas liquefaction infrastructure is proposed to be implemented in the form of a gas liquefaction mini-plant, which supplies the nearest gas stations. The capacity of such a plant can be increased through additional investment as demand from vehicle owners grows.

According to the authors, the «anchor» consumers for LNG infrastructure could be public transport fleets, river and seaports, given the tightening of fuel standards for ships [1].

Using a public commercial offer for the sale of equipment for a cryogenic filling station [14], as well as a publicly available approximate estimate for the construction of a mini-plant for liquefying gas [15], the authors formed a financial model of a private LNG-filling infrastructure project from a mini-liquefaction plant, 20 petrol stations and two port petrol terminals. The main characteristics of the project are presented below (figure 4).

The approbation of the financial model showed that the approach proposed by the authors to the development of infrastructure for wider distribution of LNG as a transport fuel in Russia would not only create a filling network, but also ensure its profitability and an acceptable payback period.

4. Discussion
The study showed that it is possible to create a cost-effective local filling infrastructure due to the low initial production capacity, reliance on «anchor» consumers and the use of mobile filling stations instead of standard cryo-filling stations. The concept of infrastructure development proposed by the authors can be integrated into the current state policy for the development of the internal LNG market or considered as a complete alternative to the current state strategy. In general, the proposed concept would require from the federal and local authorities less financial support and more assistance in organizing partnerships between factories and government-owned fleets [16-17].

If earlier the scientific «mainstream» in the application of LNG in transport was a discussion of the advantages and disadvantages of this type of fuel and the general prospects for implementation [18], at the moment the focus of the scientific community is on the issues of practical implementation of fuel in the automobile [19], marine [20] and railway [21] transport, as well as directions of infrastructure development in these areas [22].
5. Conclusion
In order to summarize the ideas it is worth to declare that LNG has exceptional environmental and economic characteristics, significantly superior to gasoline, diesel and fuel oil, which makes it possible to consider it as a new promising type of automotive, ship and train fuel. At the same time, the necessary technological base has already been created for the use of LNG in the indicated directions. The main obstacle to the introduction of LNG in transport now is the problem of creating a cost-effective infrastructure. The government of the Russian Federation is subsidizing the creation of filling stations on the main transport routes, which should allow creating the necessary minimum infrastructure and making it possible to use the first LNG vehicles.

At the same time, the authors proposed an alternative concept for the development of infrastructure, which allows creating a wider filling network, providing filling terminals for river and sea transport, reducing the amount of necessary investments and increasing economic efficiency, and based on the use of mini-liquefaction plants and mobile filling stations as well as strategies for their placement and business, taking into account the regional needs of the country's economy. The results of the research carried out may be of interest to both government agencies and businesses.

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